CONCEPT MAPPING AND STUDENT SUCCESS IN A COLLEGE-LEVEL
ENVIRONMENTAL STUDIES COURSE

by

Jennifer Moore Bernstein

A professional paper submitted in partial fulfillment
of the requirements for the degree

of

Master of Science

in

Science Education

MONTANA STATE UNIVERSITY
Bozeman, Montana

June, 2011
STATEMENT OF PERMISSION TO USE

In presenting this professional paper in partial fulfillment of the requirements for a master’s degree at Montana State University, I agree that the MSSE Program shall make it available to borrowers under rules of the program.

Jennifer Moore Bernstein

June 2011
TABLE OF CONTENTS

INTRODUCTION AND BACKGROUND .................................................................1
CONCEPTUAL FRAMEWORK .............................................................................3
METHODOLOGY .................................................................................................10
DATA AND ANALYSIS .......................................................................................17
INTERPRETATION AND CONCLUSIONS .........................................................26
VALUE ...............................................................................................................34
REFERENCES CITED .........................................................................................43

APPENDICES .....................................................................................................46
APPENDIX A: Informed Consent Form ............................................................47
APPENDIX B: ENVS 220 Entry Quiz ...............................................................50
APPENDIX C: Background Interview ...............................................................55
APPENDIX D: Learning Style Survey ..............................................................58
APPENDIX E: MyTFA Cmap Assignment .......................................................62
APPENDIX F: Reflection Cmap Assignment ...................................................65
APPENDIX G: Writing Cmap .............................................................................67
APPENDIX H: ANT Cmap Assignment ............................................................69
APPENDIX I: Concept Map Assessment Rubric .............................................73
APPENDIX J: Concept Map Questionnaire ...................................................75
LIST OF TABLES

1. Data Triangulation Matrix ..................................................................................................16

2. Concept Map Questionnaire: Factor Analysis of “Challenge” Question Items........21

3. Concept Map Questionnaire (Unit Synthesis and ANT): “Helpfulness” Descriptive
   Statistics .........................................................................................................................22

LIST OF FIGURES

1. A Basic Concept Map ......................................................................................................3

2. Concept Map Questionnaire: To what extent did you find this exercise easy or hard to do, in terms of the intellectual material you addressed? ........................................18

3. Concept Map Questionnaire: To what extent did you find this exercise easy or hard to do, in terms of assembling this material into a concept map? ...............................19

4. Concept Map Questionnaire: To what extent did you find this exercise easy or hard to do, in terms of having sufficient time to complete the task? ...............................20

5. Concept Map Questionnaire: To what extent did you find this exercise easy or hard to do, in terms of having clear instructions to guide you? ........................................20

6. Concept Map Questionnaire: To what extent did you find this exercise easy or hard to do, in terms of having sufficient mastery of concept mapping to complete the task? .......................................................................................................................21

7. Concept Map Questionnaire (Unit Synthesis and ANT): “Helpfulness” Descriptive Statistics ........................................................................................................................................22


9. Learning Style Distribution, Top and Bottom Quintiles.................................................31
ABSTRACT

Concept mapping is an educational tool that is used to facilitate and demonstrate student comprehension through the use of a visual medium. Because it provides a non-linear, multidimensional way of exploring a topic it is especially appropriate for use in environmental studies courses, where individuals, institutions, and ecosystems interrelate in complex ways. This project looked at the effect of using concept mapping as a reflective and constructive exercise in an environmental analysis course at Lewis and Clark College in Portland, Oregon. A sub-question was whether or not characteristics of certain students, such as “learning style” and background proficiency with the subject matter would affect the degree to which concept mapping proved helpful. Students created bi-weekly concept maps to review lessons, reflect on their growth throughout the course, and present the findings of their final group research projects. A sub-group of students completed a questionnaire after each concept mapping exercise, which asked them the degree to which the exercise helped facilitate the educational goals of the course. Overall, concept mapping proved helpful and moderately challenging to the students. In general, demographics, learning style, and other variables did not predict success with concept mapping or success with the course. One notable exception was that the students who felt more challenged by the concept mapping exercises ultimately did better in the course overall. This indicates that for engaged students, concept mapping has the potential to keep them at the optimal level of intellectual discomfort that ultimately fosters deep learning.
INTRODUCTION AND BACKGROUND

Introduction

This research project was conducted with students at Lewis and Clark College, a private liberal arts college with 2,000 undergraduates located in Portland, Oregon. Environmental studies (ENVS) students tend to be Caucasian, in their early 20’s, intelligent, from relatively privileged backgrounds, and largely female. The culture of Lewis and Clark is environmentally focused, and ENVS students tend to be passionate about environmental issues. The atmosphere in class is friendly, informal, and social.

I came to work with students at Lewis and Clark because my Masters thesis advisor at U.C. Santa Barbara, Jim Proctor, is now the chair of their environmental studies department. He and I share similar research interests, including the way in which technology can facilitate a deeper understanding of environmental problems. I had done preliminary research on concept mapping with Jim’s students in conjunction with the MSSE course EDCI 504, and when it came time to choose a topic for my capstone Jim and I agreed that concept mapping warranted further investigation.

We implemented the treatment on ENVS 220: Environmental Analysis, a semester-long course that follows the introductory environmental studies course (ENVS 160) and is required for all environmental studies majors. The course is methods-based, meaning that students are introduced to environmental analysis techniques such as ArcGIS, SPSS, and semiotics. We chose this class because students were familiar with environmental problems, but they did not yet possess the type of sophisticated understanding that might prevent them from being open to exploring new approaches.
Focus Question

The purpose of this study was to understand how employing a variety of concept mapping exercises affected student success in a college-level environmental studies course, and whether factors such as baseline proficiency with environmental studies topics, engagement with the subject matter, comfort with technology, and/or learning style could predict the degree to which concept maps would prove a useful tool on an individual basis.
Concept maps (or “Cmaps”) are visual depictions of concepts and their relationships and have been consistently heralded as an effective educational tool for nearly 40 years. They consist of concepts, visually represented as terms bound in a circle or square, which are linked to other concepts with lines called crosslinks. These lines are accompanied by a verb or symbol, such as “+” or “−”, which describe the relationship between the two concepts and may include an arrow indicating the relationship’s directionality. Concept maps are typically arranged hierarchically, with the main concepts placed at the top of the map and the sub-topics arranged lower down. Successful concept maps usually have a critical question that the map seeks to address (Novak, 2006). Figure 1 shows an example of a Cmap made by the professor of ENVS 220, Dr. James Proctor, to demonstrate what is expected of the students’ final projects.

![A Basic Concept Map](image)

**Figure 1. A Basic Concept Map (Proctor, n.d.)**

Joseph Novak created concept maps in 1972 when he was a professor at Cornell University. He was trying to understand how students’ understanding of science changed
as the student acquired additional knowledge. He found that interview transcripts were unsuccessful in explaining the complex processes through which students assimilated new information into their previous knowledge structures. His belief in the usefulness of concept maps was based on constructivism, or the idea that humans construct knowledge by incorporating new information and experiences into what they already know (Novak, 2006).

Concept maps are grounded psychologically and epistemologically. They are based on the Theory of Learning Psychology of David Ausubel (1963), which states that students learn through assimilating new ideas into their existing framework and cognitive structure. Epistemologically, it has been shown that concept maps help provide the mental scaffolding with which students structure new knowledge (Novak, 2006). Creating concept maps helps increase student retention of new information (Novak, 1990; Novak & Wandersee, 1991). Additionally, studies have indicated that conclusions gained when concept maps are used as an evaluation tool are comparable to traditional testing methods (Shalveson & Ruiz-Primo, 2000). Despite the fact that they were created nearly 40 years ago, concept maps remain “the most important meta-cognitive tool in science education today” (Mintzes, Wandersee, & Novak, 1997, p. 424).

Novak (2006) established the basic concept map creation process. First, one should start with a good focus question, whether provided by the teacher or the learner. The more focused and robust the question, the better the resulting concept map. Second, one should identify key concepts having to do with the topic question, list them, and rank them in order of importance. Next, one should construct a preliminary map with the central concepts near the top and sub-topics arranged below, with crosslinks between
them. Finally, one should go back in and define the relationship that the crosslink represents.

Using concept maps as a stage in the learning process is the most frequent use of concept mapping (Lomask, Baron, Greig, & Harrison, 1993; Ruiz-Primo & Shalveson, 1996; Wilson, 1993). This is because creating concept maps helps students learn (Novak, 2006). Concept mapping contributes to student confidence by letting students demonstrate what they know rather than forcing them to explain what they don’t know as in traditional testing. The process helps encourage meaningful learning and creative thinking and replaces rote learning and memorization. The creation of crosslinks encourages students to define the precise relationship between concepts, which requires creatively synthesizing and evaluating information (Kinchin, 2001). Further, concept mapping can be a useful learning tool when used in collaborative group work. It can help a group stay on task by giving them a concrete goal to work towards, rather than an abstract problem to figure out. It has been shown that just working on a concept map as a team increases group cohesion and morale (Trochim, 1989).

Concept maps prove useful when evaluating student comprehension, so much so that they have started to appear as an evaluation tool in science textbooks (Novak, 2006). Teachers are able to identify valid and invalid points through student-generated crosslinks, and evaluate the complexity of a student’s understanding through the number and breadth of concepts. Traditional types of assessment tend to focus on individual concepts rather than the relationships between concepts, ignoring a great deal of the disciplinary knowledge that a student has mastered. Concept maps are also practical since they provide comparable results to traditional testing while requiring less time and little
training for instructors (Markham, Mintzes & Jones, 1994). Further, they provide an equitable testing method for students who suffer test anxiety (Okebukola & Jegede, 1989).

Given that it has been shown that concept mapping is most effective when students work collaboratively (Preszler, 2004), it makes sense that concept maps would work well in the highly collaborative atmosphere of online learning. It has been shown that when students work collaboratively online with concept maps, learning increases (Preszler, 2004). CmapTools is a popular and widely used online concept mapping tool created at the Institute for Human and Machine Cognition (Canas, Suri, Lott, & Eskridge, 2004). This online tool has many advantages over hard-copy concept maps. Maps can be created and edited quickly and easily, and users can collaborate on maps across distance and time. The easy use of icons further adds to the effectiveness of concept maps, as it has been shown that icons are remembered longer than words (Sperling, 1960). Concept maps can be also published and collected online into groups of concept maps called Knowledge Models (Canas, Hill, & Lott, 2003; Canas & Novak, 2005).

Concept mapping proves more useful in certain contexts than in others. It proves most effective when a student is engaged in “meaningful learning” (Ausubel, 1963), for which there is specific criteria. First, the material being mapped must be conceptually clear and relate to previous knowledge. For this to occur, the student must possess prior knowledge of the topic area. Second, the student must be learning meaningfully. If a student is engaged in rote memorization, they will adopt the concept mapping method with much more difficulty. And in the same way that students must not be learning via rote memorization, teachers must not be teaching via a rote memorization method
(Ausubel, 1963). For concept mapping exercises to be useful, there must be increased teacher education to help the teacher transition from an information disseminator to a coach, guide, and collaborator (Kinchin, 2001).

There have been surprisingly few critiques of the effectiveness of concept maps. The argument has been made that some authors, professing to evaluate the effectiveness of concept maps, actually preemptively support them and hence tolerate methodologically questionable techniques such as small sample sizes and too few study sites (Kinchin, 2001). Another critique, while not specifically of the concept mapping process, is that concept maps are ineffective when tacked on to traditional teaching methods and little attention is paid to the educational context in which concept mapping occurs. And unfortunately, when initially employing concept maps, there may be a dip in student achievement as teachers restructure their teaching framework (Kinchin, 2001). Afterwards, however, students almost universally improve.

One argument that is made against concept maps, often informally, is that some people are simply not “visual learners” and hence do not find a natural affinity to the graphic medium of concept maps. This critique has some grounding in the literature-while the Theory of Multiple Intelligences defends concept mapping as an alternative to verbal evaluations because students learn in different ways, it is implicit in this argument that there is another group of students who do not learn visually (Gardner, 1983). The idea that different students learn in different ways is rooted in a field of research on learning styles.

While there is no universal consensus as to what a learning style is, they can be defined as “the preference students have for thinking, relating to others, and particular
types of classroom environments and experiences” (Grasha, 1990, p. 79). The implication is that teachers should be aware of these differences in student preference when designing their lesson plans. One of the most widely used learning style surveys that has made its way into popular culture is the VARK (visual, auditory, reading/writing, kinesthetic) learning styles survey (Leite et al, 2009). This survey-measured approach poses that there are four types of learning styles; visual learners, auditory learners, reading/writing preference learners, and kinesthetic/tactile learners. Learners can be categorized as uni-, bi-, or tri-modal learners depending on their responses to a series of question items. However, many critiques have been made against the VARK learning style, namely that it has failed to prove that it is statistically “reliable and valid” (Dunn et al 1989, p. 50) to nearly all researchers except Fleming. Dunn, specifically, has made multiple caveats about the VARK model (Dunn, 1993). His first critique is methodological, arguing that the survey itself is biased towards reading/writing style learners. He also worries about the application of the results, warning that students may categorize themselves into a single learning style category after taking the survey. The survey may unintentionally perpetuate the idea that learning styles are fixed and innate, which is outdated (Demos, 2004) and can prove a disservice for both the teacher and learner. In fact, research has shown that when students see intelligence as flexible and changeable they are more likely to improve, while those who see it as immutable may see failure as inevitable and success as hopeless (Cain & Dweck, 1989). However, this misuse of the VARK survey may not be the fault of its creators. Fleming and Mills (1992) state:

rather than a simple diagnostic tool, we wanted something that would serve as a catalyst for discussion and debate and encourage students to
collaborate in the process… Because we were seeking a quick and easy
catalyst for discussion rather than an elaborate diagnostic tool, we decided
that 13 questions would be adequate. In addition, we established that
because the instrument would be used primarily to stimulate reflection and
discussion testing for construct validity and reliability was unnecessary
and inappropriate (p. 27).

In the context of concept maps, teachers or researchers should not assume that students
with certain learning styles will find concept maps more or less useful.

Concept maps are specifically geared towards use in the sciences, which is
perhaps unsurprising given that they originated as a tool to evaluate student
comprehension of science. They have been applied to a variety of other disciplines,
notably geography and environmental studies (Leat, 1997; O’Brien, 2002; Ward, 2004;
Wood, 2007). They have been used to explore student understanding of ecosystem
structures (Martin, Mintzes & Clavijo, 2000) and biogeochemical cycles (Lin & Hu,
2003). Others have employed them to explore student understanding of sustainability
(Walse, 2008). O’Brien (2002) used concept mapping in a secondary school course on
the National Parks, arguing that “concept maps can offer a way to gather all the pieces of
the geography jigsaw and then piece them together” (p. 126). Hence, concept mapping is
a successful means of facilitating student understanding in environmental problem
solving.
METHODOLOGY

A great deal of the methodology employed was designed to rectify weaknesses in how concept mapping was assigned in previous ENVS courses. In ENVS 160, students had only two assignments involving concept mapping. These assignments primarily focused on learning the CmapTools software and did not involve much peer or faculty feedback. In previous iterations of ENVS 220, students had been assigned to submit an ANT concept map (referring to Bruno Latour’s Actor Network Theory) with their final project. However, interviews with students conducted during the spring of 2010 showed that students were creating their concept maps at different times during the research process and for different purposes. For instance, some students created the map near the beginning of their research as a means of brainstorming, while others completed it near the end as a presentation tool. Further, students were introduced to the concept mapping process only in conjunction with their final project, with limited opportunities to experiment with it in other contexts. During the summer of 2010, the course professor and I clarified the academic objectives of ENVS 220 and restructured the lectures and labs accordingly. The activities designed for this iteration of ENVS 220 were intended to make students more familiar and proficient with concept mapping throughout the course of the semester so that their final ANT cmap would be more robust. One primary objective was to involve concept mapping throughout the curriculum in a more comprehensive fashion. We decided to see if consistent exposure to concept mapping, participating in a variety of concept mapping assignments, being provided with a concept map rubric, and participating in frequent peer review would increase the quality of
student concept maps, and ultimately, success in the course overall.

Four different types of cmap assignments were created to achieve these ends; MyTFA, Unit Synthesis, ANT, and Writing. The first assignment was called a MyTFA (thinking, feeling, acting) map, which was based on the theory of education proposed by Joseph Novak, the originator of concept mapping. Novak argued that successful education synthesized cognition (thinking), emotions (feeling), and performance or motor skills (acting) in order to make sense of one’s educational experience (Novak, 2009). This is especially true with students in environmental studies programs, who, for instance, may possess sophisticated knowledge of climate science and policy (thinking), which is motivated by a deep emotional concern for the state of the planet (feeling), who may protest, attend conferences, or ride their bike as a means of addressing the problem (acting). The MyTFA assignment was conducted during the second week of the semester in order to reintroduce concept mapping with non-challenging subject matter and allow the students reflect on how their thoughts, feelings, and actions are interrelated. This enabled students to move forward in the course with perspective on their own environmental narrative. This map was done by hand as to not distract students with the software, and there was no associated questionnaire. The assignment was repeated during the last week of the semester as a way for the students to reflect on how their thoughts, feelings, and behaviors had changed throughout the course.

The second type of concept mapping assignment was called a Unit Synthesis cmap, and was intended to help students review the previous unit. Because the course focused on environmental analysis, students were introduced to a new analytical tool ("Isms" or theory, GIS, Quantitative Analysis, and Qualitative analysis) roughly every
two weeks. At the conclusion of each unit, students were asked to create a concept map of the unit and share them with one another. The first map (“Isms”) was created by hand, in order to reintroduce students to the concept of concept mapping without distracting them with the Cmap Tools software. The objective was for students to reflect on what they had learned, identify gaps in their understanding, and sequentially review the material. There was also a written component of the exercise to assess the professor’s desire to use concept mapping to improve the students’ writing.

The third type of concept map exercise was also assigned in past iterations of this course- the ANT concept map. As the course’s final project, student groups of two to four performed “situated environmental research,” meaning an in-depth analysis of the ecological, social, political, and historical forces that interrelate to create a local environmental problem. The ANT concept map was used by the groups as a visual aid in presenting project to their fellow students, as well as a substantive component of the written final report. They were created using the IHMC computer program Cmap Tools. The professor had struggled with the low level of student achievement with the concept mapping part of the project, with many maps inadequate in regards to scope and scale. The objective was for students to be better able to create a sophisticated, provocative, and appropriately scaled concept map in conjunction with their final project after a semester of employing concept maps in a variety of contexts.

A fourth type of concept mapping assignment, called a Writing cmap, was conducted once but is not included in this analysis. The assignment asked students to create a concept map based on a piece of writing, and we hoped that the students would improve their critical thinking skills by using the concept map to identify strengths and
weaknesses in the author’s argument. While we did not do a formal assessment of this exercise, we found that the students were too distracted by whether or not they agreed with the argument itself (in this case, a piece from Wal-Mart about their green initiatives) to be able to critically evaluate it. We decided to discontinue writing cmap assignments because we already had the students doing a number of other cmaps, and we did not have time seriously reassess and revise the assignment mid-semester.

While all students took part on the concept mapping exercises, it was not feasible for the whole class to participate in the additional exercises needed to deeply evaluate the effectiveness of concept maps (post-cmap questionnaires, interviews, etc.). At the beginning of the semester, students were given the option to participate in three semester-long projects, of which research for this capstone was one. Twenty-four students signed up for this project, while six students signed up for each of the other two options. While this selection process does not provide a true random sample of the students in the course, a sufficient sample size existed for students possessing a range of academic achievement levels. These students all gave their consent through the Informed Consent Form (Appendix A).

At the beginning of the course, the students’ background knowledge and general understanding of course principles were assessed. This was done to provide a baseline against which to check student achievement as the course progressed. Background knowledge was evaluated using three different measures. First, the students took the Entry Quiz created by the professor that tested their mastery of the material presented in ENVS 160 and ENVS 220 (Appendix B). This provided a baseline of their concrete knowledge of the subject. Second, structured individual interviews were conducted with
each student using the Background Interview (Appendix C). Third, grades from the
students’ introductory environmental studies course were collected (students were told
that submitting their ENVS 160 grades was a condition of participating in this project,
and they were given other projects to participate in if they did not feel comfortable
releasing this information). The quiz was graded using a basic point system. Interviews
were reviewed, but not formally analyzed. Grades were summarized and noted. Between
these three measures, we were able to see where individual students began academically
in order to analyze whether students at certain levels of academic achievement benefitted
more than others from the concept mapping process.

As discussed in the literature review, informal critics of concept mapping argue
that it appeals to certain types of learners (i.e. visual rather than verbal). To this end, we
assessed the students’ learning style. This was done through the widely recognized
VARK learning style survey, established by Neil Fleming (Learning Style Survey,
Appendix D) (Fleming, 2010). The scale was used to assign each student a learning style, which was done through the method described by Fleming on his VARK learning styles
website (Fleming, 2010). These scores were not revealed to the students until the end of
the semester because it has been shown that students can misinterpret the results by
pigeonholing themselves into a single learning style.

Students were given four types of concept mapping assignments throughout the
course of the semester, which have already been explained in detail. These were (1) A
MyTFA cmap about their own personal narrative (MyTFA Cmap Assignment, Appendix
E), (2) a Unit Synthesis cmap, which asked students to summarize the previous learning
unit (Unit Synthesis Assignment, Appendix F), (3) an ANT cmap, which is based on
Actor Network Theory and submitted in conjunction with the courses group final project (ANT cmap Assignment, Appendix G), and (4) a Writing cmap which is not included in this analysis. Beginning the first week of the semester, students were given one of these exercises nearly every week.

All concept maps created with CmapTools were assessed using a Map Assessment Rubric, which was distributed to students during their second concept mapping exercise to give them guidance as to the criteria for a good concept map (Appendix H). This rubric was standardized for all types of concept maps, though it noted additional features that should be present in an ANT Cmap. Two maps (Isms Unit Synthesis and the first MyTFA cmap) were not graded using the rubric because they were done by hand and were difficult to read. While I intended to give the students systematic weekly feedback, feedback was instead given by fellow students and the professor through discussion (this will be discussed later in greater depth). The students involved in the project were also asked to complete a Concept Map Questionnaire after nearly all concept mapping exercises which measured their assessment of the mapping process and what they achieved (Appendix I). The questionnaires were analyzed using descriptive statistics, frequencies, crosstabs, bivariate correlations, and factor analysis. There was no questionnaire associated with the two MyTFA maps, because the nature of the assignment involved a great deal of self-reported attitudinal information.

At the completion of the course, data collection instruments were analyzed longitudinally to determine whether there was overall improvement, changes in attitudes towards concept mapping process, and whether certain exercises proved more beneficial than others. The different Cmap exercises were evaluated as to the students’ success
creating them, measured both objectively through the rubric and subjectively through the self-assessment questionnaires. Students were assessed as to their overall achievement, as measured through success on their final project (which included an ANT-style concept map), and their final grade. Statistical techniques such as factor analysis and bivariate correlation were used to analyze student achievement in relation to previous assessment objectives.

The above assessment objectives and the data sources used to achieve them are shown in Table 1 below.

Table 1
*Data Triangulation Matrix*

<table>
<thead>
<tr>
<th>ASSESSMENT OBJECTIVE</th>
<th>Background knowledge of topic area</th>
<th>Learning style</th>
<th>Success creating cmaps</th>
<th>Perceived usefulness of concept mapping</th>
<th>Mastery of individual lessons</th>
<th>Overall success in course</th>
</tr>
</thead>
<tbody>
<tr>
<td>Entry Quiz</td>
<td>x</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Learning Style Survey</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>x</td>
</tr>
<tr>
<td>Background Interview</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>x</td>
</tr>
<tr>
<td>Unit Synthesis Cmaps</td>
<td>x</td>
<td></td>
<td>x</td>
<td></td>
<td></td>
<td>x x x</td>
</tr>
<tr>
<td>ANT Cmaps</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cmap</td>
<td></td>
<td>x</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Questionnaires Cmap</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cmap evaluation</td>
<td></td>
<td></td>
<td></td>
<td>x</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Rubric</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>x x x</td>
</tr>
</tbody>
</table>
DATA AND ANALYSIS

Ways in Which Concept Mapping Proved Most Challenging

Based on data from the post-concept map questionnaires, the students found that the intellectual material addressed was the most challenging part of the concept mapping process, rated as slightly greater than *somewhat of a challenge* (mean score of 3.2, between *somewhat of a challenge* (3) and *significant challenge* (4)) (Figure 2).

To what extent did you find this exercise easy or hard to do, in terms of the intellectual material you addressed?

![Figure 2. Concept Map Questionnaire: To what extent did you find this exercise easy or hard to do, in terms of the intellectual material you addressed?](image)

Said one student, “It was difficult to connect the frameworks to the theories since the frameworks tend to deal with two ways of looking at one issue. While I was able to find connections, it was difficult to find the words to explain how the connected with arrows.”

The most challenging exercise in this respect was the GIS Unit Synthesis with a mean score of 3.6, between *somewhat of a challenge* (3) and *significant challenge* (4). However being challenged was not necessarily perceived as a bad thing, as one student said, “I found it challenging to link class concepts and theories/frameworks with this particular set of tools. This was a good challenge, though, as it made me put statistics into context...
and think about how we use them.” In regards to their final project, the students felt that the intellectual material became more challenging as they narrowed their focus, with the initial brainstorming ANT Cmap having a mean score of 2.8 and the final ANT Cmap having a mean of 3.2, between somewhat of a challenge (3) and significant challenge (4).

Assembling the material into a concept map also proved challenging with a mean score of 3, or somewhat of a challenge (Figure 3).

To what extent did you find this exercise easy or hard to do, in terms of assembling this material into a concept map?

<table>
<thead>
<tr>
<th>US* Isms</th>
<th>UNGIS</th>
<th>US Stats</th>
<th>US Qual</th>
<th>ANT BS**</th>
<th>ANT Final</th>
<th>Overall</th>
</tr>
</thead>
<tbody>
<tr>
<td>38%</td>
<td>38%</td>
<td>28%</td>
<td>33%</td>
<td>32%</td>
<td>31%</td>
<td>31%</td>
</tr>
<tr>
<td>48%</td>
<td>29%</td>
<td>50%</td>
<td>33%</td>
<td>44%</td>
<td>46%</td>
<td>42%</td>
</tr>
<tr>
<td>10%</td>
<td>29%</td>
<td>17%</td>
<td>28%</td>
<td>28%</td>
<td>23%</td>
<td>22%</td>
</tr>
<tr>
<td>5%</td>
<td>6%</td>
<td>5%</td>
<td>5%</td>
<td>6%</td>
<td>5%</td>
<td>5%</td>
</tr>
</tbody>
</table>

*US: Unit Synthesis
**ANT: Actor Network Theory
***BS: Brainstorm

<table>
<thead>
<tr>
<th>n</th>
<th>Mean</th>
<th>Mode</th>
<th>StDev</th>
</tr>
</thead>
<tbody>
<tr>
<td>19</td>
<td>3.2</td>
<td>3</td>
<td>0.8</td>
</tr>
<tr>
<td>17</td>
<td>2.9</td>
<td>4</td>
<td>1.0</td>
</tr>
<tr>
<td>18</td>
<td>3.0</td>
<td>3</td>
<td>0.8</td>
</tr>
<tr>
<td>18</td>
<td>2.9</td>
<td>3.4</td>
<td>0.9</td>
</tr>
<tr>
<td>18</td>
<td>2.8</td>
<td>3</td>
<td>0.9</td>
</tr>
<tr>
<td>13</td>
<td>3.1</td>
<td>3</td>
<td>0.8</td>
</tr>
</tbody>
</table>

Figure 3. Concept Map Questionnaire: To what extent did you find this exercise easy or hard to do, in terms of assembling this material into a concept map?

The first lesson and the last lesson were most challenging (with mean scores of 3.2 and 3.1 respectively, slightly above somewhat of a challenge (3)).

Logistical challenges like lack of time and clarity of instructions did not appear to hinder the students substantially in the concept map creation process (Figure 4 and Figure 5). Of all the concept mapping exercises, the students found that the two ANT-style maps’ instructions were most challenging, which were those that asked the students to employ Actor Network Theory.
To what extent did you find this exercise easy or hard to do, in terms of having sufficient time to complete the task?

<table>
<thead>
<tr>
<th></th>
<th>n</th>
<th>Mean</th>
<th>Mode</th>
<th>StDev</th>
</tr>
</thead>
<tbody>
<tr>
<td>US* Isms</td>
<td>19</td>
<td>2.4</td>
<td>2.0</td>
<td>1.5</td>
</tr>
<tr>
<td>US GIS</td>
<td>17</td>
<td>2.1</td>
<td>2.0</td>
<td>1.3</td>
</tr>
<tr>
<td>US Stats</td>
<td>18</td>
<td>1.8</td>
<td>1.0</td>
<td>1.2</td>
</tr>
<tr>
<td>US Qual</td>
<td>18</td>
<td>2.3</td>
<td>2.0</td>
<td>1.4</td>
</tr>
<tr>
<td>ANT BS**</td>
<td>18</td>
<td>2.1</td>
<td>1.0</td>
<td>1.5</td>
</tr>
<tr>
<td>ANT Final</td>
<td>13</td>
<td>2.4</td>
<td>1.0</td>
<td>1.6</td>
</tr>
<tr>
<td>Overall</td>
<td>22</td>
<td>2.2</td>
<td>1.0</td>
<td>1.6</td>
</tr>
</tbody>
</table>

*US: Unit Synthesis **ANT: Actor-Network Theory **BS: Brainstorm

Figure 4. Concept Map Questionnaire: To what extent did you find this exercise easy or hard to do, in terms of having sufficient time to complete the task?

To what extent did you find this exercise easy or hard to do, in terms of having clear instructions to guide you?

<table>
<thead>
<tr>
<th></th>
<th>n</th>
<th>Mean</th>
<th>Mode</th>
<th>StDev</th>
</tr>
</thead>
<tbody>
<tr>
<td>US* Isms</td>
<td>19</td>
<td>1.9</td>
<td>1.0</td>
<td>1.0</td>
</tr>
<tr>
<td>US GIS</td>
<td>17</td>
<td>1.9</td>
<td>1.0</td>
<td>1.1</td>
</tr>
<tr>
<td>US Stats</td>
<td>18</td>
<td>1.6</td>
<td>1.0</td>
<td>0.8</td>
</tr>
<tr>
<td>US Qual</td>
<td>18</td>
<td>1.5</td>
<td>1.0</td>
<td>0.8</td>
</tr>
<tr>
<td>ANT BS**</td>
<td>18</td>
<td>2.1</td>
<td>1.0</td>
<td>1.3</td>
</tr>
<tr>
<td>ANT Final</td>
<td>13</td>
<td>2.1</td>
<td>1.0</td>
<td>1.4</td>
</tr>
<tr>
<td>Overall</td>
<td>22</td>
<td>1.7</td>
<td>1.0</td>
<td>1.6</td>
</tr>
</tbody>
</table>

*US: Unit Synthesis **ANT: Actor-Network Theory **BS: Brainstorm

Figure 5. Concept Map Questionnaire: To what extent did you find this exercise easy or hard to do, in terms of having clear instructions to guide you?

Students felt decreasingly challenged by the concept mapping process as the lessons progressed, ranging from a mean score of 2.1 for lesson one (slightly above minor challenge (2)) to 1.6 with the final Cmap (between not at all a challenge (1) and minor challenge (2)). The students’ proficiency increased with each concept mapping they created. But while the perceived level of challenge of assembling the material into a concept map was relatively high, the degree to which the students believed that they had sufficient mastery of concept mapping was relatively low with a mean score of 2.0.
(minor challenge) (Figure 6). This will be discussed further in the Interpretation section of this report.

To what extent did you find this exercise easy or hard to do, in terms of having sufficient mastery of concept mapping to complete the task?

When analyzed using factor analysis, the process-based question items (challenge of material, process, and assembling said material into a map) formed the first factor, accounting for 58.4% of the variance, while the logistical question items (lack of time, and clarity of instructions) formed the second factor, explaining an additional 28.9% of the variance.

Table 2
Concept Map Questionnaire: Factor Analysis of “Challenge” Question Items

<table>
<thead>
<tr>
<th></th>
<th>Factor 1</th>
<th>Factor 2</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>56.87% of variance explained</td>
<td>25.24% of variance explained</td>
</tr>
<tr>
<td>Challenge: Assembling this material into a concept map</td>
<td>.919</td>
<td></td>
</tr>
<tr>
<td>Challenge: The intellectual material you addressed</td>
<td>.894</td>
<td></td>
</tr>
<tr>
<td>Challenge: Having sufficient mastery of concept mapping to complete the task</td>
<td>.824</td>
<td></td>
</tr>
<tr>
<td>Challenge: Having clear instructions to guide you</td>
<td>\text{.949}</td>
<td></td>
</tr>
<tr>
<td>Having sufficient time to complete the task</td>
<td>\text{.918}</td>
<td></td>
</tr>
</tbody>
</table>

Extraction Method: Principle Component Analysis
Rotation method: Varimax with Kaiser Normalization
Ways in Which Concept Mapping Proved Most Helpful

Students felt that both the Unit Synthesis and the ANT cmaps made them more proficient. Overall, the maps helped the students recognize how topics we have covered relate to one another with a mean overall score of 3, or helped somewhat (Table 3, additional detail provided in Figure 7).

Table 3

| Concept Map Questionnaire (Unit Synthesis and ANT): “Helpfulness” Descriptive Statistics |
|---------------------------------|-----|-----|-----|-----|
| Recognize how topics we have covered relate to one another | 72  | 3.0 | 3   | 0.6 |
| Recognize gaps in my understanding | 72  | 2.9 | 3   | 0.8 |
| Organize my/our ideas | 102 | 2.8 | 3   | 0.8 |
| Think in a non-linear fashion | 102 | 2.7 | 3   | 0.6 |
| Recognize the academic progress I made during this learning unit | 72  | 2.6 | 3   | 0.7 |

Figure 7. Concept Map Questionnaire (Unit Synthesis and ANT): “Helpfulness” Descriptive Statistics

The exercises also helped the students recognize gaps in (their) understanding (mean score of 2.9, between helped somewhat (3) and helped a little (2)) and organize (their) ideas (mean score of 2.8, between helped somewhat (3) and helped a little (2)). The degree to which the maps helped students organize their ideas had a standard deviation of 0.8, the lowest of all the question items in this battery. The exercise proved less helpful in helping the students recognize the academic progress (they) made during this learning
unit, with a mean score of 2.6. However the two MyTFA maps (which did not have a related questionnaire so they are not included in this analytical section) helped students recognize the academic and personal progress that they made throughout the course of the semester. When the helpfulness question items were analyzed using a factor analysis only one factor was extracted, which explained 62.98% of the variance.

The results of the Concept Map Questionnaire, ANT Only, indicated that the most helpful items identified by the students were that concept maps clarified areas which needed further research and helped to pare down or expand their topics (Table 4 & Figure 8).

Table 4

<table>
<thead>
<tr>
<th>Concept Map Questionnaire (ANT Only): “Helpfulness” Descriptive Statistics</th>
<th>n</th>
<th>Mean</th>
<th>Mode</th>
<th>StDev</th>
</tr>
</thead>
<tbody>
<tr>
<td>Clarify areas where I/we need further research</td>
<td>31</td>
<td>3.4</td>
<td>4</td>
<td>0.3</td>
</tr>
<tr>
<td>Pare down or expand my/our topic</td>
<td>31</td>
<td>3.3</td>
<td>4</td>
<td>0.4</td>
</tr>
<tr>
<td>Better understand the significance of actors and relationships</td>
<td>31</td>
<td>3.1</td>
<td>3, 4</td>
<td>0.4</td>
</tr>
<tr>
<td>Better understand Actor-Network Theory</td>
<td>31</td>
<td>2.7</td>
<td>2, 3</td>
<td>0.3</td>
</tr>
<tr>
<td>Explain the environmental issue to others</td>
<td>31</td>
<td>2.6</td>
<td>3</td>
<td>0.5</td>
</tr>
<tr>
<td>Clarify possible solutions</td>
<td>31</td>
<td>2.4</td>
<td>3</td>
<td>0.4</td>
</tr>
</tbody>
</table>

![Figure 8. Concept Map Questionnaire (ANT only): “Helpfulness” Descriptive Statistics](image)

Said one student, “Overall, this type of Cmapping is a good idea and has helped my group layout the specifics of our research question, along with determining what areas of research need more information and what areas we could focus on for collecting data.”
Mapping also proved helpful in helping the students better understand the significance of actors and relationships, with a mean score of 3.1 (with 3 being somewhat helpful). Said one student, “This Cmap was very helpful in organizing all the different actors that were a part of this issue and what connections we need to focus on to address the influence of safaris in the Serengeti.” The mapping process was less helpful in assisting the students better understand actor-network theory (mean score of 2.7), explain the environmental issue to others (mean score of 2.6), and clarify possible solutions (mean score of 2.4).

Predictors of Success with Concept Mapping

The background interviews done at the beginning of the course were revisited to explore whether or not there were commonalities between the high and low achieving students, or certain characteristics that would predispose them to be successful with concept mapping. Overall, these interviews did not elucidate distinct differences between these two groups. Both groups were comfortable with technology, feeling as though they could become proficient with new software fairly easily and quickly. That said, when asked about what they disliked about concept mapping, the high-achieving students were more likely to be frustrated with the tendency of concept maps to become overly complex. Additionally, while the students varied as to the concreteness of their long-term professional goals, the high-achieving students had a slightly more focused idea of what they wanted to be doing after graduating.

We measured many quantitative variables that we thought might predict individual students’ success with concept mapping. These predictive variables included
gender, grade level (ranging from sophomore to senior), grade on a course entry quiz, and learning style (visual, auditory, reading, and kinesthetic, as measured by the popular VARK learning styles survey). While the sample size is too small for correlations to be empirically defensible, the results suggest directions for further research. In short, the bulk of these variables did not correlate with the students’ scores on either the individual concept maps or their responses to the questionnaire items, with one notable exception.

Learning style did not predict success with concept mapping, as measured by a Pearson’s bivariate 2-tailed test of correlation. Visual learners seemed to find concept mapping more challenging. They were more challenged by the “logistical” aspects of the assignments than their peers (feeling that instructions were unclear and they had too little time, with statistically significant (.05) correlations of .434 and .455, respectively), and they found the concept mapping exercises less useful overall (with a statistically significant (.05) score of -.475). The visual learners were less successful in the course overall as well: of the quartile of students who had the worst grades in the course, 33% identified as visual learners. Conversely, 0% of the top quartile of students identified as visual learners.

However, the one phenomenon that helped predict the degree to which the concept mapping exercises helped the students succeed in the course was the degree to which the students were engaged with the course material. This can be seen through two variables that correlated with the students’ final course grade. The perceived challenge of the intellectual material you addressed and assembling that material into a concept map correlated positively with the students’ final course grade, with a statistically significant (.05) correlation of .436 of the former and a statistically significant (.001) correlation of
.610 of the latter. Students who perceive concept mapping as *more* challenging did *better*, not worse, than students who found concept mapping to be easy.

While all students who participated in this project were asked to complete all questionnaires, some followed through more than others. The students who responded to more questionnaires, and were subsequently forced to reflect on their experience more frequently, seemed to get more out of the concept mapping experience overall insofar as there was a positive correlation between number of questionnaires completed and perceived usefulness of concept mapping (statistically significant to the .05 level at .449).
INTERPRETATION AND CONCLUSIONS

This research project showed that the introduction of frequent concept mapping assignments in a college-level environmental analysis course was beneficial to both the students and the professor, and aided student achievement to the degree that the students were engaged in the mapping process and course material. Level of engagement, not demographic, academic, attitudinal, or behavioral variables, increased the overall usefulness of the exercises. Each individual exercise had its own effect on the students' learning, which I will discuss in some depth below, after which I will discuss some of the cumulative findings.

Unit Synthesis Concept Mapping Exercises

Before the Unit Synthesis concept mapping assignments, there was no unit review exercise in the course. Lewis & Clark students, like many college students, have completing demands on their time and things like periodic, comprehensive review often fall to the wayside. Concept mapping introduced regular, formal unit synthesis review exercises, which undoubtedly helped the students review the material more than if they had been asked to do so on their own. They were largely open to this new way of approaching review sessions. Said one student, “I think it is very interesting that we use Cmaps to link together skills and terminology we have learned. I have never done anything like this before, but I think it is an interesting way to go over what you have learned and better implant it in your mind.” Part of the effectiveness of this process
comes from the act of building a concept map. The concept map creation process makes the review process active, as compared to the relatively passive alternative of reading over the material. Students also were forced to synthesize and critique the material as they built their concept maps, furthering their own understanding of the subject matter. Additionally, the professor used these maps as Classroom Assessment Techniques, and they served as a quick and easy way for him to see gaps in the students’ understanding without the need for formal testing. He could then address these gaps through lectures and individual consultation with students.

Actor-Network Theory/Final Project Concept Mapping Exercises

Both the students and the professor valued using Actor-Network Theory concept maps in conjunction with the final group projects. Said one student, “Overall, the use of CMAPS in the situated research process for me has been the most effective and helpful use of CMAPS so far in ENVS 220.” The maps facilitated the ability of the groups to evaluate information pertaining to their projects and determine which actors and relationships were most important. One student said, “Overall our Cmap was helpful in getting a grasp on the whole picture. From looking at our sources it is hard to get a sense of how all the issues discussed are really related to one another and this visual was actually very helpful.” As they delved into the writing phase, the map served as a visual outline which the group referenced as they wrote. Said one student, “I felt as though this activity was a different way of producing an outline for our final group proposal project, and indeed, it has been the thing that we reference every time we get off track.”
Additionally, the maps proved a useful reference point for the professor as he helped the students think through and refine their topics.

**MyTFA (Thinking, Feeling, Acting Cmap) Concept Mapping Exercises**

There was no formal questionnaire for this paired set of cmaps, which were done at the beginning and the end of the semester and gave the students an opportunity to reflect on how their environmental cognition changed during that time period. A discussion forum was employed wherein the students were asked to revisit their original Cmap and discuss how it changed over the course of the semester. Two distinct themes emerged.

First, students saw their environmental concerns evolve from generalized to place-based or “situated.” Said one student, “The first c-map felt abstract and hypothetical, and therefore I felt distanced from the issue…If I want to care about a subject, I need to create an in-depth area that gives focus to the many broader issues at stake.” Students also began to realistically evaluate their behaviors for effectiveness. Said a student when discussing organic vs. conventional agriculture:

In my new Cmap, I do not explicitly say that complete removal of oneself from the conventional agricultural system is an option. I say that we can change many parts of the system, but I do not know how to stay completely off the system. It may be possible, but in this class I have learned that there are many complex interactions going on at many different scales, and that elements of a system are
so strongly interconnected that completely changing the system could be impossible. BUT, that's not to say one should not try.

Second, the comments showed how the MyTFA map exercises helped the students evaluate their own personal progress in the course. One student wrote, “Completing this Cmap has helped me realize how much my thinking has changed this semester.” Another stated, “It was interesting to me to see review my original Cmap with my new Cmap to see how much new information has been gained and how readily applicable the information is to any environmental issue.” This exercise showed the students how they progressed in a holistic fashion (cognitively, emotionally, and behaviorally) as compared to evaluation measures like the entry quiz, which purely measured academic progress. This type of reflection is critical in increasing student “buy in,” showing the students how the environmental studies major is changing them both professionally and personally.

**Overall Findings**

The project’s most interesting finding was that the students who found the concept mapping exercises most challenging had the best overall course grades. This suggests that concept mapping is scalable depending on the motivation of the student and the degree to which they take the course material seriously. Regardless of how a cmap appears to a viewer, if the student struggles through the mapping process they are more likely to do better in the course overall. This finding is somewhat counterintuitive, but suggests that wrestling with the course material actually provides better outcomes, not
worse. This “engagement factor” and its relationship to student success was evident in other areas, such as the finding that the students who completed more questionnaires felt that concept mapping was more useful overall. Whether more questionnaires made the students reflect on the usefulness of their experience or that same students who were engaged with concept mapping were also engaged with this research project, we simply don’t know. However a higher level of participation helped predict a better grade.

Another interesting finding was the discrepancy between the students’ self-professed high level of comfort with the concept mapping process while claiming to find assembling the material into a concept map relatively challenging. Students appeared to believe that if given easier material, the concept mapping process would have challenged them less. This could be interpreted in two ways. On one hand, it could mean that students find concept mapping scalable and accessible. Conversely, these findings may indicate overconfidence on the part of the students as far as their proficiency with the process, not realizing that feeling challenged by assembling the material into a cmap is contingent on their proficiency with concept mapping itself. Regardless, this discrepancy is worth further investigation.

There a few potential explanations for the lack of correlation between proficiency with concept mapping and learning style. First, Fleming (the creator of the VARK learning styles survey) claimed that he designed VARK to be a reflective tool, not an empirically verifiable category (Fleming, 2010). Perhaps to counter his detractors, he argued that learning style should simply provide “food for thought” to students, and was not meant as a cognitive or pedagogical theory. However many people have taken this theory at face value, and so I feel that I must entertain the idea of the existence of
learning styles. One explanation for visual learners’ lack of success with concept mapping is that students who describe themselves as visual learners are simply saying that they do not learn well via other mediums such as reading or lectures (auditory). Claiming to be a “visual learner” may very well be a proxy for lower academic success. Looking at the top and bottom quintile of students in the course shows that while 25% of the low-achieving students claim to be visual learners, none of the high achieving students do (Figure 9).

![Learning Style Distribution, Top and Bottom Quintiles](image)

*Figure 9. Learning Style Distribution, Top and Bottom Quintiles*

However, it is also reasonable to believe that visual learners are predisposed to have unique troubles with concept maps. In interviews done last spring, students who felt that they were visual learners became frustrated with the IHMC Cmap Tools interface because of its lack of graphic options. It may be precisely because of a students’ visual inclination that he or she dislikes and/or does not succeed with concept mapping because they find themselves distracted by the colors, line weights, font options, etc., and are subsequently unable to focus on the material at hand. That said, the lack of importance of learning style proves promising for the effectiveness of concept mapping. Despite arguments to the contrary, the data shows that concept maps are not solely useful to individuals with a particular learning style, but rather can be a beneficial tool regardless of how one best receives information.
The Professor’s Assessment of this Project

Jim Proctor and I discussed the treatment at length after the semester was over. Overall, Jim felt as though this treatment was a worthwhile addition to the course. While he had assigned concept maps previously, he had never clearly articulated the overall strategy, differentiated between different types of assignments, or assigned as many concept map exercises as we did this semester. Some of the reasons he found the project useful were simple. For instance, he appreciated that the concept map exercises gave him an excuse to assign certain types of exercises generally: for example, the course did not include a unit synthesis exercise of *any* kind before these exercises were introduced. Additionally, he found that concept maps served as an effective classroom assessment technique, and were a great way for him to quickly ascertain where students had misconceptions or a weak understanding of course topics. Despite the students claiming that, on average, the maps were just “somewhat helpful,” he felt that was satisfactory given that the course material could be perceived as somewhat dry. He stated that engaging with concept mapping in such an intensive way was a “big risk,” because if students didn’t believe that the process was beneficial they may not engage fully. However he found that these students had considerably more “buy in” overall than in past courses, and he felt there was more affirmation for the types of exercises he incorporated.

Regarding the project’s effectiveness on student achievement, Jim and I agreed that concept mapping was not a magical tool that made all students better meet the course objectives. Rather, the more engaged students benefitted most from the concept mapping
process. It could be argued that this is true for education generally—those students who are more engaged tend to do better. However the lower-achieving students still benefitted from the project, in that the concept maps proved a useful tool through which the professor identified learning gaps. In strategizing with student groups about their final projects, Jim appreciated that concept maps gave him “somewhere to point” when discussing actors, relationships, important themes, or misconceptions. In this way, concept maps were a mirror of the students’ level of comprehension and overall attitude towards the course material—critical thinkers continued to challenge themselves, those who thought the course was easy made relatively simple concept maps, and the students with major misconceptions made those evident. That said, while the concept maps did not necessarily help the low-achievers, neither did they hinder them. And concept mapping made the implicit cognitive state of the students explicit, so Jim was able to address problems accordingly.
The findings of this project hold promise for the use of concept mapping in science education. We showed that all students, regardless of their academic standing, grade level, or learning style can benefit from using concept mapping in the classroom. Concept mapping helped most students synthesize and reflect on topics covered in the course. For those it didn’t help, the maps provided the professor with a quick way of identifying where these students’ misconceptions lie. The exercises proved specifically useful in regards to environmental studies, insofar that it provided the students with a means of synthesizing multidisciplinary material. Based on this project, I recommend the use of concept mapping in college-level environmental science courses.

However I learned that concept mapping can vary in its effectiveness when utilized in a course. Some of these conclusions are based on the quantitative data I collected, but some are also based on simply on my own observations. These findings are outlined below, and serve as a “how to” guide for fellow teachers interested in using concept mapping in their classrooms.

1. Commit Fully to Using Concept Mapping in the Course

Every new skill is uncomfortable at first, and concept mapping is no exception. For students to be able to successfully apply concept mapping to complex issues, they must first work out the mechanics of the concept mapping process, which can be deceptively simple. Students need to do frequent exercises on a regular basis for them to master the concept mapping mechanics, during which the mapping process becomes
“second nature” and they can focus fully on the material being mapped. This also means if you plan on using a computer-based mapping program, such as IHMC Cmap Tools, introduce it after very few analog concept mapping lessons for ease of assessment and information sharing. Don’t worry about becoming redundant- because students use concept mapping to work through ideas, those who are challenging themselves will find they learn something new with every exercise. By assigning multiple concept mapping exercises, I anticipate that you will ultimately find that more students find the process rewarding and worthwhile.

2. Structure Concept Mapping Lessons Sequentially and Logically

Students find concept mapping most rewarding when they feel that they have learned something new from the process, succinctly and effectively summarized the topic at hand, and created an aesthetically-pleasing map. Students will not be able to achieve these goals if given, for instance, too large or too complex a topic before they have mastered the general process. Hence, begin by assigning concept mapping exercises on a topic that is not too unwieldy. For instance in this project the students began by working on concept maps that summarized the teaching units. This worked well because the units were internally cohesive- the readings were connected with the technical skills because the professor intended them to be connected. The final concept maps of the semester pertained to the more complex topics addressed in the students’ final projects, which may or may not have been easily mapped. However the students were more proficient with concept mapping at this point, and were more likely to be able to map complex topics.

In regards to the visual aspect of concept maps, students may struggle with
creating a map that is not overly complicated, but still shows how much they know about the topic (this may occur more with high-achieving students). This should be anticipated and accounted for, lest students become discouraged with the concept mapping process. In this course, we tried to avoid the students becoming frustrated in two ways; for the Unit Synthesis cmaps we assigned an overview cmap and an in-depth cmap on a topic of the students’ interest, and with the final ANT cmaps we included a brainstorming stage and a refining stage. By anticipating the students’ need for a neat yet comprehensive map, you can diffuse the possibility that students will submit an overly ambitious (and subsequently unfocused) concept map.

3. Decide What Your Objectives Are and Know the Consequences of Those Objectives

The most critical decision a teacher must make upon introducing concept mapping to a course is whether the maps will be used as a reflective exercise for the students (internally driven) or whether the students will be learning to create concept maps to a pre-determined standard (externally driven). If the exercise is to be a reflective tool for the students (as was done in this project), there must be sufficient instruction from the instructor, and feedback should in the form of content-based discussion and writing. The downside to the internally-driven approach is that it runs the risk of perpetuating student misconceptions, and students may not fully master concept mapping in and of itself. However these types of maps may prove more beneficial to the individual students because they customize them to their own way of thinking rather attempting to fit the teacher’s idea of a good concept map. Conversely, teaching the students how to create a concept map based on a certain standard will require a more intensive role for the
teacher in terms of providing feedback in addition to instruction and in-class discussion. It is less likely that students will perpetuate their own misconceptions, but they will be creating maps to fit a certain standard rather than to work out their own ideas. Ultimately, internally driven maps are more process oriented, while externally driven maps are focused on the end product. Both approaches will likely prove beneficial in their own way, but deciding which makes the most sense for a particular class merits some reflection from the onset.

4. Get the Students Engaged

At first, concept mapping may appear to students to be overly simple. While its accessibility is one of its assets, so is its scalability. It may not be obvious to students that the more they challenge themselves through the concept mapping process, the more they will get out of it. By coupling concept mapping with reflection, students will be better able to see the connections that the concept maps are facilitating. Class discussions, writing exercises, and online discussion forums will also help students reflect on what they have gained through the concept mapping process, subsequently increasing their commitment to future concept mapping exercises. Increasing the amount of time that the students reflect on the value of their concept maps will likely increase their commitment to the concept mapping process, and consequently the seriousness with which they wrestle with complex environmental issues.

5. Focus on the Material, Not on the Concept Maps

While it may sound counterintuitive, do not focus too much on the concept
mapping itself. Concept mapping is simply a tool through which other topics can be explored. It is an effective vehicle for fostering complex thinking if a student is engaged and takes it seriously. But learning a lot about a hammer does not mean a student will build a great house. Emphasis should be placed on the material being covered, not the means through which that material is being explored.

Further Research

This project leaves a great deal of direction for further research. First, while “engagement” was determined through triangulating a variety of qualitative and quantitative variables, a method should be determined for measuring it empirically. This could include a combination of questionnaires, interviews, in-class participation, and past coursework that attempts to define the degree to which a student is deeply wrestling with the material at hand. Further, a point should be made to better understand engaged students and how they experience the classroom.

Second, in the correlation analysis the concept map served as the dependent variable and the value of this concept map was determined objectively through a rubric. This is not necessarily the “right” way to evaluate the usefulness of concept mapping, and in fact, students involved in this project may have been particularly ill-equipped to create an objectively “good” concept map due to lack of periodic feedback. While there were frequent in-class discussions, peer review sessions, and the rubric was distributed in class, ultimately I graded the concept maps via the rubric after the course was over, rather than providing periodic feedback throughout the course. The students’ maps were not held to an external standard until the ANT cmap project, which was assigned near the end
of the semester. This may have both skewed the analysis and affected the project itself to a greater degree than I anticipated. The students appeared to gradually customize the mapping process to work for them, rather than meet what was outlined in the rubric. This was evident in the student comments. One student said, “Overall, the concept map provided positive reinforcement to my understanding of course material, although I have yet to master the strategy for mapping that works best for me.” Another said, “Overall I think cmapping is getting easier for me and I'm starting to figure out what works best for organizing my ideas… I definitely feel like I have a better understanding of the material after I finish the syntheses.” The customization of the concept maps was not necessarily a negative development, and their universal usefulness shows that they are a helpful tool in and of themselves and don’t need to meet a teacher-imposed standard for them to be a helpful addition to a course. However it would be useful to understand how regular feedback would affect the evolution of the students’ concept maps, and whether it would result in more correlations between the independent variables and the quality of the students’ concept maps.

Third, a theme reoccurred throughout this project that may not be rectifiable through changing the research methodology and simply could be an omnipresent issue when working with concept maps. This was the issue of scale. Maps, by nature, can be expanded indefinitely. The students struggled with wanting to include everything they learned, while still wanting to make a map that was clear and easy to understand. One student said, “This unit included a lot of detailed oriented information that needed to be included. While everything interrelated it was difficult to display visually, without getting an overly complicated map.” The professor and I first recognized this issue during in our
preliminary research in the spring of 2010. To address it, we revised the ANT assignment to have the cmaps submitted in stages; the first stage allowed the students to flesh out their idea to the fullest extent, while the second map was a refined version of the first. For the Unit Synthesis Cmaps, the professor had the students submit an overview concept map and a nested concept map, with the students going in to greater detail about a specific subtopic with the latter. For the ANT cmaps, the students submitted a broad overview cmap, and were then asked to submit a refined cmap with their final project. This approach appeared to be somewhat successful. Compared to past courses, there were less overly complex final cmaps. That said, the students still struggled with creating a map with appropriate depth and breadth, and we didn’t discover an ideal method for the students to pare down their maps intelligently and effectively. However this situation may be specific to high-achieving student populations who are eager to demonstrate their proficiency with the topic, and might not be faced by teachers with different course demographics.

Fourth, concept maps are often posited as alternatives to traditional outlines on which students ultimately base a piece of writing. It would be interesting to explore how the use of concept maps compares with more traditional outlines when used as the basis for written reports. While one might imagine that papers based on concept maps would be more creative, multidimensional, and cohesive, further research could help validate that claim.

Finally, standardizing the data collection format from the onset would have been helpful when it came time to do the analysis. There was a lack of naming conventions for the different concept map exercises, variation in how the “overall” and “nested” maps
were saved, and some maps were analog while others were digital. This all made data analysis more complicated, and it took more time than it could have to clean the data. Especially in projects where there is more than one researcher, standards should be decided on early in the project to facilitate ease of analysis.

**How I Changed Through the Course of this Research**

I came into the MSSE program with a background in the sciences, both social and biological. My previous research had been much more traditional, insofar as the researcher was expected to not influence the results of the study and a control group was needed to prove validity. Initially, I found it uncomfortable to embark on research that I found not to be sufficiently rigorous. However through the course of this project I have realized that there are definite merits to the action research model. One, action research is accessible, allowing teachers to incorporate research into their day-to-day teaching activities. Regardless of how pressed for time a teacher is, he or she can always administer a classroom assessment technique or a survey and analyze the results to the extent that is practical. I would presume that this encourages more research to be embarked on because it removes the demanding and impractical pressures of traditional academic research. Subsequently, more teachers improve their practice. Two, action research does not expect that the researcher is emotionally removed from the outcome, which is a rather artificial demand in the first place. If a researcher is embarking on a project, chances are that he or she cares about the results. To eliminate this false pretense allows for the researcher to modify their project throughout the course of the research to
meet their objective, without having to cloak their true intentions. For these reasons, amongst others, I have realized that action research is a valid way of performing research, and its results are no less useful than the type of scientific research I am used to.

Due to my husband’s job, which requires frequent moves, I would not have been able to maintain the type of continuity in my research had I worked with a geographically-proximate course. Because I did this research from a distance, there were benefits and drawbacks to my own personal growth. On one hand, I was able to work with extremely high-caliber students in a subject area that interested me. That said, I think that the project could have been better had I gotten to know the students face-to-face. While I feel confident about the results of this study, I have a hard time feeling emotional about it on a “gut level.”

Perhaps the most important way in which this project contributed to my personal growth was that it showed me how I enjoy grappling with projects at a high level, and I enjoy working with college students. I began this program somewhat unsure of my professional goals, thinking that perhaps I wanted to teach high school. However, I have realized that I enjoy research, specifically understanding how young adults make sense of environmental problems. To this end, I applied and was accepted to the University of Hawaii at Manoa Department of Geography Ph.D. program, which I will begin this fall. Whether this degree may appear to be a detour in the larger context of my education, I feel as though it will ultimately make me better able to periodically evaluate my own teaching, and subsequently a better college professor.
REFERENCES CITED


APPENDICES
APPENDIX A

INFORMED CONSENT FORM
Appendix A
Informed Consent Form

Informed Consent

Title of Research: Cmap Semester Research Project

Investigator: Jenn Bernstein, Candidate, Masters in Science Education, Montana State University Bozeman

Before agreeing to participate in this research study, it is important that you read the following explanation of this study. This statement describes the purpose, procedures, benefits, risks, discomforts, and precautions of the program. Also described are the alternative procedures available to you, as well as your right to withdraw from the study at any time. No guarantees or assurances can be made as to the results of the study.

Explanation of Procedures
You are being asked to participate in the research project to evaluate the effectiveness of concept mapping projects in the ENVS 220 course.

The approach of the research includes interviews, questionnaires, and evaluation of the concept maps that you are assigned as a part of the course. You will also need to report your grades from ENVS 160 and ENVS 220.

Risks and Discomforts
You will not be at physical or psychological risk and should experience no discomfort resulting from the research procedures.

Benefits
There are no direct benefits by participating in this focus group, though you will receive more feedback on your concept maps than your classmates who do not participate, potentially giving you an advantage on your final concept map. You will be exposed to a graduate level research project, which may help you in your future studies.

Alternative Procedures
If a person chooses not to participate, you must choose an alternative semester project.

Confidentiality
All information gathered from the study will remain confidential. Your identity as a participant will not be disclosed to any unauthorized persons; only the researchers will have access to the research materials. Any references to your identity that would compromise your anonymity will be removed or disguised prior to the preparation of the research reports and publications. You will not be audio or videotaped. Your last name will not be used in the transcripts of the recording.

Withdrawal Without Prejudice
Participation in this study is voluntary; refusal to participate will involve no penalty. Each participant is free to withdraw consent and discontinue participation in this project at any time without prejudice from this institution.

Costs and/or Payments to Subject for Participation in Research
There will be no costs for participating in the research. Also, participants will not be paid to participate in this research project.

Payment for Research Related Injuries
Although there are no risks of injury involved with this study, Montana State University has made no provision for monetary compensation in the event of injury resulting from the research. In the event of such injury, the researcher will provide assistance in locating and accessing appropriate health care services. The cost of health care services is the responsibility of the participant.

Questions
Any questions concerning the research project and/or in the case of injury due to the project, participants can call Dr. James D. Proctor (faculty contact for this project) at 503-768-7707. Questions regarding rights as a person in this research project should be directed to Mark Quinn, Montana State University Institutional Review Board Chairman, at 406-994-6783.

Agreement
This agreement states that you have received a copy of this informed consent. Your signature below indicates that you agree to participate in this study.

Signature of Subject      Date

Subject name (printed)

Signature of Researcher     Date
APPENDIX B

ENVS 220 Entry Quiz
ENVS 220 Entry Quiz

This quiz consists of ten short-answer questions (full sentences not required) on material from ENVS 160, and ten on ENVS 220; it is expected that you will know most of the answers for the 160 questions, but not many for 220. The 220 questions will be repeated at the end of the course as a quick way for you to assess what you learned. In addition, there are two general questions at the end that will help me teach you in the best possible way. The first 20 quiz questions will be self-graded (1 = full credit, 0.5 = partial credit, 0 = no credit), with 10 points possible for each; your actual grade for this activity, however, comes from simply taking and submitting the quiz. I will return these quizzes after reviewing your answers.

ENVS 160

1. Garrett Hardin is famous in environmental studies for two arguments he made in the late 1960s and early 1970s; name and briefly summarize any one of these.

2. Environmental studies is about the environment, but what is environment? Define environment, and justify your definition via historical, practical, etc. dimensions.

3. In what way do Milankovitch cycles complexify the human role in climate change? Briefly summarize these cycles and suggest why they are significant.

4. A panarchy is typically visualized on what x and y axes (hint: Resilience Thinking)? Choose one ENVS-relevant panarchy to describe the significance of these two axes.
5. What is political ecology’s rejoinder (hint: *Lawn People*) to current emphases on changing individual behaviors as a way to solve environmental problems?

6. Many debates over environmental solutions concern regulation- vs. incentive-based approaches; briefly provide an example for each, suggesting how they differ.

7. Many college sustainability efforts focus on greening the campus. Give two major limitations in this emphasis based on a fuller understanding of sustainability.

8. Briefly list and summarize the three main human drivers of biodiversity loss.

9. Briefly define carrying capacity, and offer reasons why it may not readily apply in the case of global human population. What famous book(s) argued that it did?

10. DDT is famously linked to Rachel Carson’s *Silent Spring*. But recently, some people have called for resumption of use of DDT. What possibly could be their justification?

**ENVS 220**

1. Robert Sack views place as (in part) the intersection of views from “somewhere” vs. “nowhere.” How does this apply to situated environmental research?
2. Name and briefly summarize the four levels of environmental analysis.

3. Offer a structuralist explanation of the reason why we have traffic jams (and related pollution) on many major highways in the U.S.

4. What would be the position of a proponent of ecological modernization on how to solve problems related to anthropogenic climate change?

5. Actor-network theory offers a unique way to analyze environmental problems and solutions in terms of human/nonhuman and local/global processes; explain.

6. Why is it that a GIS map projection for Oregon would be different from a GIS map projection for the world?

7. In what cases involving a difference of means test would you use a two-tailed vs. one-tailed hypothesis?

8. If I perform an inferential statistical test and find a p value less than the stipulated alpha of .05, what does this mean?
9. Qualitative research is often distinguished from quantitative in terms of intensive vs. extensive research designs; briefly explain.

10. You are doing interviews as part of your senior thesis, and your advisor asks if you are treating data via an informational vs. interpretive analytical strategy; explain.

General Questions

1. You have most likely registered for ENVS 220 because you have an interest in majoring or minoring in ENVS; why? What do you especially want to learn by the time you finish your ENVS courses at LC?

2. Not only does everyone learn in different ways: everyone also achieves excellence via a wide range of motivators. What, in your experience, are the most important things your instructors can do so that you do your very best?
APPENDIX C

BACKGROUND INTERVIEW
Appendix C
Background Interview

Introduction: Posted on Course Website

Note: This interview is only for students participating in the Concept Mapping project.

We are conducting this interview to better understand your academic/personal background as a means of contextualizing your progress over the course of the semester. The specific objectives of this interview are to find out more about your objectives in the ENVS program, your past experience with concept mapping, and your relationship with technology.

The interview should take approximately 15-20 minutes, and will be conducted via the free internet calling service, Skype. If you do not have a Skype account, it's easy (and free) to get one- see http://www.skype.com/intl/en-us/home for instructions on how to sign up. If you are unwilling or unable to use Skype, let me know and we can figure out another way to conduct the interview.

The interviews will take place throughout the day on Friday, Sept. 10th. Please sign up for a time slot that works for you. If Friday doesn't work at all, email me and we can figure out another time. Please call ME at the time you signed up for- my Skype user name is jenn_bernstein. You can also email me at jenn_bernstein@yahoo.com, or call me at 510-393-4650 if you are having technical difficulties.

Background Interview

L & C ENVS

• First, why are you taking this class?

• Are you thinking about other majors? If so, which ones? What do you think about when considering this decision?

• What aspects of this class will be most important for you? Why?

• When thinking about the ENVS program overall, which of the following things do you think will (or already have been) be a part of your experience? Which do you think would contribute the most to your education?
  • Field trips, spending time outdoors
  • Campus greening projects
  • Discussing current events
  • Learning analytical techniques
• Local sustainability issues
• Reading and lectures
• Internships
• Group research projects

• What do you envision doing immediately after graduating?
• What about 5 years after college? 10? 15?
• Do you anticipate your ENVS degree will help you achieve these professional goals? If so, how?

Concept Mapping

• Tell me a little bit about your experience using concept maps in ENVS 160.
• What is your general level of comfort with using concept maps?
• What did you like/dislike about using concept maps?
• In general, did concept mapping help you understand the topic better?

Computers and Technology

• How comfortable do you feel using computers? Are there areas in which you feel more/less comfortable?
• Do you think of the field of environmental studies or sciences as high tech or low tech? Does this high/low tech-ness affect your interest in the subject?
• How do you typically react when a class introduces a new piece of software or a new online technology?
• What do you think is the proper place for computers and online technologies in a liberal arts education?
APPENDIX D

LEARNING STYLE SURVEY
Appendix D
Learning Style Survey

The VARK Questionnaire (Version 7.0), taken from http://www.vark-learn.com/documents/The%20VARK%20Questionnaire.pdf

Introduction: Posted on course website

This questionnaire was developed by a teacher named Neil Fleming to determine the style in which different individuals learn best. Keep in mind that while it is one of the more popular learning style inventories, it has not been rigorously validated. Part of the objective in having you take this questionnaire is to evaluate its usefulness in the context of other course activities. As such, the results should be interpreted with caution. Select the answer which best explains your preference. Choose more than one if a single answer does not match your perception. Leave blank any question that does not apply.

1. You are helping someone who wants to go to your airport, town centre or railway station. You would:
   a. go with her.
   b. tell her the directions.
   c. write down the directions.
   d. draw, or give her a map.

2. You are not sure whether a word should be spelled 'dependent' or 'dependant'. You would:
   a. see the words in your mind and choose by the way they look.
   b. think about how each word sounds and choose one.
   c. find it in a dictionary.
   d. write both words on paper and choose one.

3. You are planning a holiday for a group. You want some feedback from them about the plan. You would:
   a. describe some of the highlights.
   b. use a map or website to show them the places.
   c. give them a copy of the printed itinerary.
   d. phone, text or email them.

4. You are going to cook something as a special treat for your family. You would:
   a. cook something you know without the need for instructions.
   b. ask friends for suggestions.
   c. look through the cookbook for ideas from the pictures.
   d. use a cookbook where you know there is a good recipe.

5. A group of tourists want to learn about the parks or wildlife reserves in your area. You would:
a. talk about, or arrange a talk for them about parks or wildlife reserves.
b. show them internet pictures, photographs or picture books.
c. take them to a park or wildlife reserve and walk with them.
d. give them a book or pamphlets about the parks or wildlife reserves.

6. You are about to purchase a digital camera or mobile phone. Other than price, what would most influence your decision?
   a. Trying or testing it.
   b. Reading the details about its features.
   c. It is a modern design and looks good.
   d. The salesperson telling me about its features.

7. Remember a time when you learned how to do something new. Try to avoid choosing a physical skill, eg. riding a bike. You learned best by:
   a. watching a demonstration.
   b. listening to somebody explaining it and asking questions.
   c. diagrams and charts - visual clues.
   d. written instructions – e.g. a manual or textbook.

8. You have a problem with your knee. You would prefer that the doctor:
   a. gave you a web address or something to read about it.
   b. used a plastic model of a knee to show what was wrong.
   c. described what was wrong.
   d. showed you a diagram of what was wrong.

9. You want to learn a new program, skill or game on a computer. You would:
   a. read the written instructions that came with the program.
   b. talk with people who know about the program.
   c. use the controls or keyboard.
   d. follow the diagrams in the book that came with it.

10. I like websites that have:
    a. things I can click on, shift or try.
    b. interesting design and visual features.
    c. interesting written descriptions, lists and explanations.
    d. audio channels where I can hear music, radio programs or interviews.

11. Other than price, what would most influence your decision to buy a new non-fiction book?
    a. The way it looks is appealing.
    b. Quickly reading parts of it.
    c. A friend talks about it and recommends it.
    d. It has real-life stories, experiences and examples.

12. You are using a book, CD or website to learn how to take photos with your new digital camera. You would like to have:
a. a chance to ask questions and talk about the camera and its features.
b. clear written instructions with lists and bullet points about what to do.
c. diagrams showing the camera and what each part does.
d. many examples of good and poor photos and how to improve them.

13. Do you prefer a teacher or a presenter who uses:
   a. demonstrations, models or practical sessions.
   b. question and answer, talk, group discussion, or guest speakers.
   c. handouts, books, or readings.
   d. diagrams, charts or graphs.

14. You have finished a competition or test and would like some feedback. You would like to have feedback:
   a. using examples from what you have done.
   b. using a written description of your results.
   c. from somebody who talks it through with you.
   d. using graphs showing what you had achieved.

15. You are going to choose food at a restaurant or cafe. You would:
   a. choose something that you have had there before.
   b. listen to the waiter or ask friends to recommend choices.
   c. choose from the descriptions in the menu.
   d. look at what others are eating or look at pictures of each dish.

16. You have to make an important speech at a conference or special occasion. You would:
   a. make diagrams or get graphs to help explain things.
   b. write a few key words and practice saying your speech over and over.
   c. write out your speech and learn from reading it over several times.
   d. gather many examples and stories to make the talk real and practical.

Page After Submit

Thanks! Your questionnaire will be scored and the results will be reported to you at the end of the semester. While you may be eager to know what kind of learner this survey deems you to be, research has shown that finding out the results makes some students pigeonhole themselves as capable or incapable of learning in certain ways. We appreciate your patience!
APPENDIX E

MYTFA CMAP ASSIGNMENT
MyTFA: Thinking, Feeling, and Acting Ecologically

As prospective ENVS majors/minors, it’s important to reflect on how you personally respond to the environmental issues that concern you. Our first assignment in Environmental Analysis thus involves a bit of self-analysis, which we will organize (for reasons discussed below) via the modalities of thinking, feeling, and acting (TFA). Can you imagine possible disconnects and contradictions between these three parts of your life?

We will also introduce via this assignment one of the tools you’ll use in environmental analysis: concept mapping. You learned a bit about concept mapping in ENVS 160; for more information see our help wiki. Concept mapping is built on a particular theory of learning: Joseph Novak, who created concept mapping in the 1970s, has a theory of education that true learning occurs by creating meaning out of the subject material. This requires that a learner not only think about a topic area, but also articulate his or her emotions and behaviors pertaining to that topic as well. It is this synthesis of thinking, feeling, and acting that helps us make sense of and organize our learning experiences. We will explore this educational theory in this exercise.

**Step 1: Group Exercise**

Before you do this assignment as individuals, we will make a TFA concept map in class as a group around a familiar environmental issue: climate change. In the group exercise, we’ll focus on the different ways that people in general think, feel, and act with reference to this issue. The group exercise will help you in two ways: (a) you’ll learn the general process you’ll do below, and (b) you’ll be able to use the result to compare your MyTFA concept map to that we created in class to describe people in general (even though you may not choose climate change as your issue).

**Step 2: MyTFA Concept Map**

Now you will create your own personal MyTFA concept map. Begin by choosing an environmental issue that you feel passionate about: this can be the same issue that was discussed in class, or another issue entirely. Remember, an “environmental” issue can be defined in many different ways! Make sure to focus on something you really care about, and feel free for now to define it any scale of specificity you wish, e.g. a really local issue or a huge global issue.

For your MyTFA map, you will create a map of thinking, feeling, and acting specific to you personally. Let’s define these three modalities:

- **Thinking** involves knowledge claims you feel are important; these needn’t be specifically “environmental”
- **Feeling** involves the variety of emotions that you feel about the issue
Acting involves steps that you are taking (or want to take) in response to this issue, whether as individual behaviors or part of collective actions and policies.

Here's how to do it:

Begin by listing about six thinking, six feeling, and six acting elements that connect you to the environmental issue you chose. These elements are very short (ideally one-word) phrases that in a sentence would function like nouns. Write the elements on sticky notes (we’ll provide them in class), using one color for thinking, a second color for feeling, and a third color for acting elements.

Then go ahead and follow the process we did in class to create a concept map, arranging the thinking/feeling/acting elements as concepts (boxes) on a piece of paper and adding connections to these concepts via propositions (arrows with text). Make sure to show which colors correspond with which categories via a legend!

Affix the sticky notes to a piece of paper, organizing and connecting them spatially. As you work through the concept map, feel free not to use some of the concepts if they seem extraneous to the core themes of your map.

After you have finished your concept map it’s time to analyze it. Here are some starter questions for reflection:

What seem to be the most important thinking, feeling, and acting elements in your response to this environmental issue? How simple or complex is your overall pattern of response?

Are there any important disconnects or contradictions your concept map reveals in how you think, feel, and act with respect to this issue? For instance, are there things you feel that aren't necessarily grounded in defensible scientific knowledge? Are you acting based on these knowledge claims, or are you avoiding action? Why?

What’s missing from this concept map that you would expect other people (say, those in the community where you grew up) include, as suggested via our TFA in-class exercise? What elements of your concept map do you think would be common among your friends? Why are they not in your MyTFA concept map?

**Step 3: Writing Exercise**

Based on your MyTFA concept map and analysis above, write at least one page discussing what you learned. Make sure to include your name, class, and date. Your concept map will only be graded for having completed it (your write-up will be scored for thoughtfulness and writing quality), but you will discuss them with classmates and submit them to the instructor, so make sure they are legible and clearly written.
APPENDIX F

REFLECTION CMAP ASSIGNMENT
Appendix F
Reflection Cmap Assignment

Student:
Unit:

ENVS 220 Unit Synthesis

On a separate piece of paper, make a list of major concepts you recall from our last unit, then go through your notes and add other major ones. Next, arrange concepts into a Cmap below, connecting them with propositions. Finally, prepare a written summary at bottom.

You’ll then share this page.

If you’d like to do this synthesis on your laptop, email the Cmap link and Word file to jproctor@lclark.edu.

Concept map

Written summary
APPENDIX G

WRITING CMAP
ENVS 220 Reading Analysis: Wal-Mart Sustainability

How does Wal-Mart conceptualize and implement sustainability, and what (if anything) is missing, assuming the CEO statement is truthful?

You’ll answer this descriptive/evaluative question by sketching a Cmap connecting concepts denoting (a) major elements of Wal-Mart’s approach to sustainability, and (b) how their commitment to each is evidenced in the reading. It may optionally include concepts/propositions denoting what is missing, major contradictions, and so forth. Then prepare a written summary of your Cmap.

When done, exchange/discuss in groups of up to three. Ultimately, is Wal-Mart a leader in sustainability as claimed?

Concept map

Written summary
APPENDIX H

ANT CMAP ASSIGNMENT
Appendix H
ANT Cmap Assignment

Process Cmap with Resources

Now that you have started to gather resources on a situated theme, we need to address a few interrelated questions:
- Have you found enough resources?
- What's going on in this situated theme?

You'll answer both by constructing a process Cmap. As you remember from a previous lecture, process CMaps depict cause-effect relations between actual entities, in comparison to perspectives Cmaps (e.g., the ones you've done for unit syntheses), which depict conceptual relations between ideas. Soon we will call the elements of your process Cmap "actors" (as in actor-network theory), but for this lab we won't introduce this terminology and all the theory behind it, so you'll just brainstorm on potential process elements and organize them in terms of cause and effect propositions.

A process Cmap will provide a visual means to help you identify gaps in resources as you clarify the most important elements of the process you are investigating. When you are done with this assignment, you will post one response per situated research team in this forum, following the instructions below.

1. Start by brainstorming a list of potential major process elements your situated theme addresses, similar to what we did in class last Thursday. Using Sack's three realms (nature, social relations, and meaning), list up to a half-dozen of each. Make sure to consult the resources you've found so far to start identifying these elements, though feel free to imagine others of potential interest/relevance. At this point you may not know which ones are the most significant, nor which may be particularly important in the proposal you'll craft, so use what you know of the theme so far to come up with a general picture. Some hints:
   - Name each with a short phrase, as they will be concepts in a Cmap!
   - Split up a process into its constituent elements. For instance, instead of saying "animal trafficking," use "trafficked animals," "animal smugglers," and "purchasers of trafficked animals" so you can consider relations between these three elements and other pertinent elements.
   - Try to be as specific as possible. For instance, instead of saying "climate change" say "precipitation variability," or instead of saying "religion" say "Hindu attitudes toward animals" (and of course you could get more specific than this!).

2. Now sketch a Cmap using your list as concepts, and starting with the item(s) on the list that seem to be closest to the heart of what your theme addresses. Feel free to make your propositions brief and even speculative at this point. Make sure to save the Cmap in a folder in the ENVS 220 fall 2010 directory of the Cmap server!! This is especially important given the next step: if you don't do this expect a bit of grief from me (since I'll have to clean up the mess once you add resources in the
wrong place).

3. Once you've sketched your Cmap, it's time to add the resources you found last week that pertain to any concept and/or proposition. Some hints:

   The easiest way to add new resources to a Cmap is by dragging their URL directly onto the concept or proposition; see the adding resources section of the Cmap help wiki. For now, add a URL so that fellow LC students could readily get to the resource, its citation in Watzek Worldcat, or the citation in your RefShare folder; I'll demo in class.

   An existing resource may be added in multiple parts of the Cmap if it provides information on multiple concepts or propositions. The best way to do this is by selecting the Cmap element you want to add this resource to, then choose Edit > Add & Edit Links to Resources, which brings up a list of existing resources. (Of course, you don't want to build your whole Cmap around too small a set of resources.)

4. Now that you've added the resources you currently have, step back and take a look: what parts (including all concepts and major propositions) of your Cmap are well documented? what parts aren't? Yep, it's time for more resource hunting to see if you can clarify other parts of your Cmap! You don't have to justify all portions with resources, but try your best to do so. Some reminders:

   These new resources may be specific to your situated case or may more generally cover the issue, possibly elsewhere.

   Add any new resources to your RefWorks bibliography and your process Cmap.

5. If your new resources have led you to make any edits to your Cmap (e.g., because you've learned about a new process element, or discovered that a potential process element is irrelevant), go ahead and do so. The point at this stage, however, is not to have a final, polished, authoritative Cmap, but rather to have a visual picture of what's likely going on in your situated theme.

6. Finally, once you feel like you've exhausted potential resources and your Cmap is as good as you can do for now, it's time to label the Cmap (don't forget a legend, including team names and situated theme!). Ideally, your labeling will code two features of your process Cmap, via e.g. colors or line width:

   Which concepts/propositions seem to be more vs. less significant in your process, based on what you know so far.

   Which concepts/propositions seem to be more vs. less well-documented, based on the resources you were able to find.

7. When you are done, post to the forum one response per team that includes:

   A live link to your Cmap

   A live link to your updated RefWorks bibliography (i.e., its RefShare link)

   A brief discussion of what your team learned about (a) the process you are investigating, and (b) how well it is documented, via this exercise.
Some possible areas your team could focus on for its research proposal, bearing in mind that a good research topic addresses potentially significant processes components that are not well documented.
### Appendix I

#### Concept Map Assessment Rubric

10 pts possible: 3 = all rubric items fulfilled, 2 = some problems, 1 = major problems

<table>
<thead>
<tr>
<th>Item</th>
<th>Description</th>
<th>Score</th>
<th>Notes</th>
</tr>
</thead>
</table>
| **Concepts** | • Relevant to topic  
• Appropriate in scope and number  
• Non-redundant  
Add for ANT:  
• Full range of actors represented  
• [If resources required] Concept is adequately justified | 1-3 | Concepts are actual entities in process Cmaps vs. ideas in perspectives Cmaps |
| **Propositions** | • Clear and concise  
• Effectively connect concepts  
• Correct directionality  
Add for ANT:  
• Major network relations represented  
• [If resources required] Proposition is adequately justified | 1-3 | Propositions denote cause-effect relationships in process Cmaps vs. conceptual relationships in perspectives Cmaps |
| **Overall** | • Legend is clear, complete, and easy to understand  
• Appropriate differentiation of components  
• Conveys accurate overall understanding  
Add for ANT:  
• Demonstrates how significance of actors arises from network relations  
• Helps explain environmental problems and clarify possible solutions | 1-4 | Score of 4 reserved for superlative overall quality |
APPENDIX J

CONCEPT MAP QUESTIONNAIRE
Appendix J
Concept Map Questionnaire

Introduction:

This questionnaire is for all students participating in the Concept Mapping project. Please fill out the questionnaire below as it pertains to this week’s concept mapping exercise.

Concept Map Questionnaire

1. Briefly discuss your concept map in terms of the three assessment items included in our general rubric
   • Concepts (text box)
   • Propositions (text box)
   • Overall (text box)

To what extent did you find this exercise easy or hard to do, in terms of:
- Not at all a challenge
- Minor challenge
- Somewhat of a challenge
- Significant challenge
- (Not Applicable)

2. Intellectual material you addressed
3. Assembling this material into a concept map
4. Having clear instructions to guide you
5. Having sufficient time to complete the task
6. Having sufficient mastery of concept mapping to complete the task
7. Group dynamics in completing the task

How much did this concept map help you with the following?

(NOTE: Only the questions relevant to the week’s concept mapping exercise were included)

Didn’t help at all
Helped a little
Helped somewhat
Helped a great deal

ANT
Better understand Actor-Network theory
Better understand the significance of actors and relationships
Clarify possible solutions
Clarify areas where I/we need further research
Pare down or expand my/our topic
Explain the environmental issue to others
Think in a non-linear fashion
Organize my/our ideas

Reflection
Think in a non-linear fashion
Organize my ideas
Recognize gaps in my understanding
Recognize how topics we have covered relate to one another
Recognize the academic progress I made during this learning unit

Didn’t help at all
Helped a little
Helped somewhat
Helped a great deal

Writing
Think in a non-linear fashion
Recognize new aspects of the author’s argument
Recognize weaknesses in the author’s argument
Clarify the author’s argument

So far, to what extent has this concept map exercise (including related text exercise as relevant) helped you better understand the topic, course material, reading, or other item you analyzed via this exercise?
1. Helped a great deal
2. Helped somewhat
3. Helped a little
4. Didn’t help at all

Please add anything you would like to add about the concept mapping process below:

Page after submit:

Thanks! Your feedback helps us understand the usefulness of these exercises and improve them in the future.