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ABSTRACT

With the establishment of the Internet and World Wide Web as part of the digital revolution, there has been a trend in which synchronous and asynchronous distance education opportunities have been made available to a greater variety of learners. However, students are indiscriminately pursuing online learning opportunities for the sake of convenience without consideration of the appropriateness of online instruction for their individual learning behaviors and characteristics. This has resulted in many online courses and programs enrolling students for whom the online learning environment is less than ideal--challenging teachers, administrators, technologists, and students to see that online instruction meets its potential. It is important that educators develop and investigate teaching and learning strategies that will appeal to a broad variety of online learners. Select-and-fill-in (SAFI) concept maps may provide such a strategy. This study attempted to answer the question, How do students of different learning styles respond to online instruction in which SAFI maps are utilized? (Contains 38 references.) (MVL)

Formative Use of Select-and-Fill-In Concept Maps in Online Instruction: Implications for Students of Different Learning Styles

by
Charles W. Kaminski

FORMATIVE USE OF SELECT-AND-FILL-IN CONCEPT MAPS IN ONLINE INSTRUCTION: IMPLICATIONS FOR STUDENTS OF DIFFERENT LEARNING STYLES

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With the establishment of the Internet and World Wide Web (WWW) as part of the digital revolution, there has been, globally, a trend in which synchronous and asynchronous distance education opportunities have been made available to a greater variety of learners. The flexibility and freedom from time and attendance requirements afforded by online instruction is one of the greatest appeals for many learners. One consequence of this, however, is students indiscriminately pursuing online learning opportunities for the sake of convenience without consideration of the appropriateness of online instruction for their individual learning behaviors and characteristics (Diaz & Cartnal, 1999). Educational institutions, in an attempt to develop highly-enrolled, successful, profitable distance learning programs, are, then, accepting these students with a similar lack of discrimination. Most institutions do not perform an assessment of incoming distance education students to determine their appropriateness as online learners (James & Gardner, 1995). For those that do, most often the assessment is designed to serve only as a guide, with no formal admittance or denial policy attached to the results. This has resulted in many online courses and programs enrolling students for whom the online learning environment is less than ideal (Diaz & Cartnal, 1999), challenging teachers, administrators, technologists, and students to see that online instruction meets its potential.

The digital revolution has brought about societal change as well. It has become evident that the rate at which things change, and the unpredictability of such change, is

greater than ever. Living in such a dynamic culture, citizens today must, more than ever, be able to take information from various sources and make sense of it in order to function in society. In particular, given the rate of change of cultural knowledge and norms, it is necessary that citizens have the basic skills to solve the unforeseeable problems that will occur as a result of such dynamic changes.

In light of the convergence of the challenges described above, it is important that educators develop and investigate teaching and learning strategies that will appeal to a broad variety of online learners. Select-and-fill-in (SAFI) concept maps may provide such a strategy.

The Study

Research Question

This study attempted to answer the question: *How do students of different learning styles respond to online instruction in which SAFI maps are utilized*?

Purpose of Study

The purpose of the research was to investigate the formative use of SAFI maps in online instruction and the effects their use may have on students' responses to questions in which they are required to apply knowledge contained in the maps. In particular, the interaction between such use and the four learning styles described by David Kolb's learning style model (Kolb, 1984) was considered through the development of four, illustrative cases, with the intent of identifying those styles that may be best suited to SAFI map use given their cognitive, metacognitive, and affective responses to the SAFI maps.

Theoretical Framework

Knowledge Application

The most commonly used framework through which studies on application of knowledge have been carried out is that proposed by Bloom in his seminal work, *Taxonomy of Educational Objectives* (Bloom, Englehart, Furst, Hill, & Krathwol, 1956). In Bloom's taxonomy, educational objectives are organized in a hierarchical fashion based on learner behaviors, each level requiring skills attained in the previous level in the taxonomy. Two classes of behavior, knowledge and comprehension, represent the prerequisites to application of knowledge in an attempt to solve a problem. For correct application of knowledge to occur, it is necessary that learners master the knowledge class of the domain, requiring that they have the ability to remember and recognize appropriate ideas, content, and phenomena.

Once a learner has successfully met knowledge objectives, the next class of behaviors, those requiring comprehension, must be mastered. Successful comprehension requires behaviors of translation, interpretation, and extrapolation of information based on understanding, and abstraction, of the literal message found within the communication of the content knowledge being learned. Only when these two behaviors can be successfully completed and demonstrated will a learner be able to take the knowledge learned and apply it to a unique situation without being prompted as to the appropriate abstraction necessary to complete a task or solve a given problem. Within the framework presented by Bloom, successful application of knowledge assumes comprehension and abstraction of knowledge has occurred.

Constructivism

In the years since the publication of Bloom's taxonomy, educational practice has embraced a constructivist epistemology as a referent for teaching and learning (Tobin & Tippins, 1993). The constructivist approach to instruction is designed around the notion that individual learners take experiences and build mental structures as representations or theories of the information contained in the experience. Like Bloom, constructivists believe that the learning process begins with acquisition of information. As more is learned, more effective ways of structuring experience are developed by the learner, resulting in a more complex cognitive structure that is equivalent to progress through Bloom's taxonomy. This, in turn, leads to knowledge that can be more generally applied to any problems onto which the same structures can be imposed. It is assumed, then, that learners can apply, through generalization across situations exhibiting patterns of shared elements and similarities, the theories contained in their mental structures to similar situations to complete tasks and solve problems.

Concept Mapping

From a constructivist perspective, instruction must be designed to provide individual learners with opportunities to make the connections between the new information and his or her existing cognitive structure (Ausubel, 1968; Novak & Gowin, 1984; Shavelson, Lang, & Lewin, 1993). Representation of an individual's cognitive structure is often communicated by the use of the concept map, a tool developed at Cornell University by Joseph Novak and colleagues while looking at changing cognitive structures in science students (Novak & Gowin, 1984; Novak, 1996).

There has been a great deal of research done on the use of concept maps for teaching and learning purposes. A review of the literature shows that concept maps have been found to be useful in other aspects of teaching and learning as well. Ruiz-Primo, Shavelson, and Schultz (1997) provide an extensive list of concept map components and options as they relate to use in the classroom. Used as pre-instruction advance organizers, study aids, and, most commonly, as assessment tools, concept maps, may play a valuable role in the classroom (Cliburn, 1990; Novak & Gowin, 1984; Novak, 1996;. Ruiz-Primo et al., 1997; Willerman & MacHarg, 1991).

For online educators, technological considerations make dynamic interactivity and construction of online graphic organizers a difficult, technically complex process. However, inexpensive, commercial software is available that allows the user to create maps and export them to the WWW as a static image embedded in an hypertext markup language document. With this facility, an alternate, less-investigated form of concept-map based assessment, the use of SAFI, maps, may be of value.

This process of using SAFI maps, as described by Schau and Mattern (1997), begins with an expert-created map. Then, while maintaining the integrity of the map, some of the elements of the map are eliminated. Students are then asked to fill in the missing concepts or links by choosing them from a list of terms provided, with or without distractors (Schau & Mattern, 1997). Feedback is then provided to the students based on the number of correct responses provided.

Learning Styles

The implications of available technologies are not the only obstacles to successful, instructionally sound distance education. In addition to the technical

challenges of providing instruction online, distance educators must also consider the individual learner characteristics, including learning style, of their students. Learning style is of great importance in online instruction because instruction is most often conceptualized and designed well before it actually occurs, resulting in formative assessment of online practice lacking the flexibility and spontaneity of that in the classroom. Therefore, it is necessary that a variety of instructional strategies be used at the design phase such that the learning styles of all students enrolled may be complimented proactively.

Research on distance education and learning styles has been focused primarily on the relationship between learning style profile and student outcomes such as drop and completion rates, attitudes towards the learning process, and predictors of high-risk students (Diaz & Cartnall, 1999). There are many models of learning styles, each considering the cognitive, perceptual, or affective dimensions of students that explain why different students prefer learning in different manners. One of the most common models for learning style used in distance learning research is that developed by David Kolb (Diaz & Cartnall, 1999). Kolb's Learning Styles Inventory (LSI) instrument identifies students as having one of four styles: the converger, the diverger, the assimilator, and the accommodator. Figure 1 includes the dominant learning style preferences of the cases from the study within the framework of Kolb's model.

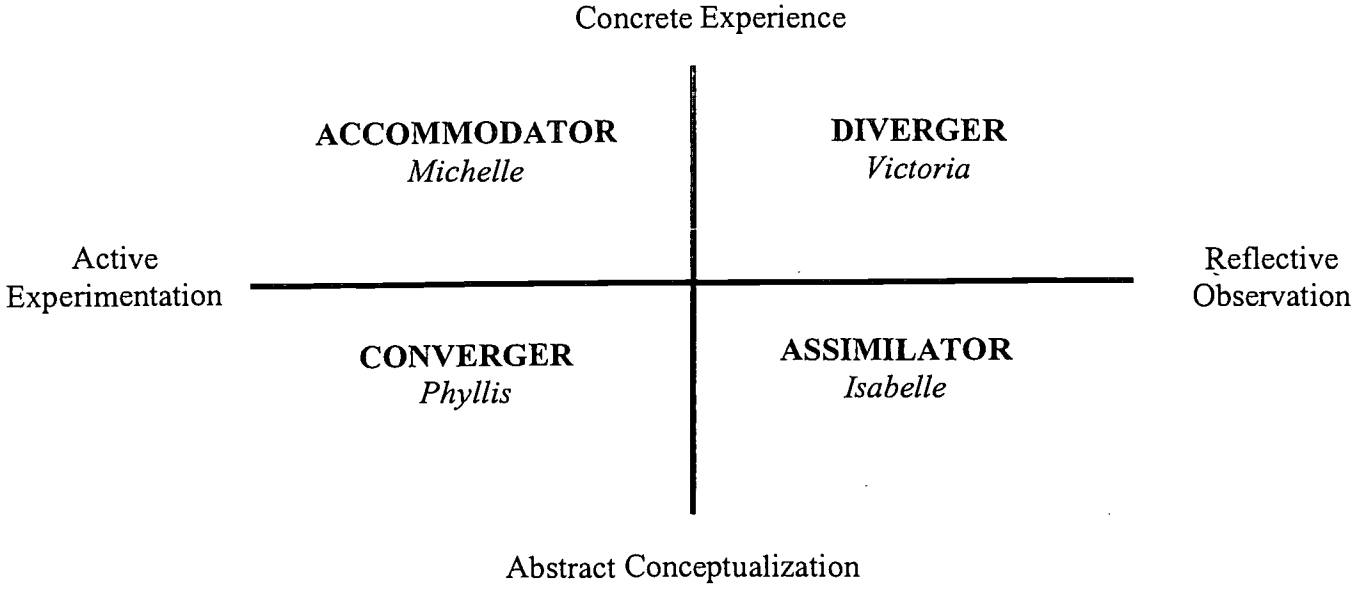

Figure 1. Case subjects within Kolb's learning style quadrants.

Given the isolated nature of online coursework, learners that require concrete experiences and are not successful at thinking abstractly have been shown to be at high-risk in distance learning environments (Dille & Mezack, 1991). These are, in Kolb's model, the diverger and the assimilator. Special consideration, then, must be given to online student learning styles. The opportunities extended by distance education cannot be taken advantage of if, during implementation, they replicate the problems found in traditional classrooms.

Formative Evaluation

Formative practice is that which explicitly or implicitly has the function of providing information in the form of feedback from which teacher and student will be able to make an informed decision with the goal of changing behavior and improving performance (Gipps, 1994; Harlen & James, 1997; Stiggins, 1991; Wiliam & Black 1996). In online instruction, communications, containing instructions to students, student

responses, and instructor feedback, can then be facilitated via e-mail or a WWW-based messaging system.

The connected, structured understanding of the information within a domain, as represented in a completed SAFI map, relates directly to the hierarchical nature of Bloom's taxonomy. Application of knowledge possesses a reliance on knowledge and comprehension, though no single piece of knowledge within a discipline exists in isolation. A more complex, integrated, and connected understanding of the structure of concepts within a discipline, then, should increase the likelihood of an individual successfully applying knowledge as attempts at abstraction are enhanced by the relationships, and their subtleties, between concepts.

Therefore, use of SAFI maps, when used formatively, should improve a learner's ability to apply knowledge by providing an accepted structure to the concepts within a domain, while indicating nuances in the relationships between these concepts that are fundamental to correct, appropriate application of the knowledge reflected in the information contained in the map. When designed carefully and deliberately, they should provide online learners with opportunities to build upon and refine their conceptual understanding, leading to improved ability in applying information contained in the concepts and their relationships. This may be facilitated without advanced or complex technologies that often distract online instructors and students from the intended roles of, respectively, teachers and learners.

Despite the volume of literature on the use of concept maps in teaching and learning, there is little on the relationship between learning style and concept maps in the classroom. Though it has been found that successful concept mappers tend to exhibit an

internal locus of control (Zeitz & Anderson-Inman, 1993), prefer learning through thought and reflection (Schreiber & Abegg, 1991), and have a preference for identifying the relationships between variables (Okebukola & Jegede, 1989), a defining relationship between learning style and concept mapping has not been identified. Furthermore, there is a paucity in the literature discussing research into the relationship between learning style and, in particular, use of SAFI maps.

The Research Design

Sample

The sample for the study was students that enrolled and participated, through a public, two-year community college, in an asynchronous, online environmental studies course. Technologically, the course is facilitated through a course web site, readable through any standard web-browsing software and a rich, intranet-based email system.

Design and Methodology

The research was an emergent design, collective case study in which several cases, sharing a dominant learning style, were to be described and presented as a single entity or case (Stake, 1995). However, distribution of participant cases among the four learning styles was not even. Upon receipt and validation of signed consent forms and evaluation of returned LSI-3s, nine subjects for the study were identified. Of these nine, five were assimilators, two were convergers, and the remaining two comprised of one accommodator and one diverger. Data were analyzed, therefore, using collective cases for assimilators and convergers, and individual cases for the accommodator and the diverger, as shown in Figure 1.

The study was carried out over a nine-week period, comprising one abbreviated summer session containing fourteen instructional units. This period, for the purposes of the study, was broken into two phases. Table 1 contains the data collected and the study-related activities occurring during each phase of the research.

Table 1

Phases of research with corresponding activities and data collection

PHASE	ACTIVITIES	DATA COLLECTED
I	• Prospective participants completed and returned LSI-3 and consent form	I. Learning Style
II	• Participants completed SAFI maps and correlating quiz items(Appendix A) • Participants completed Post-SAFI Survey (Appendix B) • Participants completed Post-SAFI Questionnaire (Appendix C)	II. SAFI map achievement scores III. Quiz item achievement scores IV. Responses to Post-SAFI Survey V. Transcriptions of email exchanges regarding feedback on SAFI task VI. Responses to Post-SAFI Questionnaire

Data Analysis

The general strategy of analysis of the data for this study was pattern-matching (Tellis, 1997; Trochim, 1989; Yin, 1994). Under this strategy, data collected was sorted and coded for each individual student case. Upon completion of each individual participant case, cases for each learning style were grouped and cross-compared, matching patterns of participant attitude and achievement around the SAFI map tasks

found in the data. The product of this was the creation of a learning style-based case representative of the individual cases. Figure 1 identifies the four cases and their dominant learning style in Kolb's model. Once the four learning style-based cases were established, these four were then cross-compared in an attempt to answer the research question and to identify cognitive, metacognitive, or affective responses to the SAFI tasks.

Cross-Case Analysis

For the purposes of this analysis, cognitive response is evident in SAFI task achievement, quiz item achievement, and successful knowledge application. These tasks can be found in Appendix A. Also, verbatim use of SAFI elements in application is indicative of SAFI map elements being instrumental in student construction of knowledge as these elements are directly integrated into the students' cognitive structure, indicating a cognitive response to the process of completing the SAFI tasks..

Metacognitive and affective responses are evident in student responses to the Post-SAFI Survey (Appendix B) and Questionnaire (Appendix C) as well as data from student email transcriptions. Individual, independent indications of student cognitive, metacognitive and affective responses to the SAFI tasks were an integral part of this analysis.

In Kolb's model, the assimilator and the coverger lie on the abstract end of the concrete-abstract continuum that is part of his learning cycle (Kolb, 1984). However, the preference for working with abstract concepts was not reflected immediately in initial SAFI task achievement, with Isabelle and Phyllis, the assimilator and the converger, having difficulty with the first SAFI task. Victoria and Michelle, the diverger and the

accommodator, were more successful at completing the maps and abstracting, from text, the concepts and their relationships such that their SAFI item responses accurately reflected the subject matter. Table 2 contains SAFI map achievement data for the cases.

Table 2.

SAFI Achievement Data

CASE	SAFI – 1		SAFI – 2		SAFI – 3		SAFI - 4	
	Number Correct	Incorrect Items	Number Correct	Incorrect Items	Number Correct	Incorrect Items	Number Correct	Incorrect Items
ISABELLE - ASSIMILATOR								
Case 1	8	1,6,8,10	12	NA	9	9,11,12	12	NA
Case 2	10	1,9	12	NA	12	NA	12	NA
Case 3	12	NA	12	NA	12	NA	12	NA
Case 4	3	1,2,3,5,6, 710,11,1 2	12	NA	5	5,6,8,9,1 0,11,12	12	NA
Case 5	10	2,10	12	NA	7	3,6,9,10, 12	12	NA
MICHELLE - ACCOMMODATOR								
Michelle	12	NA	12	NA	12	NA	12	NA
VICTORIA - DIVERGER								
Victoria	10	1,10	12	NA	12	NA	12	NA
PHYLLIS - CONVERGER								
Case 1	4	1,2,3,4,5, 7,11,12	12	NA	12	NA	12	NA
Case 2	7	1,2,5,10, 11	12	NA	12	NA	10	2,10

Number Correct = number of items answered correctly out of 12 items
Incorrect Items = specific items answered incorrectly
NA = Not Applicable

Between the first SAFI task and the corresponding quiz, all four cases completed the Post-SAFI Survey (Appendix B), which was designed to give an early sense of the metacognitive and affective impact SAFI map use may have on students. All agreed that the exercise was helpful and made them think about their own thinking. However, Isabelle and Phyllis, the more abstract-inclined assimilator and the converger, acknowledged that the SAFI task made them feel more anxious about the upcoming quiz.

Similarly, Isabelle and Phyllis disagreed and strongly disagreed, respectively, with the statement expressing that the SAFI task was enjoyable.

Michelle and Victoria, the accommodator and the diverger cases, found the SAFI task enjoyable, though neither of them found that the SAFI task showed them where they had misunderstandings or misconceptions. Similarly, Michelle and Victoria did not find the exercise to be a waste of time and felt that completing the SAFI exercise may have increased their confidence towards the upcoming quiz.

Results from the Post-SAFI Survey yielded insight into the metacognitive and affective differences between the more abstract and more concrete of Kolb's learning styles. The more concrete-oriented accommodator and diverger were more open to the task and found them enjoyable, but the metacognitive activity and awareness required to connect the task to overall learning and performance was not explicit for them. This is reflected in the lack of anxiety and admitted confidence surrounding the impending quiz. It is possible that the abstract representation of concepts and relationships reflected in the SAFI map did not have the cognitive and metacognitive value that it would to the learner with a greater affinity towards the abstract.

On the other hand, the more abstract learning styles, though not finding the task enjoyable, had made the connection between the map content and structure to the subject matter such that the anxiety and confidence towards appropriately abstracting from the SAFI map and understanding the relationships expressed in the map may have been a more conscious concern. This metacognitive activity and awareness is reflected in Isabelle's comments that "It was difficult until I stopped overanalyzing." and "I like quick answers and you did have to really contemplate the meanings of the terms and how

they could be interpreted.". Unsolicited comments suggesting a metacognitive role for the SAFI task were not received from either Michelle or Victoria.

Following completion of the Post-SAFI Survey, students completed the four SAFI tasks and corresponding quiz items through the second from final unit of the course. Table 3 includes Quiz Item Achievement data for single and collective cases. Upon completion of all of these, students completed the Post-SAFI Questionnaire (Appendix C). The questionnaire was designed to assess participant attitudes, and possible changes in these attitudes, towards the relationships between the SAFI map task, the participants' interaction with the map and content, and his or her learning and perceptions of learning after having completed SAFI maps throughout the course.

Table 3

Quiz item achievement data

CASE	QUIZ 1			QUIZ 2			QUIZ 3			QUIZ 4		
	Total	Item	App.	Total	Item	App.	Total	Item	App.	Total	Item	App.
ISABELLE - ASSIMILATOR												
Case 1	90	20	1	75	10	3	100	20	1	100	20	1
Case 2	100	20	2	100	20	1	100	20	2	100	20	1
Case 3	100	20	2	90	10	4	90	20	1	85	10	4
Case 4	90	20	1	100	20	2	100	20	2	95	15	1
Case 5	80	NA	NA	75	10	4	100	20	1	90	10	3
MICHELLE - ACCOMMODATOR												
Michelle	85	20	1	100	20	2	100	20	1	90	10	2
VICTORIA - DIVERGER												
Victoria	90	10	4	90	10	3	100	20	1	95	15	1
PHYLLIS - CONVERGER												
Case 1	100	20	2	100	20	2	100	20	2	95	15	4
Case 2	80	10	2/4	90	10	2	80	20	2	75	NA	NA

NA = Not Applicable or Not Answered
Total Points Earned = total points earned out of 100 possible points
Item Points Earned = total points earned out of 20 possible points
Application: 1 = successful application using SAFI elements
2 = successful application not using SAFI elements
3 = unsuccessful application using SAFI elements
4 = unsuccessful application not using SAFI elements

Isabelle - Assimilator

Isabelle, in answering the Post-SAFI Questionnaire items, indicated strongly that she believed that the SAFI tasks helped her learn and prepare for the quizzes, writing, "I had to read all of the chapter very carefully to find the answers and in doing so I memorized many things." This metacognitive impact of the SAFI maps is evident in her recognizing what she called "the raw understanding" represented in the structure of the maps. Isabelle recognized that the SAFI maps could provide her with a framework for conceptual organization that she could use as a basis for her own cognitive structure as well.

Isabelle also reported that the SAFI map tasks improved her confidence in that they honed her "ability to recognize important elements". This is a fundamental prerequisite to successful knowledge application in Bloom's model. Despite Isabelle's positive metacognitive response to the SAFI tasks, achievement, reflecting a cognitive response, was not consistent throughout the course. Isabelle's ability to accurately apply her knowledge was often incomplete and did not use, with any regularity, elements taken from the SAFI map.

When asked if she enjoyed the SAFI tasks themselves, Isabelle was consistent with her response to the post-SAFI survey administered seven weeks earlier in which she reported that, though she didn't find the SAFI maps enjoyable, she did feel that they were helpful. Upon completion of all of the course SAFI tasks, she replied that, given a choice of doing them or not, she "would 100 percent do them", acknowledging, though, that "This exercise was a challenge for me, one that I received much satisfaction from when I was successful at completing". This indication of a positive affective response to the

SAFI maps would be expected given the preference for working in the abstract, focusing on the activities of reflective observation and abstract conceptualization, indicative of the assimilator.

Phyllis - Converger

Phyllis' answers to the Post-SAFI Questionnaire continued to reflect the ambivalence towards the SAFI tasks expressed in her answers to the Post-SAFI Survey seven weeks earlier. Phyllis' answers to the Questionnaire items intended to probe the metacognitive response from SAFI map use were minimal, indicating that Phyllis didn't use the structure reflected in the completed SAFI in a conscious comparison to her own existing cognitive structure. Though she agreed that the SAFI maps were helpful in assisting her in "connecting specific points of a chapter", there was no evidence supporting that the maps had a cognitive effect on her ability to apply the knowledge contained in them. Throughout the course Phyllis did not use, in her quiz answers, elements or relationships presented in the SAFI map. Instead, Phyllis' comments suggest a need to connect "points of a chapter" rather than the relationships between concepts presented in the chapter. This emphasis on the practical, indicative of the converger, may have influence overwhelming any potential cognitive or metacognitive response to the SAFI maps. This practicality regarding the SAFI tasks is also reflected in Phyllis' comments regarding the maps being helpful "because the work is broken down", that "there was not a lot of other stuff getting in the way", and that, over time, "it came easier to do them".

Any affective response from Phyllis was seated in her evolving ability to successfully complete the maps and not an expressed, innate interest, enthusiasm, or

satisfaction towards their completion. For Phyllis, the maps were simply a task to be completed and forgotten, with no capacity or function to serve as a cognitive or metacognitive tool. Assigning this function to the SAFI tasks, Phyllis duly replied "no preference" when asked if she would complete the tasks if given the choice.

Michelle - Accommodator

Despite getting all of the items correct on her first attempt for all four SAFI maps, Michelle, throughout the course, showed a change in her attitude towards the tasks. In the initial Post-SAFI Survey, Michelle expressed feelings that, though she did not find the SAFI tasks enjoyable, she did feel that the maps were not confusing, were helpful, and had a positive effect on her sense of quiz preparation, confidence, and anxiety.

Michelle's responses to the Post-SAFI Questionnaire items were inconsistent with her initial response to the SAFI tasks. At the end of the course, she felt that the SAFI exercises did not help her learn better, that they were "just time consuming", and that she "did not use them for review at all". These sentiments were galvanized by Michelle's responses to the last two items on the questionnaire, where she confirmed that she "disliked" doing the SAFI maps and that, given the choice, she would choose not to do them.

Michelle's final response to the SAFI tasks is consistent with Kolb's (1984) model. In his learning cycle, the accommodator prefers learning through active experimentation and concrete experience, not the reflective observation or abstract conceptualization that are also components of his learning cycle and necessary for completion of the SAFI tasks.

Given this polarity, it stands that the accommodator's response to the SAFI maps would be nonexistent or negative. Michelle's cognitive, metacognitive, and affective responses to SAFI map use were negative in that it directly conflicted with her dominant learning style. Despite the fact that she was proficient and successful in completing the maps, she did not enjoy doing them. This dislike for the maps would make metacognitive growth a challenge in that the explicit recognition of the abstract structures reflected in the map would be, by nature, unpleasant for the accommodator.

Michelle's ability towards completing the SAFI tasks may indicate a cognitive affinity, but this does not necessarily indicate a cognitive response towards the tasks themselves. Rather, it may represent the fact that Michelle may have approached the map tasks with a thorough, accurate knowledge structure in place. Subsequently, it is possible that Michelle's success with the SAFI tasks may be attributed to the existence of a more solid understanding of the structure and relationships between concepts before attempting the tasks rather than a structure being developed as a result of the task.

Victoria - Diverger

Victoria, the other concrete-oriented learning style, had a more positive response to the SAFI maps. Upon completion of the final SAFI map, Victoria completed the Post-SAFI Questionnaire. Her feedback regarding the maps was consistent with her responses to the Post-SAFI Survey.

Victoria's cognitive response may be reflected in her gradual inclusion of SAFI elements into her answers to the corresponding quiz items. She felt that the exercises helped because "It put things in order and you could easily follow the different subjects and understand it better.". As Victoria worked on the SAFI map tasks, she was able to

compare what was reflected in the map with her own understanding, indicating that "they helped me see the relationships between parts better". Also, Victoria expresses in her responses to one of the questionnaire items that "if I could do most of the map without the help of the book I felt like I knew the material well".

Victoria's metacognitive response to the SAFI maps may have precipitated this cognitive response. Her awareness regarding the structure of the map assisting her in better developing her own understanding would increase the likelihood that her cognitive structure more closely resemble the structure reflected by the completed map. As this occurred, Victoria would have extracted elements of the SAFI map, integrated them into her own cognitive structure, and explicitly used these relationships while applying the knowledge on the corresponding quiz items.

Kolb's model supports the evidence observed in Victoria's actions and behaviors. Unlike the accommodator, the diverger, though lying on the concrete end of the abstract-concrete continuum, prefers reflective observation over active experimentation. Victoria stated "It was sometimes like a puzzle and I liked trying to solve them". The diverger prefers looking for meaning, a key activity in SAFI map completion. This would explain why Victoria claimed to have "loved" doing the exercises and became more successful at completing them as the course progressed. This success created a positive affective response to the tasks.

Table 4 presents a summary of the results stemming from the analysis of the evidence present in the data collected during this study.

Table 4

Summary of learner responses to SAFI map use

DOMINANT LEARNING STYLE (Case)	RESPONSE TO SAFI TASKS		
	Cognitive	Metacognitive	Affective
Assimilator (Isabelle)	NA	+	+
Diverger (Victoria)	+	+	+
Accommodator (Michelle)	NA	-	-
Converger (Phyllis)	NA	-	+

+ evidence supports positive response to SAFI tasks
- evidence supports negative response to SAFI tasks
NA no consistent evidence

Discussion

Significance of Findings

This research study was designed to answer the question *How do students of different learning styles respond to online instruction in which SAFI maps are utilized?* The results of this study imply that the formative use of SAFI maps in online instruction may generate cognitive, metacognitive and affective responses from learners with different dominant learning styles as defined using Kolb's experiential learning model.

Kolb's model asserts learning style as occurring along two axes, one representing a concrete-abstract continuum and the other an active-reflective continuum. Previous research (Diaz & Cartnall, 1999; Dille & Mezack, 1991; Gee, 1990; Lee, 2000; Ross & Schultz, 1999; Shih, Ingbritsen, Pleasants, Flickinger & Brown, 1998) suggests that learners with an affinity for the abstract showed greater success in distance learning contexts. Similarly, research on learner characteristics suggests that abstract learners also demonstrate greater success with tasks requiring use of concept maps (Oughton & Reed, 1999; Reed & Oughton, 1998; Schreiber & Abegg, 1991).

Evidence collected in this study suggests a different relationship between learning style and the use of online SAFI maps. In response to the use of the SAFI maps, the learners preferring reflective activities (Kolb's assimilator and diverger), not abstract conceptualization (Kolb's accommodator and converger), were more likely to demonstrate positive responses to the tasks. However, there is a lack of research on interaction between cognitive, metacognitive and affective domains, learning style, and SAFI map use. Therefore, implications drawn from the analysis reflect consistency with theoretical constructs rather than previous research.

Cognitive response, as indicated by progressive success in SAFI completion, knowledge application, and precise, verbatim use of SAFI elements in application, was evident only in the diverger. Given the concrete, reflective nature of the diverger, this is inconsistent with previous research (Schreiber & Abegg, 1991; Oughton & Reed, 1999) indicating an affinity for abstract learning in individuals for whom interactions with concept maps are a positive cognitive experience.

Under Bloom's taxonomy (Bloom et al., 1954), one requirement for successful knowledge application is careful consideration and identification of key pieces of knowledge or abstractions within the given context. Given the tendency for the diverger to consider a situation from multiple perspectives and to use unconventional solutions (Kolb, 1999), it would stand that it would be less likely for the diverger to use elements from a provided structure that represents a conventional, accepted conceptual construct. This, however, was not the case. Evidence suggests that Victoria, the diverger in the study, readily integrated SAFI elements into her cognitive structure and then used the knowledge contained in this structure, in application.

Cognitive response to the SAFI exercises was not noted with the remaining cases. There was inconsistent evidence suggesting that a cognitive response occurred as a result of SAFI map use. Subsequently, the study was inconclusive regarding identifying a cognitive response to online, formative, SAFI map use that, in turn, influenced construction of knowledge and subsequent knowledge application.

The significance of the results from this study may lie in the evidence indicating metacognitive and affective responses to the SAFI tasks. Previous research has indicated that concept map construction may have a positive effect on student attitude and feelings towards a discipline and the coursework and tasks within that discipline. (Jegede, Alaiyemola, & Okebukola, 1990; Novak, 1990; Okebukola, 1992; Okebukola & Jegede, 1989; Roth, 1994). Schau and Mattern (1997) report that students are much more willing to complete SAFI maps over other forms of concept maps, with many students finding the tasks enjoyable. Findings from this study are consistent, with only the accommodator reporting that she did not enjoy completing the SAFI tasks.

Research also indicates that concept map construction may serve as a valuable metacognitive tool, generating confidence of knowing the subject matter in the learner and therefore reducing learner anxiety towards the subject (Jegede et al., 1990; Novak, 1990; Okebukola & Jegede, 1989; Roth, 1994). Previous research related to concept map use and affective and metacognitive reactions does not address individual learning styles and involves learners constructing maps themselves, not working from a provided structure. Nonetheless, for each of the four dominant learning styles represented in Kolb's model, evidence suggests that the affective and metacognitive responses to SAFI

tasks, though not as expected, are consistent with theory and previous research and lends insight into answering the research question.

Victoria, the diverger, exhibited positive metacognitive and affective responses to the SAFI maps. Evidence also suggests that this was the case with Isabelle, the assimilator. Both of these learning style types lie on the reflective end of the active-reflective axis of Kolb's model, indicating that it may be preference for reflection upon learning, rather than abstract conceptualization of ideas, that explains the nature of their responses to the SAFI tasks. The "looking for meaning" (Kolb, 1999, p. 4) preferred by the reflective learner is the primary cognitive activity associated with completing the SAFI maps.

Phyllis, the converger, sharing with the assimilator an affinity towards working with abstract concepts, demonstrated a positive affective response to the SAFI tasks. However, evidence suggested a negative metacognitive response. This is consistent with the preference for using logical analysis typical of the abstract learner. As Phyllis is working on the SAFI task, she is carefully analyzing the relationships between concepts. This need for logical analysis is met during the SAFI task, resulting in a positive affective response to the task. However, the converger also prefers using real-world, practical experience in his or her learning. This is not part of the task of SAFI map completion and may explain Phyllis' negative metacognitive reaction to the tasks. Phyllis, as a converger, would prefer to consider her own thinking within a real-world context, not the abstract representation of the world reflected in a SAFI map. Subsequently, it may be that, though Phyllis enjoyed the activity of the tasks, they did not serve as useful tools she could employ to lend insight into her own thinking.

Michelle, the accommodator, demonstrated negative metacognitive and affective responses to the SAFI task use. It would not be expected that the accommodator, preferring to learn by experience, would use SAFI maps as metacognitive tools given the abstract nature of their representations. Michelle would rather have thought about her own thinking and understanding within a real-world context, not the artificial representation of the SAFI map. The fundamental opposition between the preferred, real-world context of the accommodator and the abstract representations of a SAFI map resulted in a negative affective response.

These results suggest that use of online SAFI maps, when used formatively, may play a particularly valuable role in generating positive responses in online learners that prefer to reflect and look for meaning over those that have an affinity for intellectually analyzing abstract ideas and their inter-relationships. It may be that the value of completing online SAFI tasks lies in the process of contemplating and making meaning of the relationships between concepts in the map, not in the product of a cognitive structure specifically reflecting the structure of concepts as they are represented in the completed map.

The study indicates a more consistent metacognitive and affective response across all cases. Given the nature of the SAFI tasks themselves, the cases representing more reflective learning styles should, by definition, prefer the activities required to complete the SAFI tasks. Evidence in the data collected supports this relationship in that the metacognitive and affective responses are the product of specific learning style preferences. The active experimentation preferred by learners at the active/experimental end of the active-reflective continuum of Kolb's model is not part of a SAFI task. This

may explain the lack of evidence indicating any consistent, positive response to the tasks in these learners.

There is a scarcity of evidence suggesting a cognitive response, as indicated by achievement in knowledge application, in all of the cases. The lack of a readily definable cognitive response may be indicative of the value of process over product inherent to the SAFI tasks. The emphasis on the process of reflection may increase the likelihood of an affective or metacognitive, rather than a cognitive, response to use of the SAFI tasks. A cognitive response, the product of abstract conceptualization and development of a cognitive structure resulting from the successful completion of the SAFI map, would be evident in application of knowledge more directly including or reflecting SAFI elements. This was not the case. It may be that students were not using the completed SAFI maps as a reference for building their own cognitive structure. Rather, they were using the SAFI tasks as a mechanism to reflect and consciously consider relationships between concepts contained in the map. Within this process, the students then were building their own, unique cognitive structure that did not necessarily reflect that which was presented in the completed SAFI map.

Limitations of Study

Though attempts at maintaining quality of design and purpose for the study were made, limitations were inherent to the design. Given the situated, evaluative nature of the proposed study, credibility may be in question due to what Mertens (1998) describes as progressive subjectivity. The blind-nature identification of the cases until after course completion was designed to counter this effect, though the possibility of an evolving subjectivity in the researcher existed. The researcher kept a journal of thought as the

research proceeded. This was read and reflected on during the data analysis as a measure by which evolving subjectivity or bias could be identified and checked during the analysis. Despite these precautions, subjectivity could exist within the presentation of cases and data analysis.

As with all case study research, the greatest limitations to the study involved generalizability. Participants were not randomly assigned to the group and were, through their enrollment choice and willingness to participate, a self-selecting sample of online-learners. It should be noted that the generalization to be derived from case study research is, according to Yin (1998), not a statistical but an analytic generalization. Within this analytic generalization, cases are used to illustrate or present a theory which, though context specific, will resonate with a large cross-section of readers (Stake, 1995).

The use of multiple cases for each learning style making up the learning style case was implemented to strengthen the analytic generalizations through replication and shared corroborative evidence. However, given the idiosyncratic nature of student behaviors and attitudes, the collective nature of the cases often presented an obstacle to objective analysis. As representative evidence was selected from individual cases for presentation within each collective case, the researcher had to choose which individual case best represented the larger trends and patterns that emerged from the coded data. Therefore, some data regarding individual student cases may have been excluded from the final data collection and analysis. The necessity to make such choices may have undermined the chances for greater objectivity of the data analysis.

With regard to the research results, the lack of evidence suggesting a cognitive response to SAFI map use poses a limitation inherent to the research design. A more quantitative

analysis of a greater number of student responses in comparison to SAFI content would have strengthened the research design and increased the likelihood of identifying a cognitive response.

Summary

This study investigated the responses to the use of formative SAFI maps in online students of different dominant learning styles. Because of the qualitative, case study design, the ability to generalize from the study to the larger population is limited. However, given the evidence suggesting a positive relationship between the response to SAFI map use and reflective learning styles, it is not unreasonable to anticipate that data collected from future research will lend additional insights into the relationships between learning style and SAFI map use.

Though the findings in this study did not indicate a cognitive relationship between SAFI map use and learning style, the metacognitive and affective responses observed in the cases suggest that online SAFI map use may be a valuable tool for teaching and learning. The existing body of research on distance learning indicates that abstract learners typically fare better in online learning contexts. However, evidence from this study suggests that there is a particular value of online SAFI map use for reflective learners. Therefore, SAFI map use may play an inclusive role when incorporated into online instruction by appealing to a reflective, rather than abstract, learning style, providing expanded access to educational opportunities to a larger segment of the population.

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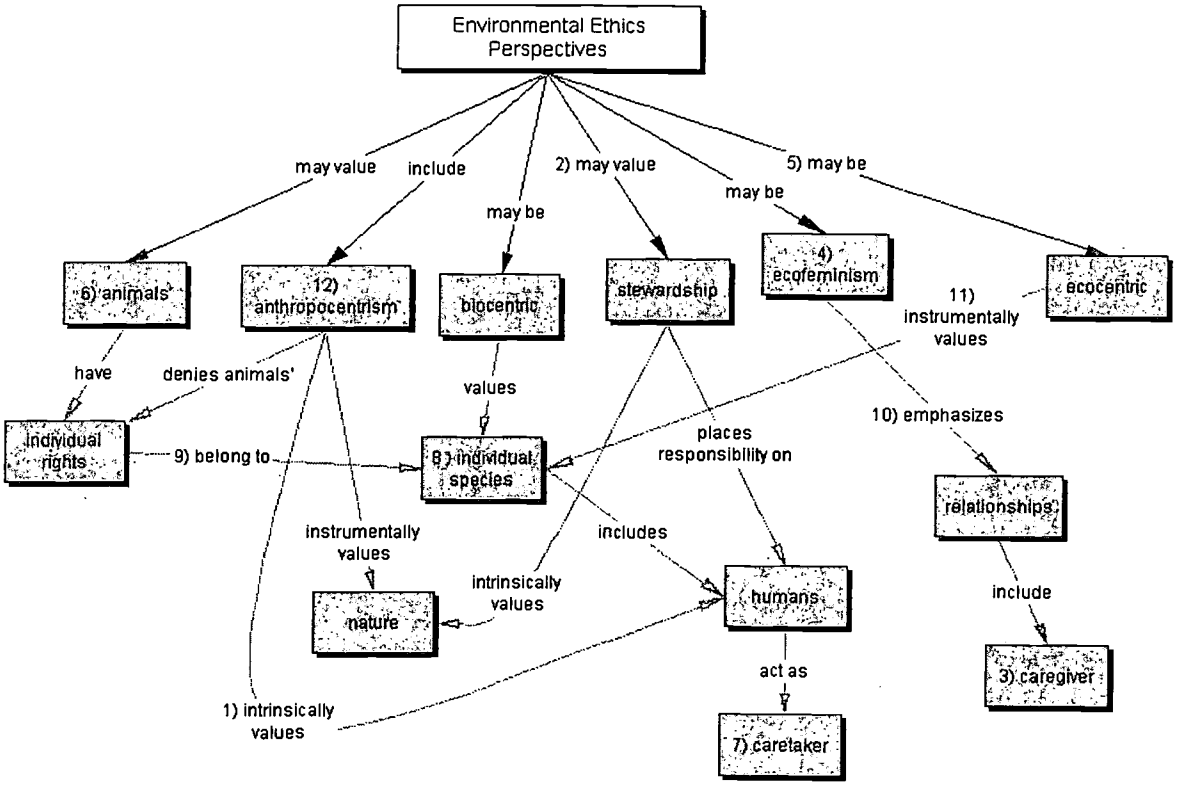
APPENDICES

Appendix A - SAFI Maps and Quiz Items

The following four SAFI maps, with items to be correctly selected and filled in acknowledged were used formatively in the study. Following each is the quiz item requiring application of content contained in each completed map.

I. SAFI Map and Corresponding Quiz Item 1 – Environmental Ethics

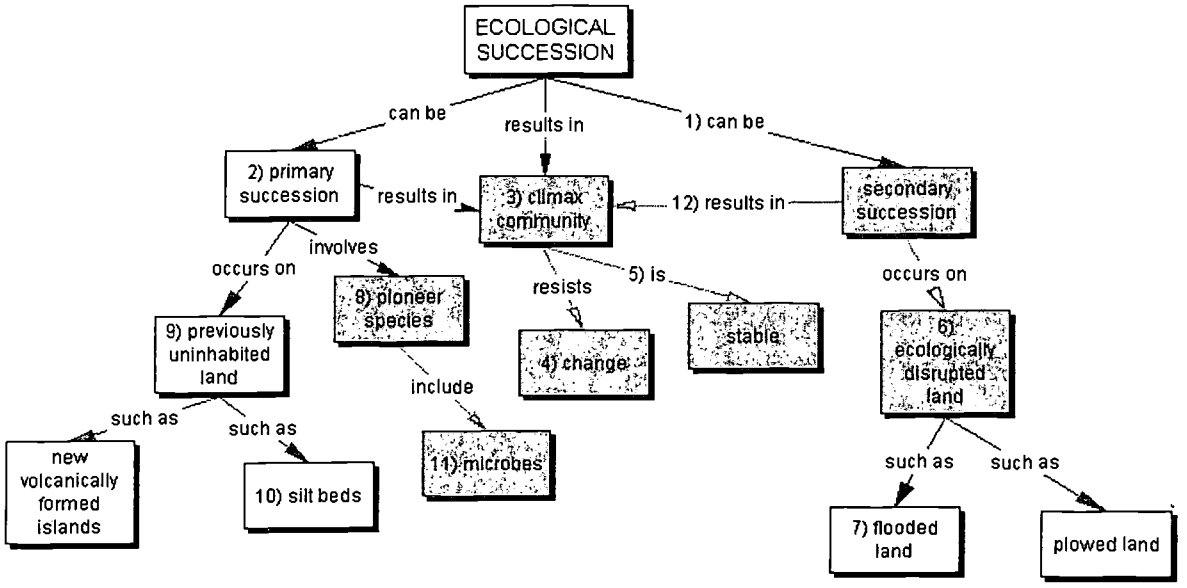


Quiz Item. Identify which ethical perspective can best be used to describe or explain each scenario. Explain your thinking as to why you chose this perspective.

A. A small parcel of land in the Amazon rainforest of Brazil contains a species of small flowering plant that has, for many years, been used by native populations for its reputed medicinal properties. The land is threatened by logging, and the plant in question is known to have only a small range of distribution. Environmental activists make efforts to legally protect the biologically diverse land from logging activities.

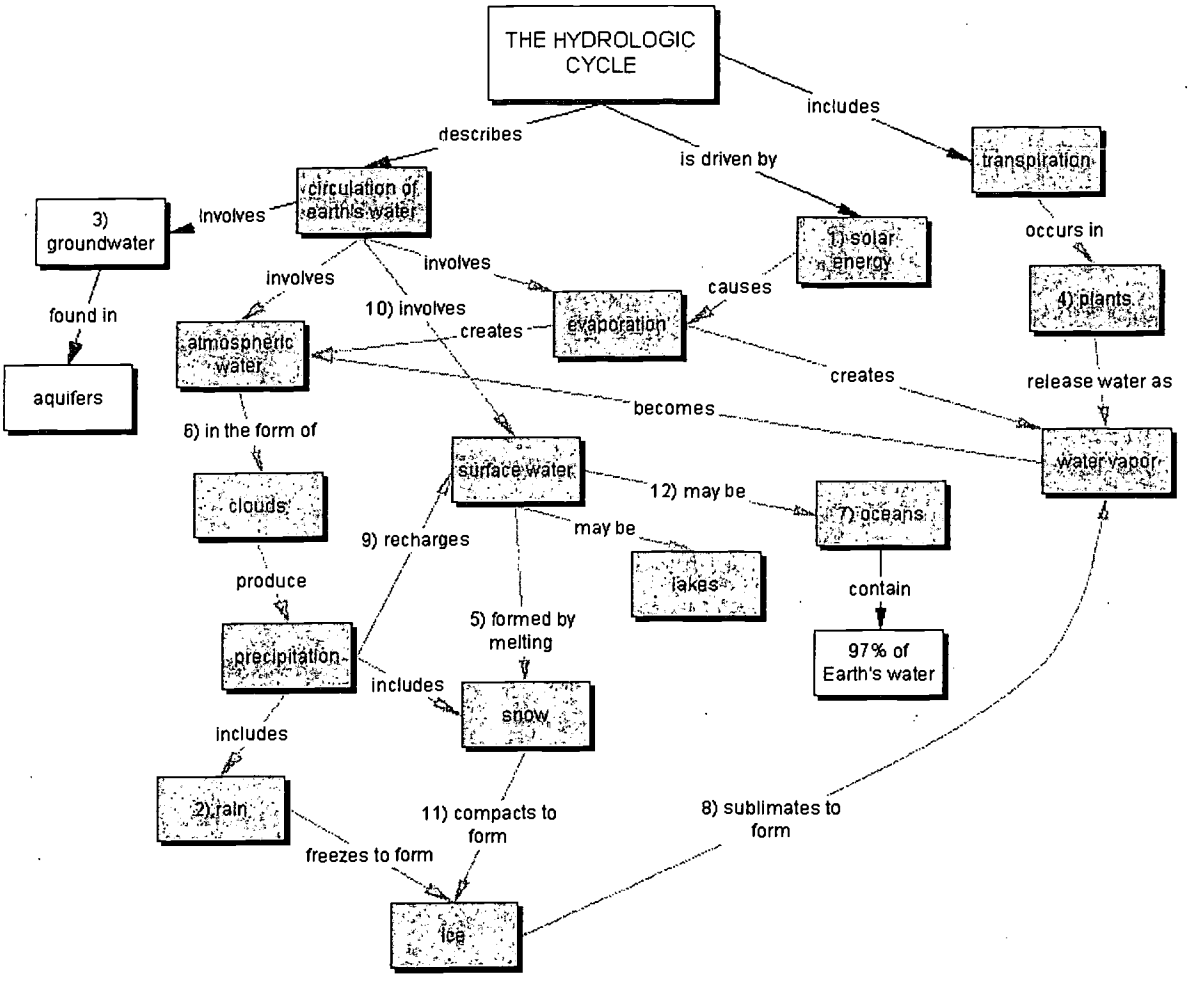
B. There are plans to reintroduce the red wolf into an area where it has locally been hunted to extinction. However, livestock herders are protesting the plans, claiming that the animals will hunt and kill their flocks. The wolves prey on small game such as rabbits, deer and wild goats, weeding out the old, injured or sick individuals and keeping natural populations of these animals, which are often found grazing alongside shepherd's stock, healthy. Wildlife biologists work with the local farmers to explain the ecology of the wolves, educating them on how the wolves and local herding activities do not have to be competitive but instead can co-exit harmoniously.

II. SAFI Map and Corresponding Quiz Item 2 – Ecological Succession



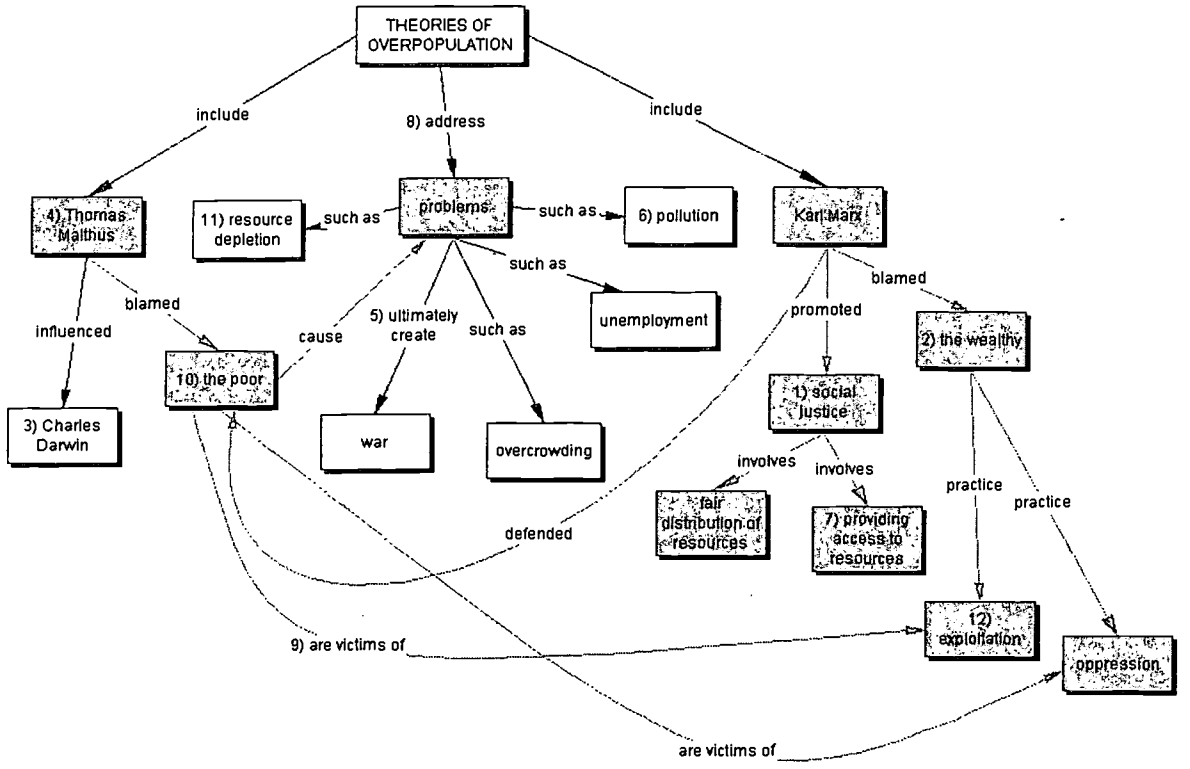
Quiz Item. In 1980, Mount St. Helens erupted in Washington State, spewing over three cubic kilometers of ash out of its crater in the process. The ash fell, creating a thick blanket that wiped out all living things in the area immediately around the volcano. Describe, in a few short sentences, the ecological succession that you would expect to occur after this blast. Also, is this a primary or secondary succession?

III. SAFI Map and Corresponding Quiz Item 3 – The Hydrologic Cycle



Quiz Item. Describe the typical path a water molecule might follow through the hydrologic cycle from the ocean to land and back again, being sure to address residence time. Then, predict the path in the hydrologic cycle for the same molecule if global climate were to cool significantly. Feel free to be creative, but your prediction much make logical, scientifically-accurate sense.

IV. SAFI Map and Corresponding Quiz Item 4 – Theories of Over-Population



Quiz Item. Imagine that, through some miraculous technological advance, resources on the planet became infinite and made available to everyone equally. Predict what effect would this would have on global populations based on both Marx's and Malthus' theories of overpopulation.

Appendix B - Post-SAFI Survey

You have just completed a SAFI map exercise on ethical principles. Below are ten statements about this exercise. Please rate, using the numeric scale below, the extent to which you agree with the statement. Thank you.

1 - Strongly Agree
2 - Agree
3 - Disagree
4 - Strongly Disagree

1. Completing the SAFI map exercise was helpful.
2. Completing the SAFI map exercise made me feel more anxious about the upcoming quiz.
3. Completing the SAFI map exercise helped me review in preparation for the quiz.
4. Completing the SAFI map exercise clarified things that were unclear to me.
5. Completing the SAFI map exercise was a waste of time.
6. Completing the SAFI map exercise was enjoyable.
7. Completing the SAFI map exercise made me feel more confident about taking the upcoming quiz.
8. Completing the SAFI map exercise confused me.
9. Completing the SAFI map exercise showed me where I had misunderstandings or misconceptions.
10. Completing the SAFI map exercise made me think about my own thinking.

Appendix C - Post-SAFI Questionnaire

Throughout this semester, you have been completing SAFI map exercises on a variety of topics. Please answer the following questions regarding the exercises. Be as honest, open, and specific as possible in response to these questions. You have my guarantee that in no way will your responses to any of these items impact your grade or status in the course. Thank you.

1. Do you think that the SAFI map exercises helped you learn better? Why or why not?
2. Did you find that the SAFI map exercises were helpful to you when reviewing things covered in the course? Why or why not?
3. Do you think that completing these SAFI map exercises helped you do better on your weekly quizzes? Why or why not?
4. Did these exercises make you feel more or less confident about how well you knew the material? Why or why not?
5. Would you say you generally liked or disliked doing the SAFI map exercises?
6. If you were given a choice of doing or not doing the SAFI exercises, would you choose to do them?

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