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The Effect of Thinking Maps on Students' Higher Order Thinking Skills

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ABSTRACT

In Advanced Placement Environmental Science, students are required to demonstrate higher order thinking skills of analysis, synthesis, and evaluation. Thinking Maps are a specific series of graphic organizer's produced by and educational consultant company and created by David Hyerle. Thinking Maps claim to increase students' higher order thinking skills, but no peer-reviewed research has been completed on the success or usefulness of these graphic organizers. In order to determine the effect of Thinking Maps on students higher order thinking skills, student ability to compare and contrast and students essay scores were compared in essays given before and after Thinking Maps instruction. Students' surveys were analyzed before and after Thinking Maps instruction on students' use of Thinking Maps. Field notes were collected. After Thinking Maps instruction, students' ability to compare and contrast increased by 69%; students' essay scores increased by 16%. Both of these changes are statistically relevant. Student's study habits and practices were surveyed before and after Thinking Maps instruction. Insignificant change in students reported study habits occurred before and after Thinking Maps instruction. Field notes were used to support these findings.

Chapter 1 Introduction

The College Board Advanced Placement program proposes that college-level curriculum can be studied successfully by secondary students and that these students can demonstrate college-level proficiencies (Dixon, 2006). Advanced Placement Environmental Science is a course where students investigate human impact on the earth. A university Environmental Science course would expect its' students to be able to problem solve and show scientific reasoning through essays. The goal of Advanced Placement Environmental Science is to provide students with the knowledge to understand interrelationships of the natural world, analyze problems, evaluate situations, and synthesize interdisciplinary information to come up with a greater understanding of our world (College Board, 2008). These skills are collectively known as higher order thinking skills. "Thinking skills are the mental capacities we use to investigate the world, to solve problems and make judgments" (Fisher, 2007, p. 72). Graphic organizers are teaching tools that may teach students' how to use higher order thinking skills (Hyerle, 2000; Gallavan & Kottler, 2007; MacKinnon, 2006; Stull & Mayer, 2007). Thinking Maps are a specific set of graphic organizers created by David Hyerle to develop students' thinking skills (1995b).

Higher order thinking skills refer to the highest levels of Blooms taxonomy, which Bloom (1956) describes as a generalized way of thinking and solving problems that could be applied to a wide variety of subjects (as cited in Boone, Boone & Gartin, 2005). Bloom identified a hierarchy for classifying instructional objectives in the cognitive domain (Boone et al., 2005). The levels of Blooms Taxonomy are **knowledge**, the ability to recall information, **comprehension**, understanding the meaning of the

material, **application**, the ability to use information in new ways, **analysis**, breaking information into parts, **synthesis**, putting together different pieces of information, and **evaluation**, the ability to judge or evaluate information (Bloom, 1956; Boone et al., 2005; Fisher, 2007; Passig, 2007; Zohar, 2004). The levels of application, analysis, synthesis, and evaluation are all considered to be higher order thinking skills, which require the levels of knowledge and comprehension**,** but are used to solve problems. Graphic organizers are a tool used to help develop students' higher order thinking skills, including synthesis, analysis, and evaluation.

Graphic organizers are shape-based diagrams that organize students' thoughts. Graphic organizers help students sort, differentiate, show relationships, make meaning, and manage data quickly and easily before, during, and after reading and discussion (Gallavan & Kottler, 2007). Concept maps are other graphic organizers that are used to help students organize thoughts and show relationships and may be the most popular graphic organizer (MacKinnon & Keppal, 2005). Concept maps include "critical features, namely hierarchical distribution of ideas and labeling of the relationship between adjunct concepts" (MacKinnon & Keppel, 2005). Concept maps and graphic organizers can show students relationships between ideas and help students develop higher order thinking skills. There are formalized graphic organizers from the Innovative Learning Group known as Thinking Maps (Hyerle, 1995b). Thinking Maps are a specific set of eight formal graphic organizers that are designed to simulate eight specific thinking processes, including defining, describing, compare and contrast, cause and effect, sequences, part to whole relationships, classification, and analogies (Hyerle, Suddreth & Suddreth, 2004). There is little formalized research available on Thinking Maps.

The North Valley High School District has developed extensive professional development for the use and instruction of Thinking Maps. The district has purchased many Thinking Maps products, including teacher training manuals, posters of individual maps, and educator time used to train teachers in the use of Thinking Maps. At WW High School, all teachers have completed a year of rigorous professional development on Thinking Maps. Graphic organizers and concept maps have extensive research that has been done to repeatedly show that they improve or are related to students' development of higher order thinking skills. However there is little unbiased research that has been presented on the eight specific maps that have been created by the Thinking Maps corporation, Innovative Learning Group. In this study, the author investigated a specific correlation between the use of Thinking Maps brand graphic organizers and students' higher order thinking skills.

Purpose Statement

The purpose of this paper is to examine the relationship between students' use of Thinking Maps graphic organizers and students' development of higher order thinking skills demonstrated through their writing in Advanced Placement Environmental Science. The fundamental question that is the focus of this study is: *What effect does the use of graphic organizers, specifically Thinking Maps, in Advanced Placement Environmental Science instruction have on student's development of higher order thinking skills?*

Importance of the Study

This information will be of value to all schools and school districts that implement the Thinking Maps program in their classrooms. This study will attempt to indicate if claims made by Thinking Maps are accurate. This information will be of

particular value to all Advanced Placement Environmental Science teachers. It will also be applied to all science teachers and teachers in other advanced placement or other disciplines. This study will evaluate students' use of higher order thinking skills through the design of their graphic organizers and their ability to transfer that knowledge and thinking process to written form in an Advanced Placement Environmental Science essay.

Definition of Terms

Higher Order Thinking Skills

Higher order thinking skills are based on the ideas from Bloom's taxonomy that there is a hierarchy of thinking (knowledge, comprehension, application, analysis, synthesis, and evaluation). Application, analysis, synthesis, and evaluation are thought to be higher order thinking skills.

Graphic Organizers

Graphic organizers are a picture or visual representation that connects key ideas in different ways. They can compare and contrast, evaluate, define in context, anticipate, show cause and effect, and create analogies.

Concept Maps

Concept maps are a type of graphic organizer that outlines a key concept, generally using vocabulary, and shows the relationships between terms, including comparisons, inter-relationships, and interactions between terms.

Thinking Maps

Thinking Maps are a specific brand of graphic oranizers that have eight specific maps that defines words, describes ideas, compare and contrast, show relationships,

shows events as sequence, cause and effect, part-whole relationships, and creates analogies (see Appendix A).

Chapter 2 Literature Review

Higher Order Thinking Skills

The amount of knowledge in science is doubling every 5 years (Boone et al. 2005). Teachers should not just teach knowledge, but teach students how to think. Thinking skills are important because mastery of the basic concepts in education, such as literacy, math, and scientific facts, is not sufficient to fulfill human potential or the demands of active citizenship (Fisher, 2007). Thinking skills include remembering, questioning, forming concepts, planning, reasoning, imagining, solving problems, making decision, and making judgments (Fisher, 2007). In 1956, Bloom stated "that unless the individual can do his own problem solving he cannot maintain his integrity as an individual personality" (Boone et al., 2005. p. 41). Educators must focus on teaching our students how to problem solve in order to help them achieve success during the tenure as our students and beyond.

In order to create a method that could be applied to classifying instructional objectives, Bloom created a taxonomy, or organized hierarchy, of thinking skills. The lower level thinking skills, or those that require a minimal amount of skill other than memorization, are knowledge and comprehension. Higher order thinking skills are application, analysis, synthesis, and evaluation. These “higher-levels of the domain are now coming to the forefront as we teach how to think, now what to think” (Notar, Wilson & Montgomery, 2005, p. 18). Educators must prepare students’ for all levels of education and employment, where people are required to think about information that is readily available and constantly changing, thanks to the flattening of the world (Freidman, 2006). For students to be able to apply their knowledge, they must be able to

implement rules, theories, information and principles to real world situations (Passig, 2007). Skills found in analysis include comparing and contrasting, categorizing, calculating, and differentiating (Boone et al., 2005). Synthesis requires students to create an entirely new combination of ideas that work together in a different way with a newly constructed meaning (Passig, 2007). Evaluation is a skill where individuals are required to make and justify arguments, identify assumptions, provide evidence or support for claims of judgment, and identify reliable sources of information (Zohar, 2004).

Metacognition is an individuals' ability to recognize that they understand the thinking process. According to Zohar (2004), many educators lack sufficient metagonative skills to scaffold higher order thinking processes. Using pre-formed graphic organizers is a way to clarify higher order thinking skills for students and educators. Graphic organizers are a way to visually display metacognition (Hyerle, 2000). More teachers are looking at strategies that can be described as *thinking-based learning* (Swartz, 2008). When teachers use *thinking-based learning*, they combine thinking techniques with content knowledge and metacognition; in many cases, visual tools such as graphic organizers are used (Swartz, 2008).

An integral part of a formalized Higher Order Thinking Skills program (HOTS) is constructivism (Pogrow, 2005). In the HOTS program, "teachers learn to guide students without simplifying problems, reducing ambiguity, or telling students what to do. The goal of HOTS is for students to construct ideas and strategies on their own" (Pogrow, 2005, p. 65). Having students construct their own ideas in a guided, facilitated manner can lead students to develop more connections between ideas and manipulate content using higher order thinking skills. Students' who construct their own questions and are

forced to reflect on content, develop patterns of thinking that can help them throughout life (Foote, 1998). "Thinking skills are habits of behavior learned by practice"(Fisher, 2007, p. 72). One way to encourage students to practice thinking is by using graphic organizers.

Graphic Organizers and Thinking Maps

"A graphic organizer consists of spatial arrangements of words (or word groups) intended to represent the conceptual organization of text" (Stull & Mayer, 2007, p. 810). The key idea within all graphic organizers, whether they are standard diagrams, concept maps, or outlines, is that they are arraignments of words in such a way to organize text. Different types of graphic organizers correspond to different types of thinking. Graphic organizers allow students to compare and contrast, create analogies, create conclusions, cause and effect relationships, part to whole relationships, define in context, describe, and classify information (Hyerle, 2000; Gallavan & Kottler, 2007; MacKinnon, 2006; Stull & Mayer, 2007). Graphic organizers have been proven to be a very useful tool for teachers because of their ability to delineate curricular objectives (MacKinnon & Keppal, 2005).

Concept maps are a type of graphic organizer where students are asked to extrapolate key information and link it, using key words, with other information, using arrows to show directionality (De Simone, 2007). Concept maps may be the most popular graphic organizer (MacKinnon & Keppal, 2005). In science, concept maps can allow teachers to see students' misconceptions and force students to explain their reasoning (Vanides, Yin, Tomita & Ruiz-Primo, 2005). One of the most important relationships illustrated by concept maps is hierarchy or part to whole relationships (De Simone, 2007; MacKinnon & Keppal, 2005). In studies completed by Pankartius (1990)

and Okebukola (1990) the use of student created concept maps that create hierarchical relationships increased student understanding and student test scores (as cited in Taricani, 2007). In addition, concept maps can help clarify student understanding of structural relationships within a process. As these ideas become clear, students are able to problem solve with more ease and integrate new knowledge with previous knowledge (Chen, Sue-Ching, Chen & Cho, 2003).

Many claims have been made stating graphic organizers and concept maps require students to use higher order thinking skills (De Simone, 2007; Hyerle, 2000; Gallavan & Kottler, 2007; MacKinnon, 2006; MacKinnon & Keppal, 2005; Stull & Mayer, 2007; Vanides et al., 2005). While most educators and researchers agree on this statement, there are many different types of graphic organizers and concept maps that are represented by these studies. There are a wide variety of graphic organizers with a plethora of shapes, patterns, and formats. Concept maps generally use a hierarchical form, but can have any modifying phrase imaginable used to link ideas. Concept maps and graphic organizers have branched into the digital world with specific software, such as Inspiration, which allows pictures and hyperlinks added to students' concept maps (De Simone, 2007; MacKinnon & Keppal, 2005). These studies have all been done with the practice that the concept maps or graphic organizers were student created. The idea of student created concept maps or graphic organizers relates to the constructivist practice that is associated with higher order thinking skills.

In a study conducted by Stull and Mayer (2007), it was concluded that the increased activity of the learner, that of them physically creating the graphic organizer, should not be interpreted as deep learning. In addition, they concluded that students can

create and complete graphic organizers without being engaged in the thinking process. In Stull and Mayer (2007) the authors stated that one of the limitations of this study was that the "level of graphic organizer training given to participants was minimal" (p. 818). Other studies have included in their methods that it is important, if not critical, to ensure that all students and instructors have been trained in the construction of concept maps and/or graphic organizers (Chen et al. 2003; De Simone, 2007; Lee & Nelson, 2005; Taricani, 2007). It is important that students are comfortable with the form of the graphic organizer that is being used. If students become focused on form, students become focused on creating the physical map, rather than making connections and increasing their higher order thinking skills (Stull & Mayer, 2007).

The eight specific graphic organizers that are represented in the Thinking Maps programs were based on the concepts created by Upton (1941) and Samson (1958) who worked together at Whittier college (Hyerle, Suddreth & Suddreth, 2004). The philosophy behind the Thinking Maps program is to instill the ability to problem solve in students and create interdisciplinary content based thinking skills programs within schools. Using Upton model, in 1988 Thinking Maps were created by David Hyerle (1988) and he created and the first resources for using Thinking Maps (Hyerle, Suddreth & Suddreth, 2004). Each Thinking Map corresponds to a single thinking process: **circle maps** define words or things in context and presents points of view; **bubble maps** describe emotional, sensory, and logical qualities; **double bubble** maps compare and contrast; **tree maps** show the relationships between main ideas and supporting details; **flow maps** show events as a sequence; **multi-flow maps** show cause and effect relationships and helps predict outcomes; **brace maps** show physical structures and part-

whole relationships; **bridge maps** help to transfer or form analogies and metaphors (Hyerle, 1995a) (see appendix A).

Concept maps and Thinking Maps are both organizers that can be referred to as thinking-process maps because they show students the metacognition required for specific thinking processes (Hyerle, 2000). According to Hyerle (2000), thinking-process maps teach, scaffold, and facilitate four specific habits of mind: questioning and hypothesizing, collecting data, metacognition, and listening with understanding. Thinking Maps can be described as a "synthesis model, or *language*, of eight thinking-process maps"(Hyerle, 2000, p. 52). According to Hyerle (2000), Thinking Maps are a variety of visual tools that combine creative thinking, organizational structure, and metacognative capacities. Hyerle (2000) claims that Thinking Maps "concretely support . . . higher order thinking and learning"(p. 53). However, while many studies have supported this claim with graphic organizers (De Simone, 2007; Gallavan & Kottler, 2007; MacKinnon, 2006; MacKinnon & Keppal, 2005; Stull & Mayer, 2007; Vanides et al., 2005), there have been no other studies on the eight specific Thinking Maps that have supported Hyerle's claims.

A characteristic of the Thinking Maps program is the philosophy of having whole school ties, or creating a common visual language among students and between teachers (Hyerle, 1995a). This approach addresses the concerns and limitations addressed in the Stull and Mayer (2007) study that concluded that full instruction in graphic organizer was an essential part of student learning.

At WW High school in the 2007-2008 school year, following the model proposed by Hyerle (1995a), the professional development team trained all teachers in the use of

Thinking Maps. This was supposed to create a school wide use of eight specific graphic organizers, allowing students to become comfortable with the form and become used to using higher order thinking processes. While the Thinking Maps program has specific examples of success in Hyerle's papers (1995a, 2000), such as increased test scores and writing scores, these successes are all documented in elementary education and do not address the idea of increased higher order thinking skills. There is no documentation of success at the secondary level and there is not a specific correlation presented linking Thinking Maps and higher order thinking skills.

It is important to teach students how to think and use higher order thinking skills, such as analysis, evaluation, and synthesis. In order to use higher order thinking skills, students and teachers need to have a good understanding of metacognition and constructivism. Graphic organizers and concept maps can help students develop metacogntive skills and help teachers facilitate learning using constructivism. A problem with the implementation of graphic organizers and concept maps is that they require students to become familiar with a specific form or different forms for the same thinking process in different classes. Students become focused on the form instead of the ideas they are presenting and do not demonstrate as much higher order thinking. Thinking Maps are a specific program of eight graphic organizers that have been developed from the research of Upton and Samson that claim to promote higher order thinking skills, as do other concept maps and graphic organizers, and solve the problem of form and continuity by creating an interdisciplinary, constructivist model for graphic organizers.

Chapter 3 Methodology

Participants

Students are enrolled in Advanced Placement Environmental Science at WW High School. 70 students, ages 16-18 participated in this study. These students were separated into two class periods. One period contained 16 boys and 19 girls. The other period contained 12 boys and 22 girls. One student is involved in independent study and meets with the instructor every other day. The classes have a mixture of ethnicities, with a majority of Asian and Caucasian students, followed by lesser minorities of Hispanic, and African American. The racial breakdown of the school as a whole is 58% Caucasian, 21% Hispanic, 12% Asian, 5% Filipino, 3% African American, 0.04% American Indian, and 0.02% Pacific Islander. Many of these students are enrolled in multiple Advanced Placement courses, while for some students, this is their first Advanced Placement course.

WW High School had been opened for four years. The first graduating class of WW was in 2008. 48 of the students that participated in this study were seniors. These students had never had any upperclassmen and were relied upon by staff and other students to take leadership roles from the time of their entry in to high school as ninth graders. As a result, this group of students had a higher level of leadership skills and expertise that other classes of students may not have.

Classes were on a block schedule, meeting 95 minutes every other day. Students met with the instructor two or three times a week. Both classes studied met during the first 95-minute block of the day, between 8:30 and 10:05. WW High School is located in a newer, upper middle class community. The school has a wide variety of socioeconomic

classes, from very poor students to very affluent students. The majority of our students are middle class to upper middle class. WW is in a suburban neighborhood in the Los Angeles metropolitan area.

Materials

Advanced Placement Environmental Science

Advanced Placement Environmental Science is a course that has a strict curriculum that is provided by the College Board (see appendix B). The course syllabus was approved by the College Board during the spring 2007 audit. The instructor used sample essay questions and previous questions that were released by the College Board.

Thinking Maps

Thinking Maps are a series of eight specific graphic organizers that illustrate eight specific thinking processes (see appendix A). These graphic organizers were created by an educational consultant and publishing company (Hyerle, Suddreth & Suddreth, 2004). The specific maps are the circle map, which defines in context, a bubble map which describes an event or action, a double bubble map, which compares and contrasts two ideas, a tree map, which classifies and categorizes ideas, a brace map, which shows part to whole relationships, a bridge map, which provides analogies and comparisons of ideas, a flow map, which shows the steps in a process, and a multi-flow map, which shows a cause and effect relationship (Hyerle, 2000).

In 2007, WW High School implemented a professional development program for its teachers on school wide Thinking Maps. All teachers were instructed in Thinking Maps using the Thinking Maps curriculum implementation. Many teachers began to use

Thinking Maps in their daily practice and students were exposed to them in multiple classrooms.

Collection Tools

An initial survey was given to participants evaluating their preparation for essay questions and their use of Thinking Maps (appendix C). A rating scale was used to determine students' evaluation of their own performance on essays and study habits. Then, a free response section was added and coded to allow students to elaborate on their study habits. This survey was given at the end of the study as well. 59 initial student surveys and 56 final student surveys were used in the findings.

Student essays were used to evaluate reasoning skills and students ability to compare and contrast. Two different essay prompts were evaluated (appendix D).

Field notes were analyzed after Thinking Map instruction for student responses and attitudes (appendix E).

Procedures

This study lasted approximately one month. The instructor collected data beginning five weeks into the second semester until nine weeks into the second semester. The instructor assigned and collected in class essays from both class periods. Students were asked to compare and contrast, a higher order thinking skill in the analysis category, in both essays. Students were given the prompt for essay 1 two days before the exam and the answers were discussed in class (see appendix D). Students were given a survey after they completed their essay, self-evaluating their study habits and enjoyment of Thinking Maps (appendix C). The next class period, students were given study guide questions that required them to create Thinking Maps (appendix F). Tree maps, double bubble

maps, flow maps, and multi-flow maps were explicitly taught to students. Field notes were taken after this lesson for both class periods. Two class periods later, the first 5 questions were reviewed in class. The instructor created each Thinking Map on the board with student input, showing and discussing the thinking process. The instructor focused on the compare and contrast and classification processes. Field notes for these class periods were taken. Two class periods later, the second five questions were reviewed in class. The instructor created each Thinking Map on the board with student input, showing and discussing the thinking process. The instructor focused on the compare and contrast, classification, and the cause and effect thinking processes. Field notes for these class periods were taken. Students were given the prompt for essay 2 that asked them to compare and contrast in a very similar way that the study guide questions asked them to. Students were given time in class to create a double bubble map for their essay. Field notes were taken. Two class periods later, students wrote in class essays. The essays were evaluated and coded for students' ability to compare and contrast correctly. After students completed their essays, they completed the same survey that self-evaluated their study habits and essay writing skills.

Analysis

Surveys were separated into quantitative and qualitative sections. Quantitative ratings scales were averaged and the before Thinking Maps instruction survey were compared to the after Thinking Maps instruction survey. A T-test was conducted under the assumption that no change had occurred. The lower the p-value, the more likely that changes were due to the methods used in the study, rather than chance. Free response survey questions were coded by students like, indifference, or dislike of Thinking Maps

and translated into quantitative data. Quantitative data was analyzed using a T-test, a statistical analysis that works by assuming no change had occurred. If p-value's of less than 5%, or 0.05 are found, then there is a less than 5% chance that the changes in data are due to chance. This means that the changes in data can be considered statistically relevant. Samples of free responses were placed in the findings. Essays were coded and comparisons of students' higher order thinking skills were made between before and after Thinking Map instruction. The coded essays were analyzed using a T-test. Raw essay scores were also compared and analyzed using a T-test. Samples from essays were placed in the text. Field notes were evaluated using inductive analysis.

Chapter 4 Findings

In order to look at the effects of Thinking Maps on students' higher order thinking skills, different collection tools were used. Student essay scores were analyzed and essays (appendix D) were coded to show students ability to compare and contrast, a higher order thinking skill. Students were given a pre-Thinking Maps instruction survey and a post-Thinking Maps instruction survey. This survey asked students to rate comments on a likert scale and had free response sections (see appendix C). In addition, field notes of class instruction were recorded and used to corroborate analysis of data (appendix E).

Table 1. Student results of first and second essay exam

Student Score	Number of students who had **no** comparing and contrasting		Number of students with 1-2 elements of comparing and contrasting		Number of students with more than 2 elements of comparing and contrasting	
	Essay 1	Essay 2	Essay 1	Essay 2	Essay 1	Essay 2
0	1	1	0	0	0	0
1	4	2	2	0	0	0
2	9	2	5	3	2	3
3	3	0	4	3	12	6
4	2	0	3	1	23	45
Total	19	5	15	7	37	54

Essay 1: n = 70
Essay 2: n = 66*

*Essay 2 has an n of 66 because several students have not made up the exam at this point.

Students' essay scores were compared before and after Thinking Maps instruction was given. Essay one was given before students received specific instruction in Thinking Maps. Essay two was give after students had received specific instruction in Thinking Maps, including double bubble maps, multi-flow maps, tree maps, and flow maps (see appendix A).

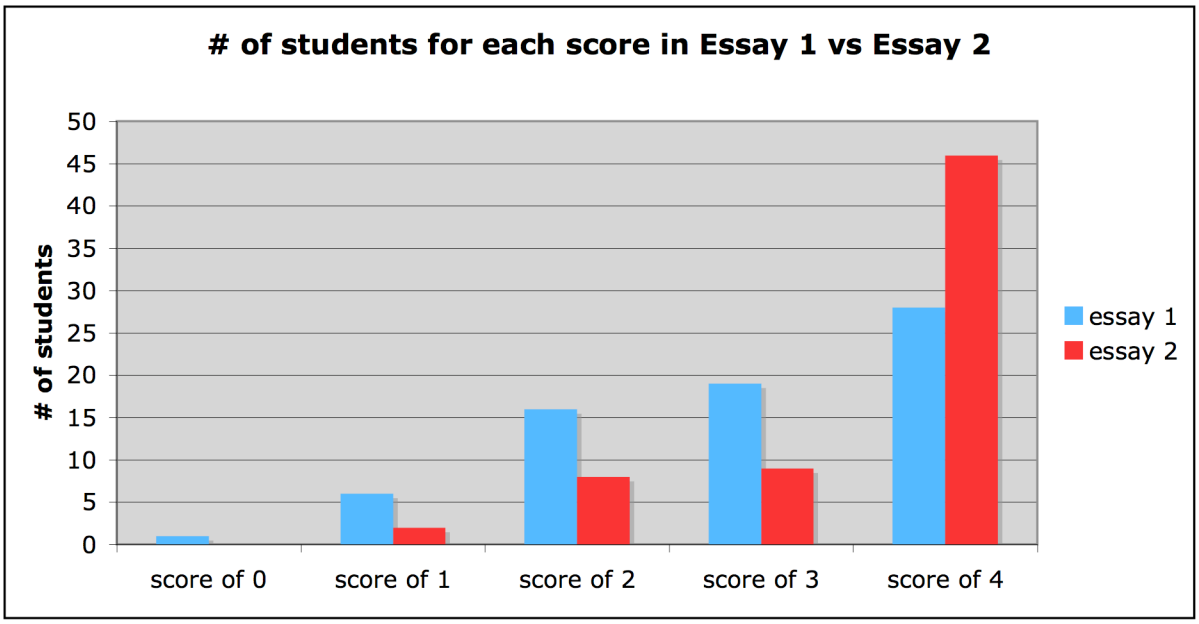

Chart 1: Student scores on essay 1 vs essay 2

In the pre-Thinking Maps instruction essay, students were asked to give to benefits and two problems with solar panels in comparison to using natural gas (see appendix E). Four points were possible. Students could have earned three or four points by providing benefits and problems with solar panels without comparing natural gas. However, the majority of students who earned three or four points were able to compare solar panels to natural gas. 19 students out of 70 students did not compare the two energy sources in their essay (see Table 1). 14 students out of 19 of these students earned two points or less on this portion of the essay; this amounts to a failing grade. 36 out of 70 students did show ability to compare the two energy sources. 34 out of 36 students who could compare in written form earned three or four points; this amounts to a passing grade. 15 students showed some ability to compare one or two elements within the two energy sources, but had difficulty translating their comparison to essay form. These students had an assortment of scores between one and four (see Chart 1).

In the post-Thinking Maps instruction essay, students were asked to give two sources of air pollution in developing countries that are not present at the same extent in developed countries (see appendix E). Then, students had to provide two explanations as to why it was more difficult to solve air pollution problems in developing nations than in developed nations. Students needed to be able to compare and contrast the sources of pollution and economic stability of developing nations with developed nations in order to answer the question. Before students answered this question, they had been asked to create a double bubble map where they compared and contrasted air pollution problems and their solutions of developed nations and developing nations. Both classes generated a double bubble map in class. Students had also created many other Thinking Maps in their notes and through their study guide questions.

5 out of 66 students did not compare and contrast developed nations with developing nations in their essay. These students earned less than two points, amounting to a failing grade. 7 out of 66 students were able to compare and contrast one element between developed nations and developing nations, but they were unable to show full understanding of the similarities and differences. These students earned between two and four points. 54 out of 66 students were able to compare and contrast more than one element between developed nations and developing nations. These students showed clear understanding of the question and of their answer and were able to fully translate their ideas into essay form. 3 of these students earned two points, amounting to a failing grade. 51 of these students earned three or four points, amounting to a passing grade. Overall, 28 students earned 100% of points possible on essay 1 and 46 students earned 100% of the points possible in essay 2 (see chart 1). This shows that 18 more students

earned full points on the essay after Thinking Maps instruction. 64% more students earned full points on the essay after Thinking Maps instruction. Overall, student essay scores increased by 14%. In comparing the essay scores using a T-test, the p value was found to be 0.00459.

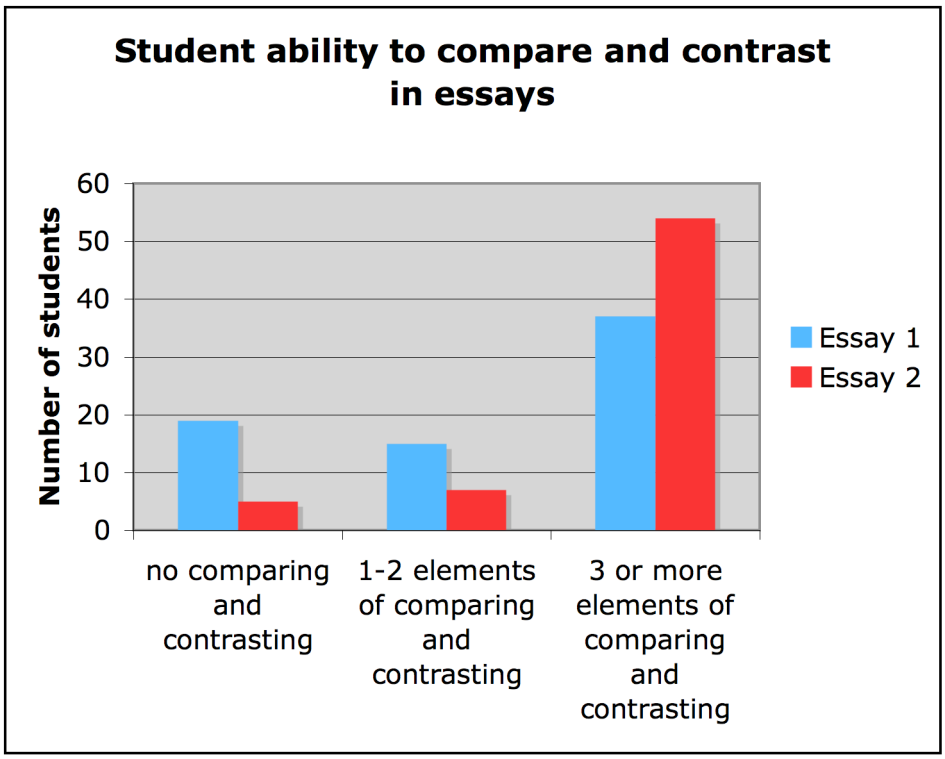

Chart 2: Changes in students' ability to compare and contrast in essays

The number of students who could not compare and contrast dropped from 19 to 5 (see Chart 2). The number of students who could only compare one or two elements dropped from 15 to 7. The number of students who were able to fully compare and contrast in their essays increased from 37 to 54. 45% more students were able to fully compare and contrast after Thinking Maps instruction. After completing a T-test on this data, the p value was found to be 0.00026.

Likert scale 1- never 2-rarely 3- sometimes 4- often 5- always

	Question	Pre-Thinking Map instruction Mean n=59	Post-Thinking Map instruction Mean n=56*	% change
1	I write essays well.	3.57	3.70	2.6%
2	I try to improve my essay writing abilities in APES.	3.15	3.32	3.4%
3	I m proud of the essays I write in APES.	3	3.20	4%
4	I spend time practicing writing my essays before a test.	2.79	2.82	0.6%
5	I review my notes before a test.	3.58	3.70	2.4%
6	I make an outline of the essay before a test.	2.68	2.88	4%
7	I like using graphic organizers in class	2.53	2.79	5.2%
8	Using graphic organizers helps me to organize my thoughts.	2.77	3.08	6.2%
9	Creating graphic organizers in class helps me to write my essays on the test.	2.8	3.07	5.4%
10	When I review my notes at home, I do well on my essays.	3.38	3.52	2.8%
11	I have made a graphic organizer at home to review for an essay.	1.95	2.2	5%
12	I plan on creating a graphic organizer at home to review for an essay.	2.17	2.41	4.8%
13	When we use a thinking map to explain a concept in class, I understand that concept better.	3.03	3.09	1.2%
14	I think using graphic organizers could help me prepare my essays.	3	2.89	-2.2%

Table 2. Likert survey results. Pre-Thinking Maps instruction vs. Post-Thinking Map instruction.
*different n values are a result of absent students.

Students were given a survey before Thinking Maps instruction, or a pre-survey, and a survey after direct instruction in Thinking Maps, or a post-survey. Students scored their answers on a likert scale from 1 to 5, 1 representing never and 5 representing always. In comparing the results of the pre-Thinking Map instruction results with the post Thinking Map instruction results, the mean average for all but one of the questions increased. Question 8, 'using graphic organizers helps me to organize my thoughts', had an increase of 0.31, or a 6% increase in students belief that graphic organizers can help

them organize their thoughts. Likewise, there was a 6% increase in students' belief that graphic organizers created in class can help them write their essays. There is a 5% increase in students who have actually created a graphic organizer at home to review for an essay. However, there was a 1% increase in students who felt that using Thinking Maps in class helped them understand concepts better. There was a decrease by 2.2% in students who said that they would use a graphic organizer to help them prepare for an essay. This was the only statistic where the mean average decreased. After running a t-test, every change in measured had a p-value greater than 0.074. The p-value for question 8, an increase of 6%, was 0.074 (See Table 2).

In the pre-survey, 6 out of 59 students, felt that they always wrote essays well or that they were always proud of the essays they write in Advanced Placement Environmental Science (see Chart 3). In the pre-survey, 9 out of 59 students often or always enjoyed using Graphic organizers in class and felt that Thinking Maps helped them understand the concept better. In the pre-survey, 19 out of 59 students thought that using graphic organizers could help them prepare their essays often or always. In the post-survey, 5 out of 56 students felt that they always wrote essays well or that they were always proud of the essays they write in Advanced Placement Environmental Science. In the post survey, 13 out of 56 students often or always enjoyed using Graphic organizers in class and felt that Thinking Maps helped them understand the concept better. In the post-survey, 14 out of 56 students thought that using graphic organizers could help them prepare their essays often or always.

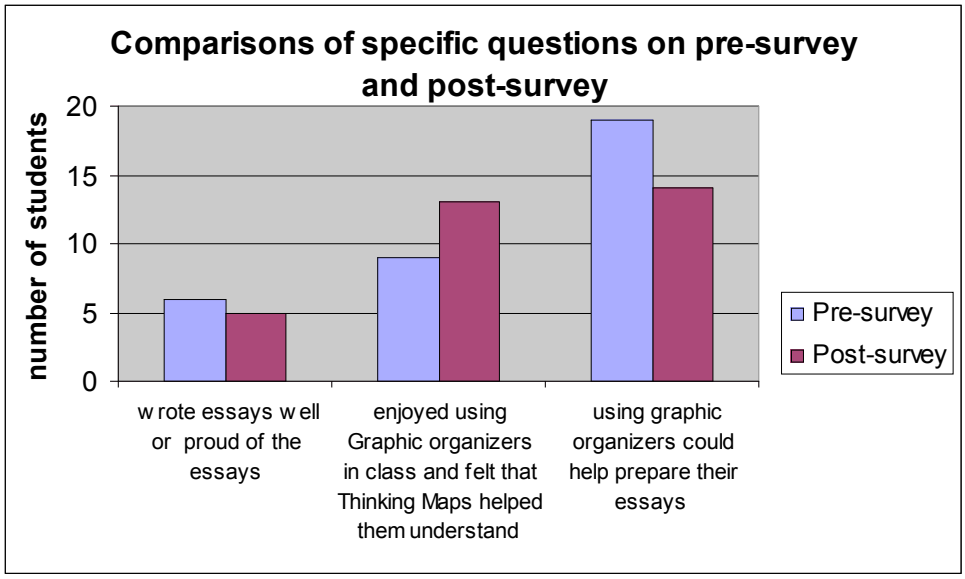

Chart 3: Comparisons of specific questions on student survey

In the post Thinking Maps instruction survey, four of five students who believed they always write essays well stated that they rarely or never create a graphic organizer at home and felt that they rarely or never helped them prepare for essays. However, 3 out of 5 of these students felt that Thinking Maps helped them understand a concept better. One student believed they rarely wrote essays well and felt that using graphic organizers and Thinking maps would often help his essays and understanding of concepts. All other students believed they wrote essays well sometimes or often. Those students' beliefs varied between one and five when asked about their use of Thinking Maps.

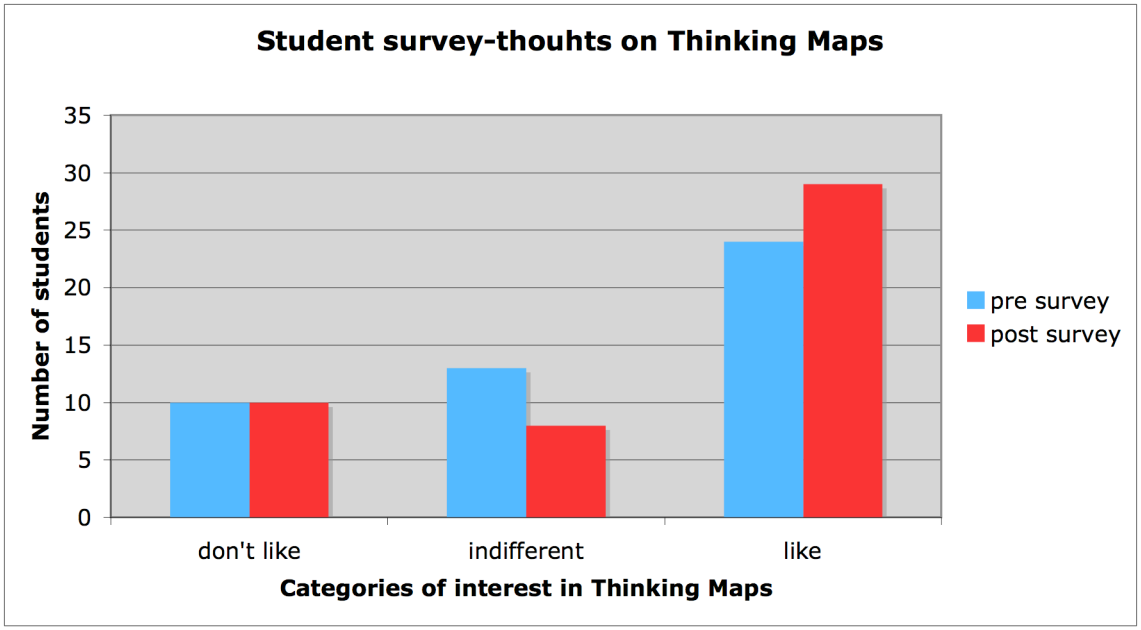

Chart 4: student survey-free response thoughts on Thinking Maps

The number of students who did not like using thinking maps in class remained the same after Thinking Maps instruction (refer to Chart 4). Some students were very adamant in their criticisms. One student remarked "requiring the use of 'Thinking Maps' as part of classroom notes or homework to prepare for a test is useless." However, that same student also went on to say "while the occasional flow chart may be useful, using 'Thinking Maps' as busy work doesn't help me learn at all. . . the use of either a class discussion or debate to reveal cause and effect relationships or compare two things would be far more compelling and educational." According to his responses on their survey, this was a student who believed he always wrote essays well, but never reviewed his notes before an exam nor does he practice writing his essays.

Before instruction in Thinking Maps one student wrote "for some subjects, Thinking Maps can help, but for others, they would probably make it more difficult to understand." Another student wrote that "Graphic organizers are the most helpful when

comparing and contrasting, especially for essay writing. Otherwise, I do not get much out of graphic organizers." These comments were labeled indifferent when they were coded. These students both thought they often wrote essays well and the both thought that Thinking Maps often helped them understand concepts better in class.

In the before survey, there were students who stated that "they liked Thinking Maps," but few if any students who gave clear examples of what they liked about thinking maps or when they enjoyed using them in class. Several students wrote "what is a Thinking Map?" as their comment and those were coded as indifferent.

In the post Thinking Map instruction survey, there were 10 students who did not enjoy using Thinking Maps. Some used strong language such as "hate," or "waste of time," without being clear about why they felt this way. One student wrote "Thinking Maps are useless because they do not go into any depth on the subject." Another student wrote "they are often not detailed enough."

Students who were categorized as indifferent had more specific information about thinking maps in their comments in the post surveys. For example, "Thinking Maps help me sometimes to better understand the material, but I don't feel like they help more than regular notes." Another student remarked, "Sometimes they help to condense large, complicated concepts, but otherwise I don't see them being more helpful than taking notes." Students who were categorized as indifferent to Thinking Maps believed they often or always wrote essays well.

Students who were categorized as liking Thinking Maps were able to vocalize their opinions much better. One student noted, "graphic organizers are beneficial during class to explain relationships in the material. They help students organize their thoughts

in a more productive way than simply reading the text and taking traditional notes." Another student stated, "They help to compare and contrast different ideas but, for me, they are sometimes a hassle to draw." Other student's remarked "I think visual learning in this manner is helpful and understandable," and "I like graphic organizers or Thinking Maps as a means of organizing thoughts and connecting concepts." Students quoted as liking Thinking Maps believed that they sometimes or often wrote essays well.

From instructor field notes taken during class instruction, it was noted that many students responded favorably to Thinking Maps. Student work was easier to analyze when student study guide questions were in a Thinking Maps format (appendix F) instead of traditional paragraph responses. It was also easier to recognize student comprehension, or lack of student understanding when students answered their study guide questions using Thinking Maps (appendix F). Students with more shapes and writing in those shapes showed a more detailed understanding of ideas, then students with fewer shapes, or less writing. It was much easier to check student work when using the Thinking Maps format. Students who had difficulty understanding, based on their Thinking Maps, were targeted and asked to discuss their maps in class. Those students were able to participate in class more often after the instructor noticed their lack of understanding. This could help those students clarify their misconceptions and increase their understanding.

In order to look at the effects of Thinking Maps on students' higher order thinking skills, different collection tools were used. Students were given a pre-Thinking Maps instruction survey and a post-Thinking Maps instruction survey. This survey asked students to rate comments on a likert scale and had free response sections (see appendix C). All but one question showed an increase in student perceived benefit. Student essay

scores were analyzed and essays were coded to show students ability to compare and contrast, a higher order thinking skill. Student essays scores improved after Thinking Maps instruction and students' ability to compare and contrast increased 45%. In addition, field notes of class instruction were recorded and used to corroborate analysis of data.

Chapter 5 Discussion

Overview of the Study

The purpose of this study was to discover the effects of Thinking Maps on student higher order thinking skills. Thinking Maps are a group of graphic organizers that are interdisciplinary and were developed by David Hyerle. Thinking Maps claim to be a tool to make students thinking visible and help organize students' thoughts. Other than general research on graphic organizers and specific case studies presented by the authors, no peer reviewed research on Thinking Maps has been completed. Over the course of the study, two Advanced Placement Environmental Science classes composed of 70 junior and seniors were instructed in the use of Thinking Maps. Students were directly instructed in five of the eight Thinking Maps. Students created maps in class, during lecture, and at home, for review questions. Students were asked to compare and contrast in two essays, one given before Thinking Maps instruction and one given after Thinking Maps instruction. For both essays, students had the prompt two days prior to writing the essay in class. Students were given a pre-survey and a post-survey on Thinking Maps after the first essay and after the second essay. Essay results, along with student surveys and field notes comprise the findings in this research.

Summary of Findings

This study found that students' ability to compare and contrast in essay writing increased by 45% after instruction with Thinking Maps. This change had a p-value of 0.00026. In general, students enjoyed using Thinking Maps in class after direct instruction and application to their essay questions. Several students, who felt that they were already doing what the course asked of them, did not enjoy Thinking Maps and felt

that they were pointless. Field notes confirmed students' satisfaction with Thinking Maps. The instructor also found that it was easier to see if students understood the details of a topic by the quantity of information presented in their Thinking Maps. Field notes indicated that that instructor could target students who did not understand the topic during discussion, in order to improve their understanding.

Conclusions

This study found that 45 % more students were able to fully compare and contrast in an essay after instruction in Thinking Maps. The p-value for this statistic is 0.00026. This shows that there is a 0.02% chance that this increase was random. This means that the increase is statistically relevant and that is data increase was not random, but a result a change in conditions. The change in the class was student's use of Thinking Maps. These results show that Thinking Maps can help students increase their higher order thinking skills. Students were able to relate one idea to another with a double bubble map, used in comparing and contrasting. Instead of using class discussion and lists, double bubble maps helped students to organize their comparisons and showed the relationships between ideas.

Students' average scores on essay exams improved by 16%. Not only were students able to compare and contrast, they were also able to answer with the best and most appropriate answers after Thinking Maps instruction. The change in exam scores had a p-value of 0.00459. This means that there is a 0.4% chance that this change is the result of chance. This is statistically relevant and shows that the change in student test scores was not due to chance. This shows that students' higher order thinking skills increased overall. Students were able to remember more of the correct answers when

they were put into a Thinking Maps format then when answers were discussed or written in lists. Improved scores overall shows that more thinking was taking place.

Student opinions on Thinking Maps overall, went up marginally, but increases can be accounted for by absent students. The largest increase of 6% can be accounted for by absent students. The p-values for the survey are all greater than 0.074. This means that all of the changes in survey results are not statistically significant. There was a 7% chance that the change was due to chance, and this means that it cannot be considered statistically relevant. Overall, students did not change their opinion of Thinking Maps after direct instruction. Students felt they didn't have to do as much work and still got something out of the questions.

Students who didn't like Thinking Maps were students who felt they were masters of writing and/or the subject. Several of these students stated, in instructor field notes, that they did not like Thinking Maps because they felt Thinking Maps didn't force them to make connections. These students tended to think, based on their survey comments, that Thinking Maps were juvenile or beneath them. This shows a correlation between the students who felt they always wrote essays well and the students who disliked Thinking Maps. Although this was a minority of the class, these students did not feel like anything was missing from the class and did not want to change the format of the class. Several of these students turned in exemplary Thinking Maps and showed true understanding of the subject. These students understood the underlying concepts before the use of Thinking Maps and couldn't realize that some people did not understand as well as they did.

Student who liked Thinking Maps felt that Thinking Maps helped them organize their thoughts and clarify ambiguous ideas. These students, in their free responses,

clearly described how Thinking Maps helped them in class. Students who felt they could improve their essay writing tended to like Thinking Maps more. They saw Thinking Maps as a tool for organization and thought they could help they organize their essays.

During classroom observations, the instructors' field notes corroborated other class data. Overall, Thinking Maps are an easy tool for a teacher to use to judge student understanding. A teacher can look at a map and see if the student understands the details of the idea or not. If there are a few one-word responses, that student isn't putting in effort and/or doesn't understand. The teacher can see this in a spot check of Thinking Maps around the classroom and then target those students during direct instruction to make sure they do understand in the future. Thinking Maps are also useful for instructors because they can fill a variety of roles. Thinking Maps are a visual organizational tool that help students' use higher order thinking skills.

The implications of this study are on the claims that Thinking Maps make. According to the results of this study, using Thinking Maps as part of direct instruction and student generated instruction (class created maps) can increase some students' higher order thinking skills. Thinking Maps do not work for all students. There are some students who will be resistant to them, just as there are students who are resistant to all types of instruction. Thinking Maps cannot replace all forms of direct instruction, such as lecture and discussion. However, for the purposes of this study, they clearly showed that by using them to organize students' thoughts, they can help students translate their ideas into essay format.

Recommendations

The results of this study show that Thinking Maps can increase students' higher order thinking skills. In particular, this study focused on the use of a double bubble map and increasing students' ability to compare and contrast. The research indicates that double bubble maps can increase students' ability to compare and contrast and organize information. The researcher recommends that double bubble maps be used in the classroom to help students compare and contrast ideas. Proper implementation of Thinking Maps is necessary for educators to use them in the classroom. Students must be taught how and when to use specific Thinking Maps and must correlate the thinking process with the Thinking Map. More details can be seen in appendix 1. The researcher also recommends the use of other Thinking Maps in the classroom as a tool to help students' organize their thoughts, teach new information, or re-teach and review content. However, the researcher does not recommend replacing other learning techniques with Thinking Maps. Thinking Maps are used to supplement lecture, notes, and other methods of direct or group instruction. Thinking Maps can be incorporated into many projects, including jigsaws, student presentations, and foldables. Thinking Maps can show a higher level of thinking than lists and descriptions. If used correctly, Thinking Maps can indicate student understanding of relationships between ideas.

Limitations of the Study

This study has many limitations. First, it only looked at students' performance on one type of higher order thinking: comparing and contrasting. Based on this research, conclusions cannot be legitimately made about the other seven types of Thinking Maps. The other Thinking Maps were taught and required of students, however, their ability to increase students' thinking skills was not analyzed.

This study only focused on Advanced Placement students who may have already had higher thinking skills. The sample size of this study is only 70 students. This is a fairly small sample and cannot be used to make any large conclusions about Thinking Maps.

Another limitation of this study was the fact that many Thinking Maps were discussed and even recreated in class before the exam. While in both instances the essay prompts were provided to students before the exam date, the essay question answer was not discussed in as much detail. In both essays, answers were discussed, but for the second essay, some of the answer was also constructed into a double bubble map. In the first essay, the answers were discussed and written in lists or bullets. Because of the nature of Thinking Maps, the answer was discussed in more detail for essay two than for essay one. This could have influenced the overall scores for essay two. However, the researcher does not believe that there was a significant interference with the integrity of the study.

Students had some background knowledge of Thinking Maps before the study began. Many students knew how to construct maps and what the maps were for, although most had not applied them to science before.

In order to come to more concrete conclusions, the researcher feels that more studies should be done in a similar manner by investigating students' abilities to use the thinking skills described by specific Thinking Maps. Students can be evaluated in written form as well as orally. This may show that Thinking Maps clearly correlate to their desired function. This study has too small of a sample size, a biased population, and too short of a study to draw any measurable conclusions.

In this study, the researcher found that after using a double bubble Thinking Map to teach students how to compare and contrast, student's ability to compare and contrast increased by 45%. This result is significant and shows a clear increase in students' ability to use the higher order thinking skill of comparing and contrasting. This study is limited by its sample size, type of population, and short time frame. More research is needed to show clear correlations between Thinking Maps and higher order thinking skills. However, this study provides an indication of correlation.

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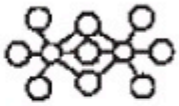
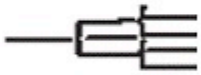
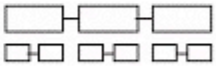
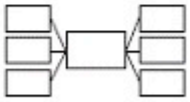
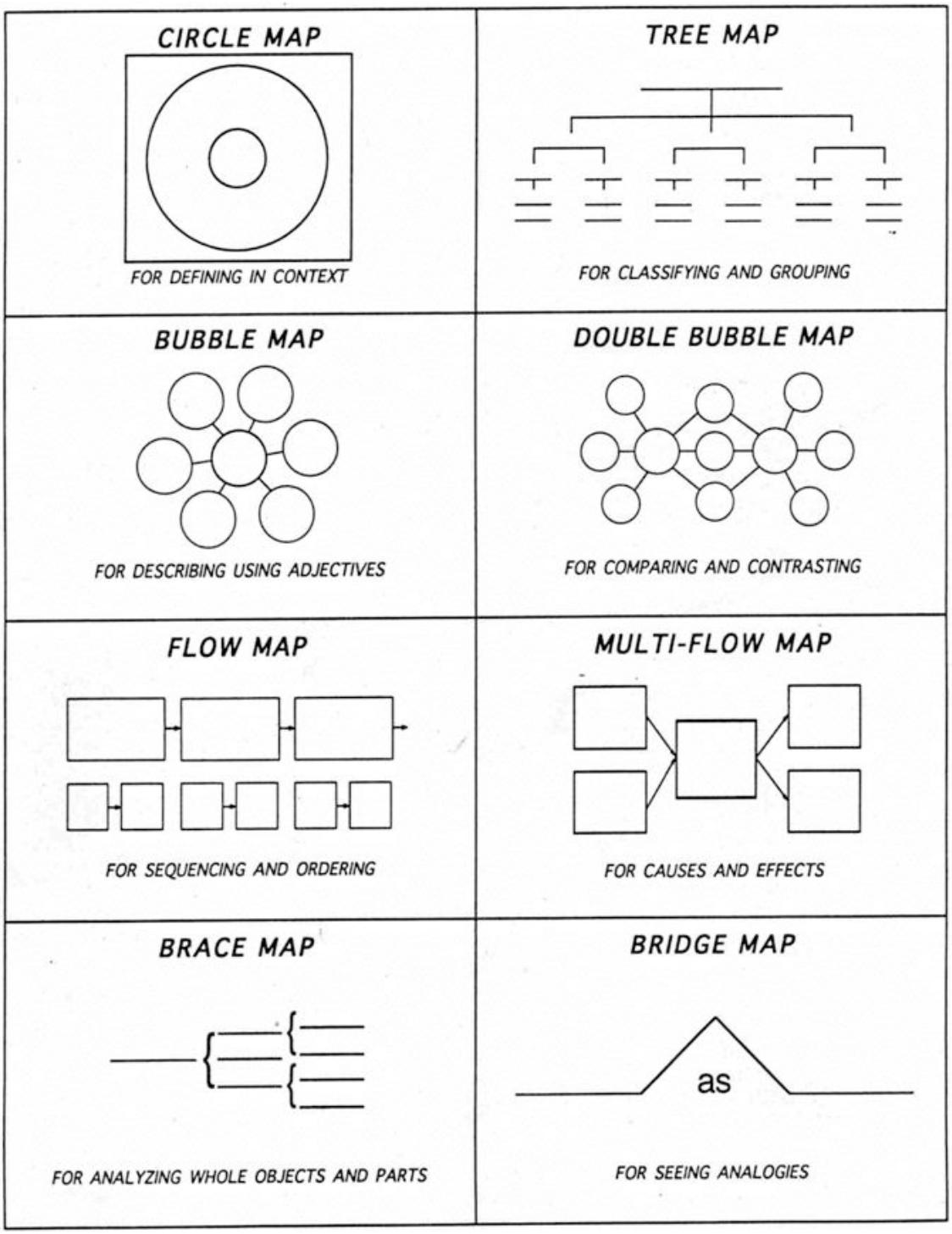
Appendix A

Eight types of Thinking Maps

Quick-Reference Content Correlation to Eight Thinking Maps for Communication Skills

Circle Map	• Representing and brainstorming ideas • Defining words by showing context clues • Identifying audience and author's point of view	
Bubble Map	• Expanding descriptive vocabulary • Describing characters using adjectives • Providing descriptive details for writing	
Double Bubble Map	• Comparing and contrasting characters • Prioritizing essential characteristics • Organizing a compare-and-contrast essay	
Tree Map	• Identifying main idea, supporting ideas, details • Organizing topics and details for writing • Taking notes for lectures and research papers	
Brace Map	• Comprehending physical setting in stories • Analyzing physical objects from technical reading • Organizing and writing technical manuals	
Flow Map	• Sequencing story plot by stages and substages • Analyzing and prioritizing important events • Sequencing paragraphs for writing	
Multi-Flow Map	• Analyzing causes-effects in literature • Predicting outcomes from previous events • Organizing "if-then" persuasive writing	
Bridge Map	• Comprehending analogies, similes, and metaphors • Preparing for testing using analogies • Developing guiding analogies for writing	

Source: Hyerle, D. (1995). *Thinking maps: Tools for learning* (Section 3, p. 4). Raleigh, NC: Innovative Sciences, Inc. Copyright © 1995 by Innovative Learning Group. All rights reserved. Used with permission.


CIRCLE MAP
FOR DEFINING IN CONTEXT
TREE MAP
FOR CLASSIFYING AND GROUPING
BUBBLE MAP
FOR DESCRIBING USING ADJECTIVES
DOUBLE BUBBLE MAP
FOR COMPARING AND CONTRASTING
FLOW MAP
FOR SEQUENCING AND ORDERING
MULTI-FLOW MAP
FOR CAUSES AND EFFECTS
BRACE MAP
FOR ANALYZING WHOLE OBJECTS AND PARTS
BRIDGE MAP
as
FOR SEEING ANALOGIES

Appendix B

The Official College Board APES Course Outline

Earth Systems and Resources
(10–15%)

- Earth Science Concepts
  (Geologic time scale; plate tectonics, earthquakes, volcanism; seasons; solar intensity and latitude)
- The Atmosphere
  (Composition; structure; weather and climate; atmospheric circulation and the Coriolis Effect; atmosphere–ocean interactions; ENSO)
- Global Water Resources and Use
  (Freshwater/saltwater; ocean circulation; agricultural, industrial, and domestic use; surface and groundwater issues; global problems; conservation)
- Soil and Soil Dynamics
  (Rock cycle; formation; composition; physical and chemical properties; main soil types; erosion and other soil problems; soil conservation)

The Living World
(10–15%)

- Ecosystem Structure
  (Biological populations and communities; ecological niches; inter- interactions among species; keystone species; species diversity and actions edge effects; major terrestrial and aquatic biomes)
- Energy Flow
  (Photosynthesis and cellular respiration; food webs and trophic levels; ecological pyramids)
- Ecosystem Diversity
  (Biodiversity; natural selection; evolution; ecosystem services)
- Natural Ecosystem Change
  (Climate shifts; species movement; ecological succession)
- Natural Biogeochemical Cycles
  (Carbon, nitrogen, phosphorus, sulfur, water, conservation of matter)

Population
(10–15%)

- Population Biology Concepts
  (Population ecology; carrying capacity; reproductive strategies; survivorship)
- Human Population
  Human population dynamics
  (Historical population sizes; distribution; fertility rates; growth rates and doubling times; demographic transition; age-structure diagrams)
- Population size
  (Strategies for sustainability; case studies; national policies)
- Impacts of population growth
  (Hunger; disease; economic effects; resource use; habitat destruction)

Land and Water Use
(10–15%)

- Agriculture
  - Feeding a growing population
    (Human nutritional requirements; types of agriculture; Green Revolution; genetic engineering and crop production; deforestation; irrigation; sustainable agriculture)
  - Controlling pests
    (Types of pesticides; costs and benefits of pesticide use; integrated pest management; relevant laws)
  - Forestry
    (Tree plantations; old growth forests; forest fires; forest management; national forests)
- Rangelands
  (Overgrazing; deforestation; desertification; rangeland management; federal rangelands)
- Other Land Use
  - Urban land development
    (Planned development; suburban sprawl; urbanization)
  - Transportation infrastructure
    (Federal highway system; canals and channels; roadless areas; ecosystem impacts)
  - Public and federal lands
    (Management; wilderness areas; national parks; wildlife refuges; forests; wetlands)
  - Land conservation options
    (Preservation; remediation; mitigation; restoration)
  - Sustainable land-use strategies
- Mining
  (Mineral formation; extraction; global reserves; relevant laws and treaties)
- Fishing
  (Fishing techniques; overfishing; aquaculture; relevant laws and treaties)
- Global Economics
  (Globalization; World Bank; Tragedy of the Commons; relevant laws and treaties)

Energy Resources and Consumption
(10–15%)

- Energy Concepts
  (Energy forms; power; units; conversions; Laws of Thermodynamics)
- Energy Consumption

  - History
    (Industrial Revolution; exponential growth; energy crisis)
  - Present global energy use
  - Future energy needs
- Fossil Fuel Resources and Use
  (Formation of coal, oil, and natural gas; extraction/purification methods; world reserves and global demand; synfuels; environmental advantages/disadvantages of sources)
- Nuclear Energy
  (Nuclear fission process; nuclear fuel; electricity production; nuclear reactor types; environmental advantages/disadvantages; safety issues; radiation and human health; radioactive wastes; nuclear fusion)
- Hydroelectric Power
  (Dams; flood control; salmon; silting; other impacts)
- Energy Conservation
  (Energy efficiency; CAFE standards; hybrid electric vehicles; mass transit)
- Renewable Energy
  (Solar energy; solar electricity; hydrogen fuel cells; biomass; wind energy; small-scale hydroelectric; ocean waves and tidal energy; geothermal; environmental advantages/disadvantages)

Pollution
(25–30%)

- Pollution Types
  - Air pollution
    (Sources—primary and secondary; major air pollutants; measurement units; smog; acid deposition—causes and effects; heat islands and temperature inversions; indoor air pollution; remediation and reduction strategies; Clean Air Act and other relevant laws)
  - Noise pollution
    (Sources; effects; control measures)
  - Water pollution
    (Types; sources, causes, and effects; cultural eutrophication; groundwater pollution; maintaining water quality; water purification; sewage treatment/septic systems; Clean Water Act and other relevant laws)
  - Solid waste
    (Types; disposal; reduction)
- Impacts on the Environment and Human Health
  - Hazards to human health
    (Environmental risk analysis; acute and chronic effects; dose-response relationships; air pollutants; smoking and other risks)
  - Hazardous chemicals in the environment
    (Types of hazardous waste; treatment/disposal of hazardous waste; cleanup of contaminated sites; biomagnification; relevant laws)
- Economic Impacts
  (Cost-benefit analysis; externalities; marginal costs; sustain- sustainability)

Global Change
(10–15%)

- Stratospheric Ozone
  (Formation of stratospheric ozone; ultraviolet radiation; causes of ozone depletion; effects of ozone depletion; strategies for reducing ozone depletion; relevant laws and treaties)
- Global Warming
  (Greenhouse gases and the greenhouse effect; impacts and consequences of global warming; reducing climate change; relevant laws and treaties)
- Loss of Biodiversity
  - Habitat loss; overuse; pollution; introduced species; endangered and extinct species
  - Maintenance through conservation
  - Relevant laws and treaties