THE COMPARATIVE EFFECT OF INDIVIDUALLY- GENERATED VS. COLLABORATIVELY- GENERATED COMPUTER-BASED CONCEPT MAPPING ON SCIENCE CONCEPT LEARNING

A Dissertation

by

SO YOUNG KWON

Submitted to the Office of Graduate Studies of
Texas A&M University
in partial fulfillment of the requirements for the degree of

DOCTOR OF PHILOSOPHY

May 2006

Major Subject: Educational Psychology

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Approved by:

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ABSTRACT

The Comparative Effect of Individually-generated vs. Collaboratively-generated
Computer-Based Concept Maps on Science Concept Learning. (May 2006)

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Using a quasi-experimental design, the researcher investigated the comparative effects of individually-generated and collaboratively-generated computer-based concept mapping on middle school science concept learning. Qualitative data were analyzed to explain quantitative findings.

One hundred sixty-one students (74 boys and 87 girls) in eight, seventh grade science classes at a middle school in Southeast Texas completed the entire study. Using prior science performance scores to assure equivalence of student achievement across groups, the researcher assigned the teacher's classes to one of the three experimental groups. The independent variable, group, consisted of three levels: 40 students in a control group, 59 students trained to individually generate concept maps on computers, and 62 students trained to collaboratively generate concept maps on computers. The dependent variables were science concept learning as demonstrated by comprehension test scores, and quality of concept maps created by students in experimental groups as demonstrated by rubric scores.

Students in the experimental groups received concept mapping training and used their newly acquired concept mapping skills to individually or collaboratively construct computer-based concept maps during study time. The control group, the individually-generated concept mapping group, and the collaboratively-generated concept mapping group had equivalent learning experiences for 50 minutes during five days, excepting that students in a control group worked independently without concept mapping activities, students in the individual group worked individually to construct concept maps, and students in the collaborative group worked collaboratively to construct concept maps during their study time.

Both collaboratively and individually generated computer-based concept mapping had a positive effect on seventh grade middle school science concept learning but neither strategy was more effective than the other. However, the students who collaboratively generated concept maps created significantly higher quality concept maps than those who individually generated concept maps. The researcher concluded that the concept mapping software, Inspiration™, fostered construction of students' concept maps individually or collaboratively for science learning and helped students capture their evolving creative ideas and organize them for meaningful learning. Students in both the individual and the collaborative concept mapping groups had positive attitudes toward concept mapping using Inspiration™ software.

DEDICATION

To my lovely and respectable husband,

KyoungHyun Kim,

To my precious treasure, my lovely son,

Ryan K. Kim,

To my parents,

Taek-Joon Kwon and Ok-Gi Kim,

who have been the most encouraging, most wonderful parents,

To my father- and mother-in-law,

Deok-Joong Kim and Deok-Ja Ko,

who have been the most supportive, most wonderful parents,

and

in loving memory of my grandmother,

Soon-Ja Park.

ACKNOWLEDGEMENTS

First of all, I would like to thank my mentor, Dr.Lauren Cifuentes, for giving me the opportunity to do meaningful research, and for her guidance throughout my graduate career. I also extend my sincere gratitude to the members of my dissertation committee, Dr. Ronald Zellner, Dr. James McNamara, and Dr. Caroline Pryor who have generously given their time and expertise to better my work. I thank them for their contribution and their good-natured support.

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CHAPTER I

INTRODUCTION

Instead of having well structured and integrated domain-specific knowledge structures, secondary school and college students' knowledge of science is frequently characterized by lack of coherence (Brandt, Elen, Hellenmans, Couwenberg, Volckaert, & Morisse, 2001). The surface learning approach, which is characterized by learning a task in isolation, negatively affects students' long-term and integrated understandings of science content and their ability to apply knowledge (Hazel & Prosser, 1994). This lack of integration and application is assumed to be at the basis of students' difficulties concerning new concept information and application of acquired knowledge from their previous learning. Consequently, students' science knowledge is a fragmented assemblage of disconnected facts and ideas. Relevant research (Nakhleh, 1992; Pendly, Bretz, & Novak, 1994) suggests that students might see different concepts as isolated elements of knowledge for the following reasons:

> the lack of uniformity of concepts and the multitude of notation systems in use; the highly fragmented and often very linear character of curricula in which insufficient attention is paid to concept definitions and their interrelationships and to relationships between concepts and phenomena; [and] limited attention in science education to opportunities for synthesis in which students are explicitly taught the links between different

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This dissertation follows the style and format of *the American Educational Research Journal*.

concepts and how to visualize the methods (as cited in Brandt, Elen, Hellenmans, Couwenberg, Volckaert, & Morisse, 2001, p. 1303-1304).

The existing research on visual displays or visual representations as adjunct aids to text has demonstrated that they facilitate both recall and comprehension (Gobert & Clement, 1999; Mayer, 1989; Mayer & Gallini, 1990). Conceptual understanding can also be facilitated by requiring students to build meaningful and appropriate mental representations and concrete, visual representations of concepts being taught (Gobert & Clement, 1999, p. 40).

Opportunities to visualize distinctive features and interrelationships among concepts enhance students' abilities to synthesize isolated facts to better understand scientific phenomena (Cifuentes & Hsieh, 2003a). According to Hyerle (1996), today's students require more support to be able to construct new knowledge that is not only interconnected but also interdependent. Making visual representations is a natural cognitive activity which facilitates active synthesis of concepts and phenomena (Ajose, 1999). Providing students with dynamic new "mind tools" (Jonassen, 1996a) enables them to build new theories of knowledge and create their own understanding.

According to Novak (1998), concept mapping is a process of organizing and representing concepts and their relationships in visual form. Concept mapping is one tool that can overtly engage students in meaningful learning processes. Further, concept mapping promotes meaningful learning and retention of knowledge for long periods of time and helps students negotiate meaning (Hyerle, 2000; Novak, 1990a, b). McKenzie (1998) said that graphic organizers such as concept maps or thinking maps allow students to convert complex and messy information into meaningful displays. A variety of research studies have demonstrated the positive value of using concept mapping in the science classroom (Boujaoude & Attieh, 2003; Boxtel, van der Linden, Roelofs, & Erkens, 2002; Fischer, Bruhn, Grasel, & Mandl, 2002; Madrazo & Jordi, 2002; Odom & Kelly, 2001; Okebukola & Jegede, 1988; Roth, 1994; Snead & Snead, 2004). Concept maps are a useful science education tool for engaging students' understanding (Jonassen, 1996a, b; 2000).

Studies by both Reader and Hammond (1994) and Hsieh and Cifuentes (2006) provided evidence that effective visualization and concept mapping can be supported by personal computers and computer software. Utilizing computer-based concept mapping, rather than paper based representations, enables students to more easily construct, modify, or maintain concept visualizations.

Statement of the Problem

There are many studies that provide evidence of the positive effects of collaborative learning in a face-to-face environment (Anderson-Inman & Ditson, 1999; Boxtel, van der Linden, Roelofs, & Erkens, 2002; Brown, 2003; Fischer, Bruhn, Grasel, & Mandl, 1999, 2002; Horton, MacConney, Gallo, Woods, Senn, & Hamelin, 1993; Madrazo & Jordi, 2002; Mereer, 2000; Roth, 1994; Stoyanova, 2000; Stoyanova & Kommers, 2001, 2002). However, little research has been conducted to compare the effect of individually generated computer-based concept mapping and collaboratively generated computer-based concept mapping on science conceptual learning. Brown (2003) found those students who collaboratively generated concept maps on paper outperformed students who individually generated concept maps on paper on a high school biology test. Although he found a positive effect of collaborative concept mapping on paper, test scores for students who individually generated concept maps were not higher than those for students who did not generate concept maps.

Thus far researchers have explored only the effect of student-generated concept mapping on computer or paper form, or they have investigated separately the effect of individually computer-based concept mapping or collaboratively computer-based concept mapping. Further research needs to explore comparative effects of individual-visualization and collaborative-visualization using a computerized concept-mapping tool. This comparative experiment provides evidence regarding the effectiveness of visualization for collaborative learning in middle school science.

The main assumption underlying this research is that computer-supported collaborative learning strategies enhance cognitive construction and that visualization and concept mapping are useful tools for mediating shared cognition and meaningful learning.

Purpose of the Study

The purpose of this study is to investigate the comparative effects of individually or collaboratively generated computer-based concept mapping on middle school science learning and quality of concept maps. The specific objective of this study is to provide middle school students with the opportunity to identify three types of expository text structures - categorical, sequential, and comparative-contrasting, and apply visual conventions to represent those structures.

Students in the experimental groups received concept-mapping training and used their newly acquired concept mapping skills to individually or collaboratively construct computer-based concept maps during study time. Both experimental groups (individual and collaborative) that created concept maps on computers while studying the science concepts attended three days of workshops on computer-based concept mapping of science concepts on computers in their computer laboratory before starting to study science concepts. The control group spent the same amount of time as the experimental groups watching a video, “Flying Away Home”, about a young girl who raises geese and helps them migrate.

The computer-based concept mapping workshop lasted 50 minutes each of three days. The workshop had the same content, materials, and processes for each experimental group except that the collaborative group was informed in the last five minutes of the last day of training that they would be concept mapping collaboratively the following day.

Assumptions

For the purpose of this study, the following assumptions will be made:

1. that participants provided honest answers on self-report surveys, and
2. that participants did not experience significant test anxiety that affected their performance on a comprehension test.

Significance of the Study

This present study is significant because it builds on previous research on the effect of the use of visualization during study time (Cifuentes & Hsieh, 2003a, 2003b) and the effect of using student constructed visualization using computers as a cognitive tool (Cifuentes & Hsieh, 2004; Hsieh & Cifuentes, 2006).

Visual representation facilitates both recall and comprehension (Cifuentes & Hsieh, 2003a, 2003b; Gobert & Clement, 1999; Hsieh & Cifuentes, 2006). In a study by Hsieh and Cifuentes (2006), students who constructed visualizations on computer out-performed those who constructed visualizations on paper during study time.

Concept mapping, a form of visual representation, can be supported by computer software (Fischer, Bruhn, Grasel, & Mandl, 2002; Hsieh & Cifuentes, 2006; Reader & Hammond, 1994;). The use of a computer-based concept mapping tool, Inspiration™ enables learners to interrelate the ideas that they are studying in multidimensional networks of concepts, and to label and describe the relationships between those concepts.

According to Fischer, Bruhn, Grasel, and Mandl, (2002) processes of collaborative knowledge construction can support learners' scientific knowledge construction more effectively than individual knowledge construction. Collaboratively-generated concept maps have power in supporting the process of meaningful knowledge construction. For this reason, a visual representation technique such as concept mapping is often integrated into collaborative learning activities (Okebukola & Jegede, 1988; Roth, 1994). Using concept maps allows learners to communicate representations of their cognitive structures with other learners (Novak & Gowin, 1984).

Studies have shown that concept mapping positively affects science concept learning. When students have computer skills, computer-generating concept maps can positively affect learning. Also, collaboratively generating concept maps on paper positively affects learning beyond individually generating concept maps.

Therefore, the next logical step in the body of research on visualization is to explore comparative effects of individually generating concept maps and collaboratively generating concept maps using a computerized concept-mapping tool. This study will inform classroom practice and application of concept-mapping for learning.

Definition of Terms

Concept map – "A schematic device for representing a set of concept meanings embedded in a framework of propositions" (Novak & Gowin, 1984, p. 15). In other words, a cognitive tool for organizing and representing a learner's knowledge structure visually.

Concept mapping – The process of developing a concept map (Heinze-Fry & Novak, 1990, p. 461).

Cognitive tools – Cognitive tools are both mental and computational devices that support, guide, and extend the thinking processes of learners (Derry, 1990). "Cognitive tools actively engage learners in creating knowledge that reflects their comprehension and conceptualization of information and ideas rather than absorbing predetermined presentations of objective knowledge" (Jonassen & Reeves, 1996, p. 697).

Collaborative learning – When learners work in groups on the same task simultaneously, thinking over demands together and tackling complexities (Dillenbourg, 1999). In this study, student pairs learn or attempt to learn science concepts together.

Comprehension – An ability to understand the meaning or importance of something or the knowledge acquired as a result. In this study, comprehension is measured by a multiple-choice test.

Graphic organizers – A pictorial or graphical way to organize information and thoughts for understanding, remembering, or writing. In other words, visual representations that organize information and thought in a manner that makes information easier to understand (Meyen, Vergason, & Whelan, 1996).

Individual learning – A learning process taking place in isolation but not necessarily without teacher direction and structured activities. In this study, an individual student learns or attempts to study science concepts without the help of other students.

Nodes – Concepts or propositions within a concept map.

Meaningful Learning – Anchoring new ideas or concepts with previously acquired knowledge in a nonarbitary way (Novak, 1977). Meaningful learning occurs when an individual assimilates or accommodates new information within an existing cognitive structure of an individual’s prior knowledge (Reese, 2004).

Metacognition - "one's knowledge concerning one's own cognitive processes" (Flavell, 1976) which influences the execution of cognitive tasks. Through metacognition, a person confronting a cognitive task can select a strategy and then monitor and regulate their progress on a task.

CHAPTER II

LITERATURE REVIEW

This study examines two strategies that are thought to help middle school students engage in a level of reflection necessary to achieve a more meaningful understanding of new concepts than does traditional note-taking. The two strategies to be investigated are individually generated computer-based concept mapping and collaboratively generated computer-based concept mapping. This chapter provides an elaboration of the definition of concept mapping provided in chapter I, a summary of literature and learning theories pertinent to concept mapping, and a summary of literature and theory pertinent to the specific topic of this study, the comparative effectiveness of individually and collaboratively generated concept maps on science concept learning. The chapter ends with research questions that are the next logical step in research on concept mapping.

Concept Mapping

Joseph Novak and his colleagues at Cornell University developed the visual process of “concept mapping” for facilitating learning. When generated by learners, concept maps represent meaningful relationships between concepts and propositions (Novak & Gowan, 1984) as they are understood by those learners.

A cognitive map is a type of visual road map showing some of the pathways that learners can take to connect meanings of concepts. Concept maps are schematic devices for representing interrelationships among a set of concept meanings embedded in a framework of propositions and two-dimensional, hierarchical, node-link diagrams that represent verbal, conceptual, or declarative knowledge in visual or graphic forms (Quinn, Mintzes, & Laws, 2003). In other words, concept maps are visual representations of students' understandings of concepts, hierarchically organized and connected by labeled lines and propositions (Snead & Snead, 2004). Concept maps are composed of nodes (or ovals) and arcs (or links) that connect them. Nodes represent concepts and links represent the relationships between concepts. Concept maps should be hierarchical; the more general, more inclusive concepts should be at the top of the map, and the more specific, less inclusive concepts should be at the bottom of the map (Novak & Gowin, 1984).

Constructivist Learning and Cognitive Psychology

Chang, Sung, and Chen (2001) proposed that concept mapping is a powerful learning strategy consistent with constructivist learning theory (Duffy, Lowyer, & Jonassen, 1991; Madrazo & Jordi, 2002).

Constructivism implies that there is no objective reality since individuals construct their own ideas about the world through experience. By describing knowledge as constructed mental representations of the experiential world (Glasersfeld, 1989), the constructivist theory of learning offers an important interpretation of learning processes that occur in science classrooms. According to Saunders (1992), learners respond to their sensory experience by mentally constructing schemas or cognitive structures, which constitute the meaning and understanding of their world. Constructivists (Novak, 1998; Piaget, 1966) theorized that the individual learner acquires knowledge by linking new information with past experiences to create a personal process for meaning-making. In constructivist learning, learners are involved in knowledge construction and not knowledge absorption. This learning process is also knowledge-dependent because learners use their own current knowledge to construct new knowledge (Neo & Tk, 2002).

According to Lambert, Walker, Zimmerman, Cooper, Lambert, Gardner, and Ford Slack (1995), the multiple principles of constructivist learning theory include the following major features:

> (a) Knowledge and beliefs are formed within the learner; (b) learners personally imbue experience with meaning; (c) learning activities should cause learners to gain access to their experiences, knowledge and beliefs; (d) learning is a social activity that is enhanced by shared inquiry, and (e) reflection and metacognition are essential aspects of constructing knowledge and meaning (p.17-18).

Within a constructivist framework, learning takes place as learners progressively differentiate concepts into more complex understandings and also reconcile abstract understanding with concepts acquired from experience. New knowledge is meaningfully constructed when learners establish connections among knowledge learned, previous experiences, and the context in which learners find themselves (Daley, 2002; Jonassen, 1994; Novak, 1998).

Novak (1998) proposed that concept maps embody constructivist theory. Concept mapping is a tool for helping learners organize, restructure, and represent what they know. Through constructivist approaches learners actively build their own knowledge, rather than recapitulating the teacher’s interpretation of the world. In constructivist environments where students use concept mapping tools, learners are actively engaged in reflecting on their interpretation of the external world and constructing meaningful learning (Jonassen, 1996a; 2000).

The Importance of Learning How to Visualize

Arcavi (as cited in Ajose, 1999) defined visualization as “the ability, the process and the product of creation, interpretation, and use of and reflection upon pictures, images, diagrams, in our minds, on paper or with technological tools, with the purpose of depicting and communicating information, thinking about and developing previously unknown ideas and advancing understandings”(p. 81). Cifuentes and Hsieh (2004) defined student-generated visualization as the learning process of creating direct representations or visual representations of sequential, causal, comparative, chronological, oppositional, categorical, and hierarchical relationships among concepts, whether using hand or computer drawings.

There are various approaches to visualization in education. For instance, students might use analogies (Gabel, 2003; Thiele, 1991; Yerrick, Doster, Nugent, Parke, & Crawely, 2003), advanced organizers (Ausubel, 1968), visual elaboration (Chanlin, 1997; Cox, Smith, & Rakes, 1994), illustration (Hibbing, & Rankin-Erickson, 2003; Hodes, 1993), semantic networks (Marra & Jonassen, 2002; Jonassen, Beisssner& Yacci, 1993), mind maps (Buzan, 1989; Peterson & Snyder, 1998), and concept maps (Andersen-Inman & Diston, 1999; Anderson-Inman & Horney, 1996; Anderson-Inman & Zeitz, 1993; Novak, 1990a, b). Although each of these approaches is established from different perspectives, each shares the goal of helping students create visuals using prior experience and knowledge to build conceptual understanding. Visualization, regardless of approach, has been shown to be effective as a metacognitive strategy for students (Cifuentes & Hsieh, 2003a; 2003b).

Visual representation has several advantages for structuring knowledge as follows: (a) visual symbols are quickly learned and easily recognized by students; (b) minimum use of text makes it easy to scan for a word, phrase, or general idea; and (c) visual representation allows for development of a holistic understanding that words alone cannot transmit (Plotnick, 1997). Also, visualization provides a useful cue for retrieving information and concepts from memory. For the above reasons, theorists and researchers agree that students should be encouraged to generate their own visualizations during study time.

Visual tools and benefits for meaningful learning

According to the cognitive psychologist, Ausubel (1962; 1968), meaningful learning is “nonarbitrary and nonverbatim” and involves “the assimilation of new concepts and propositions into an existing cognitive structure” (Novak, 1993). In Ausubel's view, to learn meaningfully, students must relate new knowledge (concepts and propositions) to what they already know. He proposed the notion of an advanced organizer as a way to help students link their ideas with new information or concepts and claimed that new concepts can be incorporated into more inclusive concepts or ideas during learning. Advance organizers can be verbal phrases or a graphic. Meaningful learning occurs when an individual assimilates or accommodates new information within the existing cognitive structure of an individual’s prior knowledge (Reese, 2004). In other words, meaningful learning occurs when learners can connect new knowledge with something they already know or have experienced, thereby altering what is known (Snead & Snead, 2004). Rote-learning, on the other hand, is arbitrary, non-substantive storage of facts and information in a cognitive structure without effort on the part of the learner and has a limited retention time and no direction as to how and when to use it (Ausubel, 1962; 1968). Jonassen, Peck, and Wilson (1999) argued that meaningful learning has the following features:

> (a) Active (manipulative/observant) – learners interact with an environment and manipulate the objects in that environment, observe the effects of their interventions and construct their own interpretation of the phenomena and the results of the manipulation; (b) constructive (articulative/reflective) – learners integrate new experiences and interpretations with their prior knowledge about the world, constructing their own simple mental models to explain what they observe; (c) intentional (reflective/regulatory) – learners articulate their learning goals, what they are doing, the decisions they make, the strategies they use, and the answers that they find; (d) authentic (complex/contextual) – learning tasks are situated in some meaningful real-world task or simulated in some case-based or problem-based learning environment; [and] (e) Cooperative (collaborative/ conversational) – learners work in groups, socially negotiating a common expectation and understanding of the task and the methods they will use to accomplish it (as cited in Jonassen, 2000, pp.11-12).

In Novak's interview with Cardellini (2004), he stated that only meaningful learning allows extensive transfer of knowledge to novel settings and supports progressively greater skill development in attacking and solving novel problems.

By concept mapping, students can learn meaningfully. Meaningful learning underlines the constructive integration of thinking, feeling, and acting leading to empowerment for commitment and responsibility. As students progressively reconstruct their knowledge and construct a complex framework of interrelated concepts with many levels of hierarchy, branching, and cross-linking using visual tools, individual learners engage in meaningful learning (Quinn, Mintzes, & Laws, 2003). This process refers to grafting new knowledge onto an old framework to create meaningful learning (Niehaus, 1994). Thus, concept mapping is a useful process for mediating shared cognition and meaningful learning.

Many studies exploring the use of concept maps as visual tools have indicated that concept mapping promotes novel problem solving abilities, raises mean scores on achievement of content units, decreases students' anxiety levels, and increases students' positive attitudes toward the content of study (Daley, 2002; Novak, 1990b). Evidence related to concept maps shows that an increase in depth and complexity of an individual's knowledge framework enhances a person's ability to use knowledge and draw scientifically valid inferences and conclusions (Quinn, Mintzes, & Laws, 2003). Concept mapping as a visual tool helps facilitate an understanding of conceptual relationships and the structure of knowledge (Novak, 1998). Concept mapping is a scientific tool which enables the measurement of higher-order conceptual understanding that characterizes meaningful learning (Ausubel, 1962; Novak & Gowin, 1984).

The importance of student-generated concept mapping in science education

Student-created concept maps can help students construct knowledge by providing a vehicle for integrating new knowledge with knowledge previously learned. When learners play an active role in creating and modifying concept maps, this learning strategy promotes student engagement (Anderson-Inman & Zeitz, 1993). Student-constructed concept maps provide both qualitative and quantitative measures of understanding in conceptual learning and have considerable potential for revealing changes in knowledge over time (Kinchin, Hay, & Adams, 2000; Rye & Rubba, 2002). Student-constructed concept mapping proves to be more efficient than pre-made ones presented to students by teachers (McCagg & Dansereau, 1991). Odom and Kelly (2001) found that students who generated concept maps significantly outperformed the non-concept mapping students in high school biology.

In the process of student-generated concept mapping, the role of the student evolves from being a passive learner to becoming an active participant in the learning process (Jonassen, Peck, & Wilson, 1999). In this student-centered learning mode, students must play an active part in their learning and construct their own knowledge or meaning from content, and learning builds on what learners have already constructed in other contexts. In other words, students are involved in learning as a process of knowledge construction and not knowledge absorption (Neo & Tk, 2002). When students construct concept maps by themselves and are encouraged to produce open-ended maps that allow revision and sharing with peers, concept mapping has a positive effect on their learning (Royer & Royer, 2004). Concept maps are useful mediators of knowledge that allow instructors to recognize conceptual difficulties and to facilitate interaction among students (Quinn, Mintzes, & Laws, 2003). Therefore, to encourage students to recognize the interrelationships of complex knowledge and to value and engage in meaningful learning rather than rote-learning, passive learning, or memorization, the concept mapping strategy is a powerful learning technique.

The Effects and Impact of Concept Mapping

Concept mapping by students is a common visualization method assigned by instructors from elementary schools to adult learning environments and has been used as a teaching, learning, and assessment tool. Concept maps offer a user-friendly way of evaluating learning and are valuable alternatives to multiple-choice tests (Quinn, Mintzes, & Laws, 2003). The concept map is a useful science education tool, used for both increasing students' learning abilities and assessing their understanding of subject matter (Good, Novak, & Wandersee, 1990; Rye & Rubba, 1998; 2002). Concept maps can be used as formative assessment tools to shape learning progress toward instructional goals that require higher-order conceptual understanding (Reese, 2004). Concept mapping offers a close correspondence between psychological constructs and their external modes of representations. Generating concept maps composed of nodes, links, and labels on the links, integrates verbal and visual coding and externalizes both cognitive and affective processes which stimulates self-appraisal and self-reflection and supports mental imagery (Stoyanov & Kommers, 1999). Also, concept mapping can enhance students' motivation (Novak, Gowin, & Johansen, 1983) and creativity (Lanzing, 1998).

Quinn, Mintzes, and Laws (2003) summarized several advantages of concept mapping in science education as follows:

> (a) concept maps offer a global picture of students' conceptual understandings rather than a piecemeal depiction of isolated facts; (b) concept maps are useful in emphasizing the importance of quality of knowledge rather than just its quantity in conceptual learning; (c) to encourage students to become meaningful learners, we can use concept maps in study and review in preparation for a formal assessment such as learning how to learn; [and] (d) students benefit from sharing ideas with instructors and other students (p.15).

According to Jonassen (2000), concept mapping engages learners as follows:

> (a) reorganization of knowledge; (b) explicit description of concepts and their interrelationships; (c) deep processing of knowledge, which promotes better remembering and retrieval and the ability to apply knowledge in new situations; (d) relating new concepts to existing concepts and ideas, which improves understanding; [and] (e) spatial learning through spatial representation of concepts in an area of study (p.60).

Including concept mapping in a lesson increases students' cognitive and discovery learning, enhancing retention, and producing a higher order of logical thinking, analysis, and application. In the process of mapping concepts, students' concepts and ideas are revealed and, thus, instructors may trace and correct students' misconceptions

(Snead & Snead, 2004). When instructors examine student-generated concept maps, they access a student's understanding and are enabled to provide feedback and clarification during instruction. Concept maps help to increase the total quantity of formal content knowledge because they facilitate learners' abilities to use the skill of relating patterns and relationships (Jonassen, 2000).

Quinn, Mintzes, & Laws (2003) investigated the value of using successive concept maps as vehicles for assessing and documenting conceptual learning in a college geology course and found them to be highly useful. They found that concept maps are useful in emphasizing the importance of quality of knowledge rather than just its quantity in conceptual learning. In this context, concept maps become more than just another way of evaluating learning – they become "meta-learning" tools. Concept maps can be used as alternative assessments (Ruiz-Primo & Shavelson, 1996) of declarative and procedural knowledge in the science classroom (Rice, Ryan, & Samson, 1998).

The necessity of training students in concept mapping

Cifuentes and Hsieh (2004) demonstrated that given proper instruction and training in constructing visualizations on paper, middle school students can significantly increase their learning in the science class. In an experiment to test for transfer of learning in a group of 8^{th} grade science students, they found that students who were trained in constructing visualizations performed significantly better on a science test than students who were not trained in constructing visualizations.

Cifuentes and Hsieh (2004) also explored the effects of computer-based visualization as a study strategy for middle-schoolers' science concept learning. An orientation to visualization skills prepared students for using visual techniques to represent interrelationships among science concepts. In their quasi-experimental study, although visualization on paper improved test scores for middle schoolers', scores on a test did not improve as a result of computer-based visualization training or computer-based visualization during study**.** Qualitative findings indicated that students were quite unskilled at visualization and required more training in both computer skills and visualization on computers to successfully apply the strategy. Because visualization is a factor in scientific understanding, they concluded that visualization of concepts should be a focus of science curriculum, but students required more training in development of computer graphics to be effective visualizers on computers.

In response to their finding, Hsieh and Cifuentes (2006) developed a seven-and-a-half hour visualization and computer skills training workshop for preparing students to represent interrelationships among science concepts. In that controlled study, 8th grade students who used computer visualization as a study strategy outscored students who did not construct visual representations on computers on a comprehension test. They concluded that, given training in computer visualization, middle school students can generate visual representations that show interrelationships among concepts to demonstrate their understanding. These findings provided strong evidence of the effectiveness of training students how to generate visualizations using computers, and of the effectiveness of visualization for the improvement of students' concept understandings.

The need for extensive practice in constructing concept maps was specifically supported by findings of Brandt et al. (2001) and Boujaoude and Attieh (2003). It is important to provide training on how to use computers for concept mapping or visualization so that the strategies can lead students to successful learning. Similarly, when students are provided with proper computer training, they can more easily and effectively construct, modify, or maintain their concept maps during conceptual learning (Jonassen, Reeves, Hong, Harvey, & Karen, 1997; Reader & Hammond, 1994; Royer & Royer, 2004).

The Effect and Impact of Computer-Supported Concept Mapping

Although in one controlled study Cifuentes and Hsieh (2004) found that computers can distract learners as they visualize on them, other researchers have found that visualization and concept mapping can be effectively supported by the use of personal computers and computer software (Anderson-Inman & Ditson, 1999; Anderson-Inman & Zeitz, 1993; Fischer, 1990; Royer & Royer, 2004).

Based upon their findings that computers distract learners from effectively creating visualizations while they study, Hsieh and Cifuentes (2006) created a seven-hour training in computer-based visualization as a study strategy. Data collected in school settings was analyzed both quantitatively and qualitatively. The results showed that eighth grade students who received the visualization workshops and constructed visualizations on paper as well as on computers during study time scored significantly higher on a science comprehension posttest than those students who applied an unguided study strategy. They concluded that training is necessary for effective computer-based visualization.

Computer-based concept mapping enhances students' abilities to effectively organize their conceptual ideas because electronic maps transcend page size, are easy to create, and are dramatically faster to revise than their paper-and-pencil counterparts (Anderson-Inman & Ditson, 1999). Therefore, when students have computer skills, they can more easily construct, modify, or maintain their visualizations than they can on paper, and skilled teachers can monitor and evaluate students' understandings effectively (Jonassen, Reeves, Hong, Harvey, & Karen, 1997; Reader & Hammond, 1994; Royer & Royer, 2004). Anderson-Inman and Horney (1996) indicated that computer-based visualization makes the learning process more accessible to students, and it helps alleviate the frustration felt by students while constructing concept maps using paper-and-pencil. Computer-based concept mapping fosters knowledge representation and construction (Anderson-Inman & Zeitz, 1993). Interacting through computer-based concept mapping enables students to take a look at the whole problem space as it is visualized by other group members (Stoyanova & Kommers, 1999, 2001, 2002). According to Lanzing (1998), the use of computer-based concept mapping supports - (a) ease of adaptation and manipulation, (b) dynamic linking, (c) conversion, (d) communication, (e) immediate analysis, and (f) storage. The use of computer-based visualization tools such as Inspiration™, Mind Mapper™, and Microsoft™ Visio enables learners to interrelate the ideas that they are studying in multidimensional networks of concepts, and to label and describe the relationships between those concepts (Jonassen, 2000; Jonassen, Carr, & Yueh, 1998).

Such visual thinking tools open up new avenues for incorporating technology into the teaching and learning process, and provide students with powerful concept mapping software with lots of helpful features built into the interface (Anderson-Inman, 1996). Inspiration™ is currently one of the most popular computer software programs for creating concept maps in K-12 education environments. This program allows the organization of concepts and brainstorming and mapping of ideas. It also helps students to build graphic organizers to represent concepts and relationships and use the integrated outlining capability to further organize ideas for reports. Using the proven power of visual learning, Inspiration® was developed to help K-12 students strengthen critical thinking, comprehension, and writing skills across the curriculum (Inspiration, 2005).

Many researchers report the positive effects of computer-supported concept mapping using Inspiration™. Anderson-Inman and Zeitz (1993) found that computer-based concept mapping using the Inspiration™ program encouraged students to revise or change their maps more when compared to their maps drawn with paper and pencil.

Royer and Royer (2004) investigated the difference between hand drawn and computer generated concept mapping with 9th and 10th grade biology classes using Inspiration™ software on desktop computers. They found that the group using the computer created more complex maps than the group that used paper and pencil. Also, this study, which revealed that students prefer using Inspiration™ to facilitate their concept mapping, highlighted the idea that when used properly, concept mapping and computer tools can work together to promote meaningful science learning. In summary, previous studies have shown that computer-supported concept mapping has positive effects on conceptual learning.

The Importance of Collaborative Concept Learning

Collaboration and scaffolding (Vygotsky, 1978) allows students to perform tasks that would normally be slightly beyond their ability without assistance and guidance from a teacher. In Piagetian cognitive development theory (Piaget, 1966), an individual's cognitive structure can develop through the resolution of cognitive conflicts that are generated during peer interaction. Cognitive processing of interactions with others leads to active processing of information, which in turn modifies the individual learner's cognitive structures (Brandon & Holingshead, 1999).

Many researchers (Ashman & Gillies, 1997; Johnson, & Johnson, 1994; Slavin, 1995; Stoyanov & Kommers, 1999; Veenman, Kenter, & Post, 2000) have indicated that cooperative or collaborative learning is related to positive affective and cognitive outcomes, primarily in K-12 settings. According to Millis (2002), cooperative learning helps students foster not only learning, but also positive outcomes such as increased self-esteem, respect for others and civility. Ashman and Gillies (1997) indicated the necessity of training students in group work and found that the trained groups are consistently more cooperative and helpful to each other than non-trained groups and become more responsive and active learners during group work. Training in how to collaborate teaches interpersonal skills and knowledge about how to listen and contribute to discussion, and establishes expectations about an appropriate style of interaction (Yager, Johnson, &

Johnson, 1985). Collaborative concept mapping can assist students in taking more responsibility for their own conceptual learning during study time and provide students with the opportunity to talk about and use concept maps to describe and explain phenomena (Boxtel, et al., 2002).

In collaborative learning, students are enabled to discover and construct their own cognitive structures by representing and explaining their concepts and ideas socially (Stoyanova & Kommers, 2001, 2002). Other research (Mereer, 2000; Okeukola & Jegede, 1988; Roth & Roychoudhury, 1994) has found that collaborative concept mapping leads to effective discussion concerning interrelationships among concepts because this task enables students to use language for thinking and reasoning together, and thus enhances meaningful learning. A meta-analysis of the effects of small group learning in postsecondary science, math, engineering, and technology classes indicated that students who learn in collaborative or cooperative groups demonstrate greater achievement and more positive attitudes toward learning than students who are not exposed to collaborative methods (Springer, Donovan, & Stanne, 1999). Concept maps help students communicate with each other about what they know or think they know as tools for negotiating meaning (Anderson-Inman & Ditson, 1999). Therefore, concept maps are useful tools for provoking students' interaction and collaboration.

According to Millis (2002), group size should remain small during collaboration. Students who collaboratively construct conceptual knowledge in dyads using a content-specific computer-based visualization tool reach a substantially higher quality on their outcomes (Fischer, Bruhn, Grasel, & Mandl, 2002). Small groups of three to four learners will actively contribute to a discussion with other members (Shepperd, 1993). Using groups of three to four students optimizes team cohesion and eliminates many of the dysfunctional aspects of groups. Teacher-selected heterogeneous groups usually function better than randomly selected or student-selected groups. The roles assigned within the groups – typically leader, recorder, presentor, and reflector - must be rotated frequently to form positive interdependence. When learners work in groups on the same task simultaneously, thinking together about demands and tackling complexities, positive cognitive outcomes are demonstrated (Dillenbourg, 1999). However, how groups are formed, and how students are trained to assist each other appears to be an important aspect for successful group outcomes in K-12 environments.

The Comparative Effectiveness of Individually and Collaboratively Generated Computer-Based Visualizations

Previous research (Boujaoude & Attieh, 2003; Chang, Sung, & Chen, 2001; 2002; Cifuentes & Hsieh, 2003a; 2003b; 2004; Hsieh, 2003; Royer & Royer, 2004) on individually student-generated visualization found that visualization techniques are effective in supporting processes of individual knowledge construction.

And, many current research studies report positive effects of collaboratively-generated visualization on computer or paper form (Boxtel, et al., 2002; Brown, 2003; Bruhn, Grasel, & Mandl, 1999; Chiu, Wu, & Huang, 2000; Fischer, Bruhn, Grasel, & Mandl, 1999; 2002; Madrazo & Jordi, 2002; Roth, 1994). However, further research needs to explore comparative effects between individual-visualization and collaborative-visualization with a computer concept-mapping tool.

Brown (2003) found those students who collaboratively generated concept maps on paper outperformed students who individually generated concept maps on paper in high school biology. Although he found a positive effect of collaborative concept mapping on paper, students who individually generated concept maps were not outscored by those who did not construct concept maps. According to Fischer, Bruhn, Grasel, and Mandl, (2002) processes of collaborative knowledge construction can support learners' scientific knowledge construction more effectively in the environment of collaborative versus individual learning. Stoyanova (2000) proposed that collaborative concept mapping facilitates the process of group negotiation of meaning, and it promotes a deeper mutual understanding between groups. The process of group negotiation allows for a shift from internal negotiation for students, and it also results in meaningful integration of new concepts in the cognitive structures of learners. During the process of collaboratively developing concept maps using visualization tools, the role of the student should evolve from being a passive learner to becoming an active participant in the learning process as the student's perceptions and representation of those perceptions are challenged, and learning builds on what the learner has already constructed in other contexts (Fischer, Bruhn, Grasel, & Mandl, 2002).

Computer supported collaborative learning has powerful effects on numerous cognitive and affective outcomes, including academic achievement, cognitive development, interpersonal relations, self-esteem, motivation, and anxiety (Alavi, 1994; Brandon & Holingshead, 1999; Courtney, Courtney, & Nicholson, 1994; Johnson, & Johnson, 1994; Slavin, 1995; Webb & Palincsar, 1996).

Collaboratively-generated visualization has power in supporting the process of meaningful knowledge construction. For this reason, a visual representation technique such as concept mapping is often integrated into collaborative learning activities (Okebukola & Jegede, 1988; Roth, 1994). Lumpe and Staver (1995) demonstrated that collaboratively creating propositions in small groups had positive effects on student achievement. They compared collaborative conceptualizing of photosynthesis with individual conceptualizing of photosynthesis and found that high school students who worked collaboratively out-performed those who worked independently on a comprehension test. The computer-based visualization tool that they used, “CoStructre-Tool,” proved to be a method for facilitating cooperation, which is effective in supporting specific processes and in improving transfer of prior knowledge (Fischer, Bruhn, Grasel, & Mandl, 2002).

According to Roth (1994), when students reconstructed concepts on paper in small groups, they were able to demonstrate what they knew about a subject while listening, observing, and learning from others which resulted in the modification of their own meaningful understandings. In other studies, concept mapping on paper had a positive effect on both knowledge attainment and attitude (Horton, MacConney, Gallo, Woods, Senn, & Hamelin, 1993). Using concept maps allows learners to communicate representations of an individual’s cognitive structure with other learners (Novak & Gowin, 1984).

Previous studies have shown that computer-generated visualization and collaborative concept mapping positively affect science concept learning. Therefore, the next logical step in the body of research on visualization is to compare individually and collaboratively generated computer-based concept mapping to determine which approach is more effective for science concept learning.

Pilot Study

In the researcher's controlled pilot study, 74 students in five 8^{th} grade science classes at a middle school participated. In order to determine the extent to which collaboratively-generating concept maps supports the process of meaningful knowledge construction, the study explored the comparative effects of individually and collaboratively generating computer-based concept maps on 8^{th} grade middle school science learning as measured on a forty item comprehension test. Internal consistency was established at .824 (coefficient alpha) for the comprehension test. Collaborative groups consisted of three to four students working on one computer.

The findings revealed that individually generating concept maps on computers during study time positively influenced science concept learning above and beyond both studying independently and collaboratively-generating concept maps on computers during study time. This finding means that those students who individually generated concept maps outperformed students who studied independently without being instructed to generate concept maps (p = .006, d = .9931). Also, students who collaboratively generated concept maps did not score significantly higher than did the control group on the comprehension test (p = 0.79, d = .6532). However, students in both individual and collaborative concept mapping groups had positive attitudes toward concept mapping using Inspiration software.

Even though there was no significant difference between individual and collaborative groups in this group of participants, the researchers found worthy interpretation from this result. In this case, the reason that the collaborative group did not score significantly higher than the control group on achievement might have been lack of a disciplined, supportive collaborative working environment. According to results of a learning strategy questionnaire and observation, motivational problems among collaborative students and the distractions created by the computers and software explained the lack of the effectiveness of computer-based concept mapping for collaborative groups. Also, most students had had few opportunities to develop collaborative learning skills in their young school careers.

One of the researchers observed that students in the collaborative groups spent excessive time competing for time on the keyboard and were generally distracted by their three member group. Cifuentes and Hsieh (2004) had previously demonstrated the distractions that computers and software create as students generate computer-based visualizations. Findings in the pilot study indicated that collaborative groups were difficult to maintain for middle school students. Teachers indicated that collaborative pairs of students with experience collaborating would likely work more effectively.

Therefore, this investigation of individually generated computer-based concept mapping and collaboratively generated computer-based concept mapping differs from the pilot study in two ways. First, collaborative groups consisted of two students sharing a computer. Second, as in studies by both Reese (2004) and Rye and Rubba (2002), the quality of concept maps generated across groups was compared. This study goes a step beyond those studies, however, by comparing the effects of individually and collaboratively generating concept maps on quality of those concept maps.

Research Questions

Using a quasi-experimental design, the comparative effect of individually and collaboratively generated computer-based concept mapping on science concept learning was investigated. The researcher asked the following research questions:

1. Do middle school students who collaboratively or individually generate computer-based concept maps perform better on a comprehension test than those who do not generate computer-based concept maps?
2. Do middle school students who collaboratively generate computer-based concept maps perform better on a comprehension test than those who individually generate computer-based concept maps?
3. Will the quality of concept maps generated collaboratively exceed the quality of concept maps generated individually?

Additionally, answers to the following questions will help explain results:

4. How did students' attitudes toward generating concept maps during study time differ across the individually-generated concept mapping group and the collaboratively-generated concept mapping group?
5. What specific learning strategies were used in each group to prepare for the test and did they differ according to group?
6. How do individuals in each group use their study time and did study time behavior differ across groups?

7. What are the elements in the class environment and learner behaviors that may contribute to the effectiveness or lack of effectiveness of the use of a computer-based drawing program (such as Inspiration™) to generate concept maps during study time?

CHAPTER III

METHODOLOGY

This chapter describes the participants, the design and procedures, the data sources, and the data analyses. The design and procedures included the administered instruments, a description of the workshop training, and the instructional format of treatments across groups. A non-randomized, control-treatment group, post-test only, quasi-experimental design, was used to investigate the relative effect of individually or collaboratively generated computer-based concept mapping on 7th grade science concept learning. Mixed methods combining qualitative and quantitative data collection and analyses strengthen findings by offsetting the limitations and biases of either method (MacConney, Rudd, & Ayres, 2002). Using both quantitative and qualitative methods helps a researcher triangulate results from diverse data sources. Within mixed methods the researcher can inspect overlapping and different facets of phenomenon; discover paradoxes, contradictions, and new perspectives; and expand the scope and breadth of a study (Tashakkori & Teddlie, 2003).

Participants

The potential participants were the entire 7th grade student body (N=174) of a rural middle school in Texas. However, some of the students did not turn in consent forms, some were absent for part of the treatment, and others were absent for testing. Therefore, 161 students (74 boys and 87 girls) in eight 7th grade science classes at a middle school in Southeast Texas completed the entire study.

Prior to the study, the students were informed that participating or not participating in the study would not affect their school grade. The class requirements were for students to study given textual materials and to take a test. All students' products and testing results were coded. The identities of the students were kept confidential. Parental consent, teacher's consent, and student's assent were obtained prior to the study to allow the researcher to analyze the students' study notes, concept maps, testing results, and the video recording. The teacher consent, parent/guardian informed consent, and student assent forms are presented in Appendices A, B, and C.

The ethnic distribution of the classes combined was 30.7% African American, 26.3% Hispanic, and 43% white. Ethnicities were equally distributed across the classes. Two science teachers taught these eight classes. Using prior science performance scores to assure equivalence of student achievement across groups, the researchers assigned the teacher's classes to one of the three experimental groups. Those groups were: control, computer-based individual concept mapping strategy, and computer-based collaborative concept mapping strategy.

The control group's and two experimental groups' mean scores and standard deviations of those scores on prior science performance are presented in Table 1.

The One-Way ANOVA results indicated that no significant difference existed among the control, individual, and collaborative groups on the mean scores of the prior science performance scores, $F = .86$ ($p < 0.05$ level) as seen in Table 2. Therefore, the three experimental groups were equivalent across students' academic performance.

Table 1

Means and Standard Deviations on Prior Science Performance Scores

Groups	N	Mean	Standard Deviation
Control Group	40	79.90	8.61
Individual Groups	59	81.80	8.08
Collaborative Groups	62	82.00	8.61
Total	161	81.40	8.41

Table 2

One Way ANOVA Summary Table for the Effects of Prior Science Performance Scores

Source	Sum of Square	Df	Mean Square	F	Significance
Group	121.60	2	60.80	.86	.43

$*p < .05$.

To determine whether the groups differed in their knowledge of five science topics to be used in the experiment: “Weathering,” “The Nature of Soil,” “Soil Erosion,” “Erosion by Gravity,” and “Erosion by Winds,” students were asked to report the extent to which they had been previously exposed to the information presented in the science essays that they studied during the five day experiment (see Appendix D). The question read as follows:

> To what extent had you been exposed before to the information in the handout about “Weathering”? (Please check one.)
>
> A. I knew none of the information.
> B. I knew some of the information.
> C. I knew a lot of the information.
> D. I knew all of the information.

The frequency counts of the extent to which the students had been exposed to the content in the study essays are shown in a 4x3 chi-square contingency table (see Table 3).

Table 3

Participants' Knowledge of the Content in Five Study Essays

Study Topics	Control Group	Individual Group	Collaborative Group
Weathering			
Knew none	34 %	23 %	23 %
Knew some	54 %	64 %	54 %
Knew a lot	10 %	11 %	17 %
Knew all	2 %	2 %	6 %
Nature of Soil			
Knew none	43 %	46 %	40 %
Knew some	44 %	43 %	45 %
Knew a lot	5 %	9 %	13 %
Knew all	8 %	2 %	2 %
Soil Erosion			
Knew none	47 %	45 %	38 %
Knew some	44 %	48 %	50 %
Knew a lot	9 %	5 %	10 %
Knew all	0 %	2 %	2 %
Erosion by Gravity			
Knew none	47 %	48 %	44 %
Knew some	44 %	38 %	44 %
Knew a lot	7 %	14 %	12 %
Knew all	2 %	0 %	0 %
Erosion by Winds			
Knew none	50 %	61 %	50 %
Knew some	41 %	34 %	36 %
Knew a lot	7 %	5 %	12 %
Knew all	2 %	0 %	2 %

Five Pearson Chi-Square tests were also conducted for the comparison among three groups (see Table 4). The Chi-square results indicated that there was no significant difference in knowledge of units “Weathering,” “The Nature of Soil,” “Soil Erosion,” “Erosion by Gravity,” and “Erosion by Winds” among the proportion of students in the three groups, $X^2 = 9.65$ ($p = .14$), $X^2 = 10.02$ ($p = .12$), $X^2 = 5.18$ ($p = .52$), $X^2 = 7.12$ ($p = .31$), and $X^2 = 7.46$ ($p = .28$) respectively.

Table 4

Pearson Chi-Square Group Differences in the Content Knowledge in Five Study Essays

Topic	Pearson Chi-Square	Df	Significant (2-sided)
Weathering	9.65	6	.14
Nature of Soil	10.02	6	.12
Soil Erosion	5.18	6	.52
Erosion by Gravity	7.12	6	.31
Erosion by Winds	7.46	6	.28

*$p < .05$.

According to their self-report, the students in each group did not differ in their prior knowledge on the content in study essays for treatment. Therefore, the three experimental groups were equivalent across students’ prior knowledge on content during treatment.

In addition, Chi-Square tests were used to investigate whether the three groups were different from each other in their frequency of accessing computers at school and at home, in the number of computer courses taken in the past, in the amount of the time spent each time using a computer in school and at home, and in the frequency of using computer tools to support various learning tasks, such as word processing, E-mail, Internet, games, spreadsheets, presentations, graphics, and webpage development. The results are fully presented in the "Computer Use Survey Results" (see Appendix L). Results showed that the students in each group did not differ significantly in those factors that showed in Table 5. According to their self-report, students in all three groups were not different in their frequency of accessing computers at school and at home, the number of computer courses taken in the past, the amount of the time spent each time using a computer in school and at home, and the frequency of using computer tools to support various learning tasks. Therefore, the three experimental groups were equivalent across students' previous experiences on computer use during treatment.

Table 5

Pearson Chi-Square Group Differences in the Factors in Computer Use Survey

Topic	Pearson Chi-Square	Df	Significant (2-sided)
Frequency – Chatting	5.28	8	.73
Frequency – Create computer graphics	2.18	8	.98
Frequency – E-mail	2.76	8	.95
Frequency – Games	3.57	8	.89
Frequency – Internet	1.78	8	.99
Frequency – Presentations	5.23	8	.73
Frequency – Programming	4.11	8	.85
Frequency – Spreadsheets	9.62	8	.30
Frequency –Use of computer at home	1.26	8	1.00
Frequency – Webpage development	4.23	8	.84
Frequency – Word	4.86	8	.78
Numbers of computer courses	2.82	8	.95
Time spent at home computers	2.04	8	.98
Time spent at school computers	4.90	8	.77
Use computers at school	3.24	8	.92

*$p < .05$.

Design and Procedures

The independent variable was treatment group. The treatment group consisted of three levels: control group of 40 students, 59 students trained to individually generate concept maps on computers, and 62 students trained to collaboratively generate concept maps on computers. The dependent variable was science concept learning as demonstrated by comprehension test scores and rubric scores for assessing the quality of concept maps.

Instruments

Four instruments were used to collect data: (a) a comprehension test, (b) the Learning Strategy Questionnaire, (c) the Computer Use Survey, and (d) a rubric for assessing the quality of concept maps.

The comprehension test

The comprehension test (see Appendix F) was developed by referencing the Glencoe Science/ Texas Science for 7th grade curriculum (Biggs, Feather, Snyder, & Zike, 2002). After the experimental treatment, students took a ten-item multiple choice comprehension test each day during the five days of the experiment. A total of fifty items was administered to each student; those scores were compiled into one score for each student. Two teachers and the investigator reviewed the answers to assure reliability of scoring. There was 100% percent agreement on students' comprehension test scores.

As measured on a fifty-item comprehension test, internal consistency was established at .86 (coefficient alpha) for the comprehension test. The comprehension test consisted of fifty paper-and-pencil multiple-choice items from the Glencoe Science/ Texas Science for 7th grade (Biggs, Feather, Snyder, & Zike, 2002) that was provided with the seventh grade textbook adopted by the participating school district (see Appendix F). Items were criterion referenced to concepts that students studied during their experimental study time.

The multiple-choice comprehension test items were constructed and validated by three content experts to be appropriate for this study. For the purpose of scoring students' responses to the comprehension test items, one point was given for a correct answer, and no credit was given for incorrect or unanswered questions. For the five days of the experiment, the total possible range of each student's score was from 0 to 50.

Learning strategy questionnaire and computer use survey

All participants were asked to fill out a "Learning Strategy Questionnaire" (see Appendix D) in the last minutes of the fifth day. The "Learning Strategy Questionnaire" is a student self-report instrument developed by the researcher. Students were asked to determine whether or not they had been exposed to the reading content prior to studying. Also, students were asked to explain how they felt about making concept maps that show interrelationships among concepts during study time and discuss how making concept maps helped them learn content.

In addition, students were asked to describe the steps that they took to prepare for the test. The individually-generated concept mapping group answered the following additional questions: When you created concept maps on a computer during study time, do you think that working by yourself helped you learn the content better than if you had worked with others? Why or why not?

Likewise, the collaboratively-generated concept mapping group answered the following questions: When you created concept maps on a computer during study time, do you think that working with others helped you learn the content better than if you had worked by yourself? Why or why not?

All students completed the "Computer Use Survey" (see Appendix E), administered to investigate students' use of computers at school and at home as well as the frequency of using computers to support a number of purposeful tasks.

Rubric for assessing the quality of concept maps

Concept maps generated by students individually and collaboratively during five days of treatment and testing were analyzed for quality by three reviewers (two teachers and one researcher). Concept maps were scored according to the four scoring components created by Novak and Gowin (1984) as follows: (a) valid relationships; (b) valid hierarchical levels; (c) valid cross-links; and (d) valid examples (see Table 6).

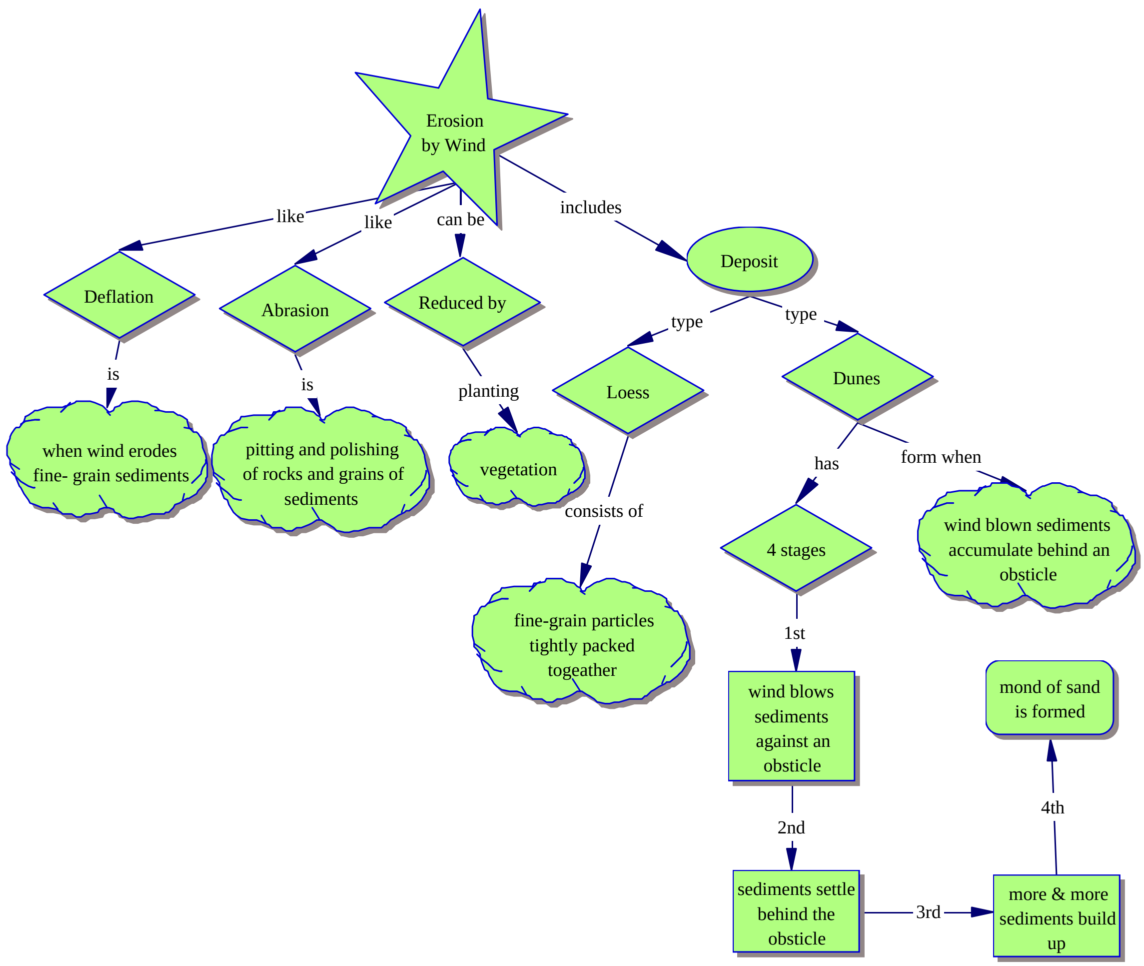
Figures 1 and 2 show examples of concept maps that students created during the study time and rubric scores for these concept maps.

Table 6

Concept Maps Scoring Formula

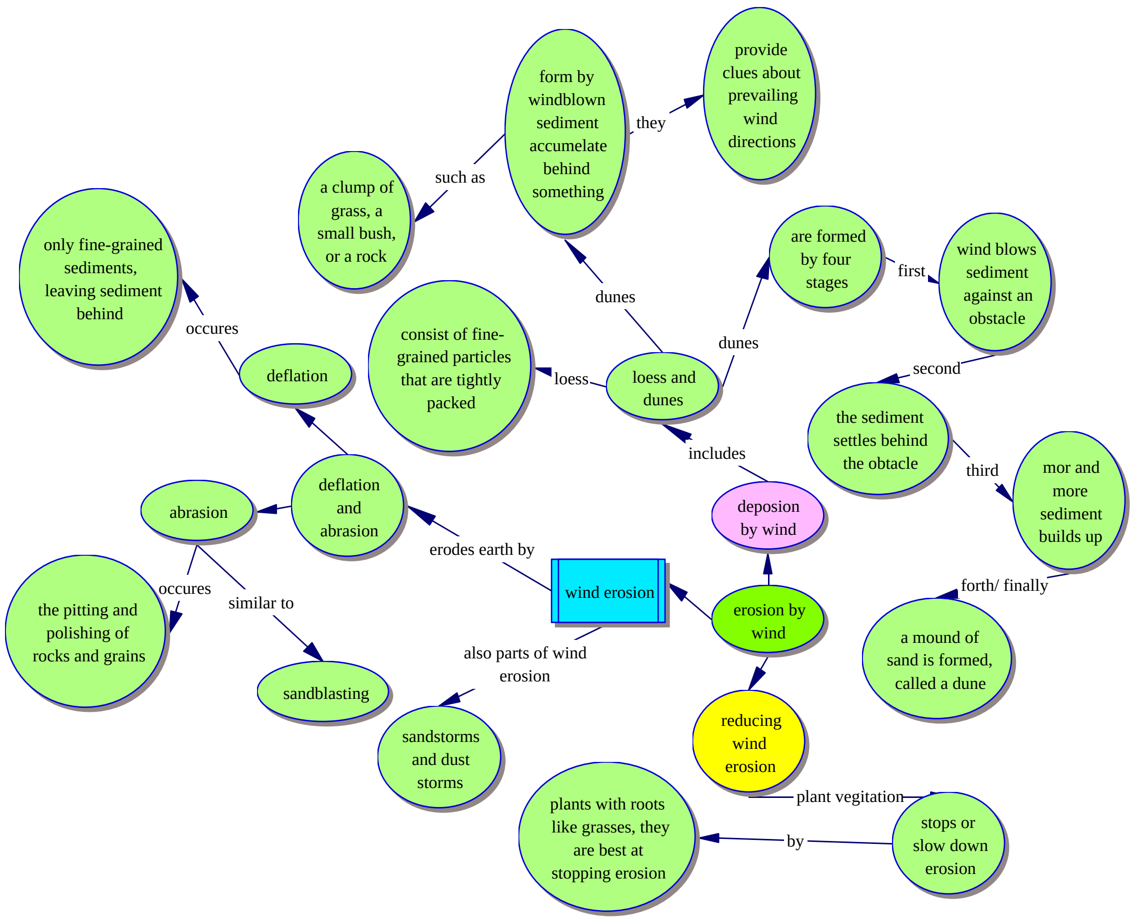
1. Relationship (if valid)	= 1 point
2. Hierarchy (for each level)	= 5 points
3. Cross links (for each cross link)	= 10 points
4. Examples (for each example)	= 1 point
Total Score	= Sum of above

(Adapted form Novak and Gowin, 1984)



	A Reviewer	B Reviewer	C Reviewer
1. Relationship (if valid)	= 16 x 1 point	= 14 x 1 point	= 14 x 1 point
2. Hierarchy (for each level)	= 7 x 5 points	= 7 x 5 points	= 7 x 5 points
3. Cross links (for each cross link)	= 0 x 10 points	= 0 x 10 points	= 0 x 10 points
4. Examples (for each example)	= 0 x 1 point	= 0 x 1 point	= 0 x 1 point
Total Score	= 51	= 49	= 49

Figure 1. Sample of a concept map developed by one student in the individual group and scoring for that concept map.



	A Reviewer	B Reviewer	C Reviewer
1. Relationship (if valid)	= 17 x 1 point	= 17 x 1 point	= 17 x 1 point
2. Hierarchy (for each level)	= 7 x 5 points	= 7 x 5 points	= 7 x 5 points
3. Cross links (for each cross link)	= 0 x 10 points	= 0 x 10 points	= 0 x 10 points
4. Examples (for each example)	= 2 x 1 point	= 2 x 1 point	= 1 x 1 point
Total Score	= 54	= 54	= 53

Figure 2. Sample of a concept map developed by pairs of students in the collaborative group and scoring for that concept map.

Reliability was established by obtaining three independent scores on each concept map. Three reviewers independently scored students' concept maps as the final products of the five day experiment based on the rubric formula created by Novak and Gowin (1984). Later each student's rubric scores for assessing the quality of concept maps were compiled into one score. Inter-rater reliability was computed by determining the correlation between three reviewers and scoring for each concept map.

Table 7 shows the reviewer reliability correlation between reviewer A and reviewer B using Pearson's Correlation was .99**, indicating a significant correlation at the 0.01 level. Also, the reviewer reliability correlation between reviewer A and reviewer C using Pearson's Correlation was .98**, indicating a significant correlation at the 0.01 level. The reviewer reliability correlation between reviewer B and reviewer C using Pearson's Correlation was .98**, indicating a significant correlation at the 0.01 level.

Table 7

Inter-Rater Reliability Correlation

		Reviewer A	Reviewer B	Reviewer C
Reviewer A	Pearson Correlation			
	Sig. (2-tailed)			
	N			
Reviewer B	Pearson Correlation	.99**		
	Sig. (2-tailed)	.00		
	N	12		
Reviewer C	Pearson Correlation	.98**	.98**	
	Sig. (2-tailed)	.00	.00	
	N	121	121	

** $p < .01$.

Essays studied by students

The study essays (see Appendix G) were developed by referencing the Glencoe Science/ Texas Science for 7th grade (Biggs, Feather, Snyder, & Zike, 2002). The contents of the five essays to be studied by students were constructed and validated by a subject matter expert and teachers. The five essays were expository text without illustrations or graphics and were developed from school curriculum and texts.

According to the teachers' request, the key concepts in each content were bracketed and/or bolded to help students catch the main concepts in those five study essays.

Computer-based concept mapping workshop training

Both experimental groups (individual and collaborative) that created concept maps on computers while studying the science concepts attended three days of workshops on computer-based concept mapping of science concepts on computers in their computer laboratory before starting to study science concepts. Science concepts explored during the computer-based concept mapping workshops were "The Eye," "Muscle tissue," and "Joints" in an organ system. These topics were not related to topics tested after experimental treatments. The control group spent the same amount of time as the experimental groups but watched a video, "Flying Away Home," during the experimental groups' workshop training. The movie was also not related to topics tested after experimental treatments (see Table 8).

Table 8

Design and Procedures for Workshop Training

	Day 1 50 minutes	Day 2 50 minutes	Day 3 50 minutes
Control Group	Watch a video "Flying Away Home"		
Experiment Groups (Both individual and collaborative)	Training on how to identify and visualize expository text with sequential structures using Inspiration.	Training on how to identify and visualize expository text with categorical structures using Inspiration.	Training on how to identify and visualize expository text with compare and contrast structures using Inspiration.

The computer-based concept mapping workshops lasted fifty minutes each of three days. The workshops had the same content, materials, and processes for each experimental group except that the students in the collaborative group were informed in the last five minutes of the last day of training that they would be concept mapping collaboratively the following day. Each of the three days of the workshop, both the individually-generated concept mapping groups and the collaboratively-generated concept mapping groups were given the same science essays to study. The science content of the workshops did not contain any concepts to be covered during the experimental study time. For the first day of workshop training, the teachers trained students focusing on how to identify and visualize expository text with sequential structures using Inspiration (see Appendix H). On the second day of workshop training, the teachers trained students to identify and visualize expository text with categorical structures (see Appendix I). For the third day of workshop training, the same teachers trained students to identify and visualize expository text with compare-contrast structures (see Appendix J).

Instructional format of treatment across groups

The control group, the individually-generated concept mapping group, and the collaboratively-generated concept mapping group had equivalent learning experiences for fifty minutes during five days, excepting that students in the control group worked independently without being told to apply a particular study strategy, students in the individual group worked individually to construct concept maps, and students in the collaborative group worked collaboratively to construct concept maps during their study time (see Table 9). Students in the individual and collaborative experimental groups first learned how to develop concept maps on computers using Inspiration™, were then given science concepts to study using concept mapping, and were then tested on those concepts.

After three days of the concept mapping workshop training, the control, individual, and collaborative groups were given the same five science essays to study each of five days. The only difference among groups was that the control group was told to simply study the concepts however they wished. Computers were not available to them. In the individual group, students worked independently to use their learned computer-based concept mapping skills to show interrelationships among concepts during their study time. Each student worked alone at a computer.

However, in the collaborative group, students were required to study together in pairs per computer using their learned computer-based concept mapping skills to collaboratively create visual representations that showed interrelationships among concepts during their study time. Students had not had prior training in how to work in such groups nor did they receive training as part of the experiment.

The two science teachers for all groups implemented instructional procedures during the five day experimental period by providing the same instructional design and materials. When students from either group asked for help and information, the teachers gave feedback equally to the students of each treatment group. After forty minutes of treatment, each day for five days, students were given the ten-item comprehension test to measure their understanding of the science concepts in the text that they studied that day using the concept mapping strategy that they were taught during the workshop.

After students in the experimental groups received the workshop on computer-based concept mapping, the procedure for all three groups followed three steps. First, the teachers gave ten minutes of instruction for each group in five different science units during each of five experimental days. Giving the ten minutes of instruction by the teachers provided basic understanding of new knowledge of each of the five topics to students, so that it enabled students to study science concepts and prepare for the test more effectively by themselves. Second, after the teachers' instruction, the students in the control group studied individually to prepare for the comprehension test. The control group students followed their own learning strategies such as highlighting, memorization, or taking notes to prepare for their test for thirty minutes. The two experimental groups' students created concept maps using computers for thirty minutes. Individual groups' students created concept maps and studied independently using computers. The collaborative groups' students, however, created concept maps in pairs and studied together using computers. The two experimental groups' students saved their files on their computer-server and printed out their concept maps to use during study time. Finally, all three groups of students turned in their study notes and concept maps. After thirty minutes of study, each day for five days, students in each group were given ten-item multiple choice questions (paper-and-pencil form) to measure their understanding of the science concepts in the text that they studied that day so that the comprehension test consisted of fifty items (see Table 9). A learning strategy survey was administered to students on the last day to determine their experiences prior to the study and attitudes toward their experiences during the study. The computer use survey was administered to students on the last day. Each step of instruction for all groups is described in Appendix K.

Table 9

Design and Procedures Each Day of Five Days

<table>
<tr><th></th><th>10 minutes</th><th>30 minutes</th><th>10 minutes</th></tr>
<tr><td>Control Group</td><td rowspan="3">PowerPoint Instruction by teachers on “Weathering,” “The Nature of Soil,” “Soil Erosion,” “Erosion by Gravity,” or “Erosion by Winds”</td><td>· Study essay independently
· No concept mapping activity</td><td rowspan="3">Ten-items multiple choice test (Paper-and-pencil form) on “Weathering,” “The Nature of Soil,” “Soil Erosion,” “Erosion by Gravity,” and “Erosion by Winds”</td></tr>
<tr><td>Individual Group</td><td>· Study essay and create concept maps by themselves</td></tr>
<tr><td>Collaborative Group</td><td>· Study essay and create concept maps in pairs</td></tr>
</table>

Control group

Students were given the same science concepts to study as were the experimental groups, but they were told to use a study strategy of their choice, and they were then tested on those concepts.

For the first of the five days of study time, students in the control group independently studied an essay of expository text on “Weathering.” For the second day, they studied “The Nature of Soil,” for the third day, they studied “Soil Erosion,” On the fourth day, they studied “Erosion by Gravity,” and finally, on the fifth day, they studied

"Erosion by Winds." During study time, the control group students followed their own strategies such as highlighting, memorization, or taking notes.

Experimental groups

The only difference between the two experimental groups was that the individually-generated concept mapping group students worked independently to use their learned concept mapping skills to create visual representations that showed interrelationships among concepts on computers during their study time. The teachers emphasized that the individually generated concept mapping students should work alone and study by themselves without discussing or giving feedback to peers. However, the collaboratively-generated concept mapping groups were required to study together within collaborative pairs using their learned visualization skills to create visual representations that showed interrelationships among concepts on computers during their study time.

Before starting the workshop training for the collaboratively-generated concept mapping group, the teachers organized students into pairs. First of all, the teachers divided students into two groups: high-achieving and low-achieving groups by average scores on prior science test. The teachers considered students' personalities and attitudes to build positive collaboration and assigned them to pairs from those two groups. To the extent possible, each collaborative pair consisted of one high-achieving student and one low-achieving student based on previously taken science test scores. Each group member was assigned to be either a leader or a monitor. They studied together and dynamically facilitated their learning by discussing, sharing ideas, and giving feedback.

Students rotated through these two roles daily for five days to form positive interdependence (Millis, 2002). The 62 students in the collaboratively-generated concept mapping group formed 31 pairs. For the first of the five days of study time, students in the individually-generated concept mapping group studied individually and visualized the expository text on “Weathering.” They constructed concept maps using Inspiration™ software. Students in the collaboratively-generated concept mapping group studied the same information but constructed concept maps collaboratively with a partner. For the second day of study time, students in both groups studied and visualized the expository text on “The Nature of Soil.” They used computers to construct concept maps. For the third day, students in both groups studied and visualized the expository text on “Soil Erosion” using computers. On the next day, both groups studied and visualized the expository text on “Erosion by Gravity.” Finally, on the fifth day, both groups studied and visualized the expository text on “Erosion by Winds.”

During three days of workshop training and five days of the experiment, all students’ class activities were recorded by video. The investigator set up the video equipment in the back of the classroom before students came to the classroom. The video equipment in the back of the classroom was set to automatically take the video recording for class observation. During fifty minutes of class activity, the researcher observed students’ behaviors and class activities.

Data Sources

Data sources included (a) students’ comprehension test scores, (b) students’ responses to the “Learning Strategy Questionnaire,” (c) students’ responses to the

"Computer Use Survey," (d) rubric scores for assessing the quality of concept maps, (e) students' study note, (f) students' concept maps, (g) the video recording, and (h) the researcher's reflective journal that documents observations of students' learning behaviors during the workshop and experiment.

Data Analysis

Analysis of quantitative data

The quantitative data analyses can be summarized as follows: to answer research questions one and two, "Do middle school students who collaboratively or individually generate computer-based concept maps perform better on a comprehension test than those who do not generate computer-based concept maps?" and "Do middle school students who collaboratively generate computer-based concept maps perform better on a comprehension test than those who individually generate computer-based concept maps?" a One-Way Analysis of Variance (ANOVA) using "treatment" as the independent variable and "the comprehension test scores" as the dependent variable was administered among the control, individual, and collaborative groups.

To answer research question three, "Will the quality of concept maps generated collaboratively exceed the quality of concept maps generated individually?" a One-Way Analysis of Variance (ANOVA) using "treatment" as the independent variable and "rubric scores for assessing the quality of the concept maps" as the dependent variable was administered between the individual and collaborative groups.

Analysis of qualitative data

The qualitative data analyses can be summarized as follows: to answer research questions four, five, six, and seven, "How did students' attitudes toward generating concept maps during study time differ across the individually-generated concept mapping group and the collaboratively-generated concept mapping group?" "What specific learning strategies were used in each group to prepare for the test and did they differ according to group?" "How do individuals in each group use their study time and did study time behavior differ across groups?" and "What are the elements in the class environment and learner behaviors that may contribute to the effectiveness or lack of effectiveness of the use of a computer-based drawing program (such as Inspiration™) to generate concept maps during study time?" the researcher analyzed the Learning Strategy Questionnaire, the Computer Use Survey Questions, the students' study notes, the students' concept maps, the video recording during study time, and the researcher's reflective journal.

Content analyses approaches as described by Emerson, Fretz, and Shaw (1995) were applied to the researcher's journal entries, the video recording during study time, and students' response to the Learning Strategy Questionnaire. Focused coding was applied to analyze the qualitative data. For focused coding analyses, the researcher independently compiled and numbered the data sources and color-coded the contents according to the categories that emerged (Merriam, 1998). To analyze the video recording, the researcher watched the video several times and independently identified categories of student behaviors. Then she watched the video to count the frequency of those behaviors.

CHAPTER IV

RESULTS

This study was designed to investigate the implementation of concept mapping as a constructivist learning strategy for organizing science conceptual knowledge for middle school science learners. The comparative effects of the individually and collaboratively generated concept maps were measured by (a) students' comprehension test scores, (b) students' responses to the Learning Strategy Questionnaire, (c) students' responses to the Computer Use Survey, (d) rubric scores for assessing the quality of concept maps, (e) analysis of students' study notes and students' concept maps, (f) analysis of video recording and observations of students' learning behaviors during the workshop training and experiment. This chapter presents the results of the data collection and analyses. The findings of this research are presented in the order of the research questions addressed:

Effects of Individually or Collaboratively Generating Concept Maps on Comprehension

An one-way analysis of variance (ANOVA) applied using treatment group as the independent variables and comprehension test scores as the dependent variable revealed that means differed across groups (see Table 10). The two experimental groups' mean scores were respectively: individual group (n = 59, mean = 29.10, SD = 8.85), and collaborative group (n = 62, mean = 31.39, SD = 8.46). The control group (n = 40) yielded a significantly lower mean score of 19.13 (SD = 8.24) than two experimental groups.

The assumption of equal variance (Levene's Test of Equality of Error Variances) was tested and groups were found to be homogenous (F = .18, *p* = .83). Therefore, the data satisfied ANOVA assumptions. In addition, the assumption of normality (Shapiro-Walks Test of Normality) was met (S-W= 1.99, *p* = .86). Therefore, non-parametric tests were not necessary.

Table 10

Summary Statistics on Comprehension Posttest Scores

Summary Indications	Collaborative Group	Individual Group	Control Group
Minimum	5.00	4.00	0.00
Quartile 1	26.00	24.00	15.50
Median	30.50	30.00	19.00
Quartile 3	38.00	35.50	25.00
Maximum	49.00	47.00	38.00
Mean	31.39	29.10	19.13
Standard Deviation	8.46	8.85	8.24
Sample Size	62	59	40

The one-way ANOVA results indicated that a significant difference existed among the control, individual, and collaborative groups on the mean scores of the comprehension posttest, F = 26.62 (*p* < .05.) as seen in Table 11.

Table 11

One Way ANOVA Summery Table for Effects of the Types of Treatment and Comprehension Posttest Scores

Source	Sum of Square	Df	Mean Square	F	Significance
Group	3893.77	2	1946.89	26.63	.00*
Error	11552.48	158	73.12		

*p < .05.

The Tukey Honestly Significant Difference (HSD) post hoc test was performed for group comparison. The Tukey HSD post hoc test revealed that the group that individually generated concept maps (individual group) significantly outscored the group that did not generate concept maps (control group). The group that collaboratively generated concepts maps (collaborative group) significantly outscored the group that did not generate concept maps (control group) in its performance (see Table 12). Cohen's *d* indicated a positive large effect size (d = 1.17) for the comparison of the individual concept mapping group and the control group as seen in Table 12. Additionally, Cohen's *d* indicated a positive large effect size (d = 1.47) for the comparison of the collaborative concept mapping group and the control group. The effect size indicated that training students to individually or collaboratively create concept maps on the computer and then encouraging them to generate concept maps while studying had positive effects on the middle school students' science concept learning.

Also, students' learning of visualization skills and the generation of concept maps on the computer during study time resulted in a significant positive effect on science concept learning. Therefore, the first research question asking if middle school students who collaboratively or individually generate computer-based concept maps perform better on a comprehension tests than those who do not generate computer-based concept maps was answered affirmatively.

In addition, the Tukey HSD post hoc test revealed that the group that collaboratively generated concepts maps (collaborative group) did not significantly outscore the group that individually generated concept maps (individual group) in its performance (see Table 12). Cohen's *d* only indicated a small effect size ($d = 0.27$) for the comparison of the individual concept mapping group and the collaborative concept mapping group as seen in Table 12. Although students who generated concept maps on the computer during study time performed significantly better than those who did not, there was no significant difference between the individual and the collaborative groups (Cohen's $d = 0.27$). Therefore, the second research question asking if middle school students who collaboratively generate computer-based concept maps perform better on a comprehension test than those who individually generate computer-based concept maps was answered negatively according the Tukey HSD post hoc test results.

Table 12

Post Hoc Test Table for the Effects of the Types of Treatment and Comprehension Posttest Scores

Tukey HSD

(I) Group	(J) Group	Mean Difference	Sig	Effect Size
Control	Individual	9.98	.00*	Cohen's *d* = 1.17
				r = 0.51
Control	Collaborative	12.26	.00*	Cohen's *d* = 1.47
				r = 0.60
Individual	Collaborative	2.29	.31	Cohen's *d* = 0.27
				r = 0.15

*$p < .05$.

Effects of Individually or Collaboratively Generating Concept Maps on Quality of Concept Maps

To determine whether or not concept maps generated collaboratively exceed the quality of concept maps generated individually, the one-way analysis of Variance (ANOVA) was applied using treatment group as the independent variables and rubric scores for assessing the quality of concept maps as the dependent variable.

The assumption of equal variance (Levene's Test of Equality of Error Variances) was tested and groups were found to be homogenous (F = 3.51, p = .06). Therefore, the data satisfied ANOVA assumptions. In addition, the assumption of normality (Shapiro-

Walks Test of Normality) was met (S-W= .98, *p* = .44). Therefore, non-parametric tests were not necessary.

The analysis revealed that means differed across groups (see Table 13). The mean score on the quality of concept maps for the collaborative group was 141.27 (SD = 30.10) while the individual group yielded a significantly lower score of 108.74 (SD = 40.31).

Table 13

Summary Statistics on Rubric Scores

Summary Indications	Collaborative Group	Individual Group
Minimum	94.70	19.70
Quartile 1	114.05	85.35
Median	143.30	101.10
Quartile 3	157.05	139.25
Maximum	215.80	182.00
Mean	141.27	108.74
Standard Deviation	30.10	40.31
Sample Size	31	59

The one-way ANOVA results indicated that a significant difference existed between the individual and the collaborative groups on the mean scores of the rubric assessing the quality of the concept maps, F = 15.58 ($p < .05$.) as seen in Table 14. The results revealed that the students who collaboratively generated concept maps significantly outscored those who individually generated concepts maps in their performance on the quality of concept maps. Cohen's *d* indicated a positive effect size (*d* = 0.91) for the comparison of the group who collaboratively generated computer-based concept maps and the group who individually generated computer-based concept maps on the quality of concept maps. Therefore, the third research question asking if the quality of concept maps generated collaboratively will exceed the quality of concept maps generated individually was answered affirmatively.

Table 14

One-Way ANOVA Summery Table for Effects of the Types of Treatment and the Rubric Scores for Assessing the Quality of Concept Maps

Source	Sum of Square	Df	Mean Square	F	Significance
Group	21496.63	1	21496.63	15.58	.00*
Error	121419.81	88	1379.77		
Effect Size (individual vs. collaborative): Cohen's *d* = 0.91					
r = 0.42					

*p < .05.

Figures 1 and 2 show examples of concept maps that students created during the study time and rubric scores for these concept maps. Each student in both the collaborative and the individual groups created concept maps in a different way with unique bubbles. Each student across groups showed logical and systematic thinking to make creative concept maps that demonstrated their meaningful learning.

These two figures were the best examples in each group. Using Figures 1 and 2, we can see that the collaborative group's concept maps showed more valid propositions and relationships between concepts and links than the individual group's concept maps. The students who created concept maps with a partner made more complex maps that included concepts, sub-concepts, and linkages that constructed propositions.

Students' Attitudes Toward Generating Concept Maps

To determine how students' attitudes toward generating concept maps during study time differed across individually-generated concept mapping groups and collaboratively-generated concept mapping groups, the researcher analyzed the Learning Strategy Questionnaire.

Students' responses to the question, "How did you feel about making concept maps that show interrelationships among concepts during study time?," "Do you think it helped you learn the content? Why or why not?," "When you create concept maps on a computer during study time, do you think that working by yourself helped you learn the content better than if you had worked with others? Why or why not?," and "When you create concept maps on a computer during study time, do you think that working with others helped you learn the content better than if you had worked by yourself? Why or why not?" in the Learning Strategy Questionnaire, were analyzed between the experimental groups (individual and collaborative).

In Table 15, the student input on the Learning Strategy Survey shows that attitudes toward concept mapping for science concept learning were quite positive. Most students agreed that concept mapping was a good technique for studying. Both 93% of the collaborative group students and 89% of the individual group students thought that creating concept maps using the computer program was helpful and useful to study science concept learning.

Their reasons are summarized as follows: Students stated that concept mapping helped them organize information leading to better understanding and the ability to answer questions easily. Concept mapping assisted them in memorizing the science concepts and helped them retain the learned concepts to prepare for an exam. Concept mapping allowed them to add, delete, revise and save their concept maps easily on computers.

Both 87% of the collaborative group and 87% of the individual group felt that making concept maps during study time was helpful and fun. Some students thought that it was more effective than a paper-based worksheet or a regular class activity. In this context, the researcher can conclude that creating concept maps using the computer program, Inspiration™, provided students with a useful learning strategy and a positive learning experience.

An interesting finding was that the students in the collaborative group were more positively engaged in their studying with a partner than the students in the individual group. Only 52% of the individual group students thought that working by themselves was helpful and useful for learning science concepts while 70% of the collaborative group students thought that working with a partner was helpful and useful to study science concepts.

The researcher inferred that students' positive attitudes toward collaboration positively influenced the results on the quality of concept maps. Additionally, using the Inspiration™ program to create concept maps during study time was a first time experience for every participant, although some students knew what concept maps were before the training.

Table 15

Learning Strategy Survey Results during Study Time

	Individual Group	Collaborative Group
Feeling about concept maps	87% of the students said helpful and fun. Some students thought better than worksheet on paper or regular class activity. 13 % No response	87% of the students said helpful and fun. Some students thought better than worksheet on paper or regular class activity. 13 % No response
Helping to learn the content	89% of the students thought concept maps helped with learning the science content. 11 % No response	93% of the students thought concept maps helped with learning the science content. 7 % No response
Opinion of working with group		70% of the students thought that working with group was helpful and useful. 20 % students thought negative. 10 % No response
Opinion of working with individual	52% of the students thought that studying by themselves was helpful and useful. 33% students thought negative. 15 % No response	
Steps of the preparing the test	Students studied their concept maps and tried to understand the relationships among the bubbles	Students studied their concept maps and tried to understand relationships among the bubbles
Exposure to concept maps before	12% had created concept maps before. 100% did not know Inspiration™ program before.	9% had created concept maps before. 100% did not know Inspiration™ program before.

Learning Strategies Used by Students Across Groups

To identify specific learning strategies used in each group to prepare for the test and to determine if they differed according to group, the researcher analyzed the Learning Strategy Questionnaire, the students' study notes, the students' concept maps, the video recording during the study time, and the researcher's reflective journal.

Students' responses to the question, "Could you describe the steps that you took to prepare for the test?" in the Learning Strategy Questionnaire, were analyzed among the three groups (control, individual, and collaborative).

When they prepared for the test, the control group students just studied the essays and read them using a marker or colored pencil to highlight or underline; while the two experimental groups' students studied the relationships between bubbles on their concept maps and links that they created with propositions as they studied (see Table 15). Both experimental groups' students said that creating concept maps and studying relationships between bubbles and links (propositions) were quite helpful, fun, and useful for learning science concepts.

Therefore, the researcher concluded that students in the control group and both experimental groups studied science concepts differently as follows:

Students in the control group studied using their own chosen learning strategies (read, highlighted, underlined, or memorized etc.). Students in both of the computer-based concept mapping groups studied by showing relationships between concepts and created visual links that reflected their own understandings of science concepts.

Students' Use of Study Time Across Groups

Some variables, such as students' activities during the prescribed study time, students' responses to the computer-based concept mapping workshops, and concept mapping activities, might have influenced the outcomes of this study. Therefore, findings from the students' study notes, the students' concept maps, the observational data, and the video recording during study time were analyzed to describe how individuals in each group used their study time and how study time behavior differed across groups.

Control group

On the first day, 40 students (11 boys and 29 girls) in the control group were told that they would not use computers but that they were part of the study, that they would receive ten minutes of instruction each of five days, and that they would study each different science topic essay each day for thirty minutes by themselves. After thirty minutes of study activity on each five days, students were told that they would receive a ten-item multiple-choice test. Several students asked the teachers whether their test would be graded. The teachers responded to them by saying that their test would be graded, and the score would be used for the teachers' reference. After ten minutes of instruction, students were asked to study the science essay using the students' own learning strategy such as highlighting, underlining, taking notes, reading, or memorizing, etc. When asked to study the provided science essay, most of the students started making noise and asked many questions related to their own learning strategy. For example, they asked questions about "Can I use my color pen?" "Can I take a note on my paper?" "Can

I underline them?” “Can I mark or circle sentences?” The teachers responded to students’ questions and engaged them in their studying. Four students studied very hard, but three students showed no interest in doing the assigned work. When the prescribed study time was over, no students requested more time to study before the test. Prior to taking the test, all students were asked to turn in their study notes and science essays.

On the second day, when asked to study the provided science essay after ten minutes of instruction, most students studied the essay without asking questions. 5-7 girls focused on highlighting and marking the sentences using many colored markers. For fifteen minutes, they engaged in studying the essay, but after that, they started to make noise and chat with peers. To the control group students, thirty minutes for study time seemed to be quite a long time because they finished studying the essay in ten or fifteen minutes.

On the third, fourth, and fifth days, many students (17-21 students) stated that studying by themselves was boring. An interesting observation was that three students asked whether they could study together. Those students said, “Can I study with A?,” “I want to study together,” “Can I have a partner?” Also, two students asked whether they could change from the control group into the experimental groups to create concept maps. They said that they wanted to study concept maps. One student said, “Can I study concept maps like Mrs. A’s class?” “Why don’t we use computers for this class?” Another student said, “ I’d like to study concept maps in the computer lab.” During thirty minutes of study time, many students were losing interest in studying and started making a lot of noise. Five to seven students bothered the other students with chatting and moving chairs. During the comprehension test, most students (34-36 students) were able to work on the test items quietly.

Individual group

On the first day, 59 students (21 boys and 38 girls) in the individual group were told that they were in the individually-generated concept mapping group, that they would receive ten minutes of teachers' instruction during five days, and that they would individually study each different science topic essay and create concept maps on the computer for thirty minutes. The teacher asked them to sit at assigned chairs that were marked by their nametag.

After thirty minutes of study activity to create concept maps by themselves, students were told that they would receive a ten-item multiple-choice test. Several students (3-4 students) asked the teachers whether their test would be graded. The teachers responded to them by saying that their test would be graded, and the score would be used for the teachers' reference. After ten minutes of instruction, students were asked to study the science essay and create concept maps using Inspiration™ by themselves. When asked to study the provided science essay, most students quietly started to read the study essay and create concept maps on their computers. A few students asked how to create concept maps or asked technical questions about the computer program. Three students did not follow the steps to engage in creating concept maps. Because of their low ability reading skill, these students did not understand the topics and themes. For example, they asked questions such as "What's the main topic?"

“I don’t understand the relationships,” “I don’t know where I start,” “What is the next step?” or “How can I put the word in a bubble?”

Most of the students (49-53 students) showed high interest in doing the assigned work. When the prescribed study time was over, four students requested more time to finish concept maps. Five students had a problem with slow typing, printing their outcome, and saving the file on the computer. When the thirty minutes of study time were over, all students saved their files in an administration folder and printed out concept maps. When students finished creating concept maps on the computer, they studied the essay and their concept maps that printed out as a final outcome to prepare for a comprehension test. Before taking the test, on each of the five days all students were asked to turn in their study notes, science essays, and concept maps generated during the five day experiment.

On the second day, when asked to study the provided science essay, most of the students (48-50 students) quietly started to read the essay and create concept maps on their computers. But, a few students (2-3 students) asked how to create concept maps, and asked technical questions about the computer program. Four students still did not follow the steps to engage in creating concept maps, and they asked for help. Most of them (52-54 students) showed high interest in doing the assigned work. Two female students stated that they had no interest in creating concept maps because they did not like to work with a computer. They made noise, talked aloud, and bothered the others. The teachers tried to make them be quite, but they still made noise and talked loudly to the others. When the prescribed study time was over, two students still requested more time to finish their concept maps. Two students had a problem with slow typing, printing their work, and saving files on their computer.

On the third, fourth, and fifth days, most of the students (48-50 students) quietly started to read the essays and to create concept maps on their computers. An interesting observation was that, as with the control group, two students asked whether they could study together with a partner. The teachers did not allow the students to work together. Still, three students had no interest in creating concept maps and made noise, talked aloud, and bothered the others. A few students (2-3 students) asked technical questions about the computer program. Two students still did not follow the steps to engage in creating concept maps, and they asked for help. Although three students still requested more time to finish concept maps, most students showed positive attitudes toward doing the assigned work and were getting better at creating concept maps within a time frame. During the comprehension test, most of students (51-54 students) were able to work on the test items quietly.

Collaborative group

On the first day, 62 students (41 boys and 20 girls) were told that they were in the collaboratively-generated concept mapping group, that they would receive ten minutes of teachers' instruction during five days, and that they would collaboratively study each different science topic essay and create concept maps on the computer for thirty minutes with a partner. Teachers organized students into pairs and asked them to sit with a partner at assigned chairs that were marked by their nametag.

The 62 students in the collaboratively-generated concept mapping group formed 31 small groups of pairs. To the extent possible, each small group consisted of one high-achieving student and one low-achieving student based on previously taken science test standard scores. The role of leader was to lead their group, type the words, and create concept maps. The role of monitor was to observe, comment, and support the leader. The roles of leader and monitor were assigned, and the role was rotated daily for five days.

After thirty minutes of creating concept maps with a partner, students were told that they would receive a ten item-multiple choice test. Several students (3-4 students) asked the teachers whether their test would be graded. The teachers responded to them by saying that their test would be graded, and the scores would be used for the teachers' reference. After ten minutes of instruction, students were asked to collaboratively study the science essay and create concept maps using Inspiration™. When asked to study the provided science essay, most of the students quietly started to read the essay and create concept maps on their computers. A few students asked technical questions about the computer program. Four students did not follow the steps to engage in creating concept maps. Because of their low ability reading skill, these students did not understand the topics and themes. For example, they asked questions about "What's the main topic?" "I don't understand the relationships," or "How can I put the word in a bubble?"

Most of the students (47-49 students) showed high interest in doing the assigned work like the individual group. When the prescribed study time was over, many students requested more time to finish their concept maps. Four students had a problem with slow typing, printing their work, and saving the files on the computer. When thirty minutes of study time were over, all students saved their files in the administration folder and printed out concept maps. When students finished creating concept maps on the computer, they studied the essay and their concept maps that printed out as a final outcome to prepare for a comprehension test. Before taking the test, all students were asked to turn in their study notes, science essays, and concept maps generated during the five-day experiment.

On the second day, when asked to study the provided science essay, most of the students (45-49 students) quietly started to read the essay and create concept maps on their computers. About five students asked how to create concept maps, and also asked technical questions about the computer program. Two students asked about changing their role from leader to monitor. Because three low-achieving students had a problem with slow typing and performing the role of leader, their role assignment did not work properly in the group. The teachers allowed two groups to change roles to make the process work as intended. Five students stated that they had no interest in creating concept maps because they did not like to work with a computer or with a partner. For example, one boy stated that he did not want to be grouped with his current partner. He wanted another boy as his partner. During group work, those students made noise, talked aloud, and bothered the others. When the prescribed study time was over, three students still requested more time to finish their concept maps. Three students had a problem with printing their work and saving the file on the computer. Most of them (52-57 students) showed high interest in doing the assigned work, although three groups had a problem with group work.

On the third, fourth, and fifth days, most of the students (45-49 students) quietly started to read the essays and to create concept maps on their computers. An interesting observation was that two students asked if they could study alone without a partner. They said that they could perform better if working alone. The teachers did not allow them to work alone. Still three students stated that they had no interest in creating concept maps and made noise, talked aloud, and bothered the others. Those students did not work together with a partner. Four students talked to other friends and did not focus on their group work although their partner worked alone to create concept maps. The teachers tried to make them engage in their collaborative work, but they did not follow the teacher's direction well. A few students asked technical questions about the computer program. Although three students still requested more time to finish concept maps, most of the students showed positive attitudes about doing the assigned work, and they were getting better at creating concept maps within a time frame. The researcher observed that students in the collaborative groups spent excessive amounts of time discussing and completing concept maps, and that some students were distracted by their partners. Generally, the collaborative students were noisier than the individual group during study time because the collaborative students discussed with a partner. During the comprehension test, most of the students (55-58 students) were able to work on the test items quietly.

Elements in the Classroom Environment and Learner Behaviors Across Groups that Contributed to the Effectiveness or Lack of Effectiveness of the Generation of Computer-based Concept Maps

Elements in the classroom environment and learner behaviors that may have contributed to the effectiveness of the computer-based drawing program to generate concept maps during study time were – (a) well-provided learning facilities (twenty wireless laptop computers, five desktop computers, two printers, a smart board, a projector, round tables, and chairs) and (b) well-organized class guidance (name tags for each group, file folders on computers for each student, and proper directions for students for choosing three colors and bubble shapes and for having their names and class periods on concept maps before printing them out).

Participants in the experimental/individual computer group and experimental/collaborative computer group were provided with technologically rich facilities. Students were taken to the computer lab in the science classroom for eight days. The school provided twenty laptop computers and five desktop computers, two printers and a projector for this study. Science teachers set up the computer lab in one of the science classrooms because the science classroom is a bigger space, and students are familiar with this workspace. The science classroom had two different spaces that consisted of the regular classroom section and the computer section. In the classroom section, there was a big white board and a smart board in front of the teacher's desk and her computer. The students' regular desks and chairs were arranged in three rows for watching the Power Point workshop and instruction. On the other side, there were eight big pentagon shaped tables. Each table had three laptop computers and each computer was connected to the printers. Also, there were five desktop computers behind the round tables in the back of the classroom. All students could access wireless laptop computers and desktop computers. Each table had students' name tags to assign them to sit individually or collaboratively.

Teachers for both experimental groups guided students through their activities in a highly organized and orderly way. Students were asked to save their work in their folders on the computers at the end of the study time and print out final concept maps. The researcher learned from the pilot study that students spent a lot of time finding their final concept maps at the printer. Therefore, during the entire eight days of the experiment, all students were told to write their names with class periods on concept maps before printing them out. Teachers and the researcher had access to students' final concept maps on the administration server.

On the first day of the experimental study session, students were excited to create concept maps. During the teachers' instruction, they wanted to move to the computer workstation to quickly create concept maps with the computer. After instruction, they rushed to their computers. The teachers continuously walked around the lab to make sure every student followed directions. Some students did not bring a pencil to the classroom, so the researcher and teachers provided those students with pencils and pens for five days. On the third day, the school Internet was down in the morning. Teachers asked students to temporally save their files in a folder on the computers with the class period and their first name. Teachers and the researcher later put the student files into the administration folder.

The structured organization of the classroom activities helped students work effectively. The two teachers delivered the concept mapping workshop and instruction using Microsoft PowerPoint™ slides, which were presented on a big Smart Board screen at the front of the classroom. During the workshop or the ten minutes of teachers' instruction, students were required to sit at their regular desks to watch the presentation. After the workshop or the ten minutes of teachers' instruction, students were asked to move to the computer workstations to create concept maps alone or in pairs. During the workshop and teachers' instruction for each unit, students had to sit at assigned chairs that were marked by their name tag.

Some simple rules for software use helped students stay on track. The researcher had learned from the pilot study that students were easily distracted by having to choose colors and bubble shapes. Because students in the pilot study spent time making choices rather than creating concept maps, some students did not complete their assignment within the time frame provided. Therefore, during the entire eight days of the experiment, all students were told to use three colors and no illustrations in their concept maps. Students were told to pick up three bubble shapes – an oval, square, cloud, diamond, or star – and three different colors that were not extremely dark or bright so that the concept maps would print out in a readable format.

Elements in the class environment and learner behaviors that may have contributed to the lack of effectiveness of the computer-based drawing program to generate concept maps during study time were – (a) video recording by the researcher, (b) distraction of Inspiration™ software (such as illustrations, choices of colors and bubble shapes), (c) use of laptop computers (preference for using desktop computers with mouse), and (d) lack of typing skill.

During three days of workshop training, students' class activities were recorded by video. The investigator set up the video equipment in the back of the classroom before students came to the classroom. The video equipment in the back of the classroom was set to automatically keep a video record of the class session. On the first day of the workshop, many students were excited to be recorded by video, and they asked some questions about video recording. Some students liked the video, and some of them disliked the video. One student said, "Are you going to show this video to X University?" Several students responded, "Don't show our video to them." "Why do you take a video recording?" Teachers and the researcher informed students about the video record that would be used to analyze students' eight days of learning activities and would not be used to show to the public. On the second day of the workshop, a few students were still concerned about the video. Three male students played with the video equipment after class or before class. After three days of the workshop, most of them were accustomed to the video recording. They seemed to accept the video recording as part of the natural environment.

The software for generating concept maps proved to be a distraction for some learners. Even though students were told to use three colors and no illustrations in their concept maps, some students still played with fancy colors and illustrations provided by Inspiration clipart.

Four students complained about the difficulty of using the laptop computer because they did not have a mouse. Several students raised their hands and expected the teachers to come to their seats and instruct them on what to do. They were not accustomed to manipulating laptop computers with their fingers, and they wanted to use a mouse. Because of one student's request, the teacher changed him to a desktop seat.

Six students were very slow typers. Most of the students (90 percent of students) did not have a problem with typing words and creating concept maps with the computer during the five days. Two male students typed using only the forefinger of their right or left hands, and they said that this slow typing process made them dislike what they had to do on the computers.

Therefore, some elements such as well-provided learning facilities and well-organized class guidance may have contributed to the effectiveness of the students in the groups that generated concept maps during study time. However, some elements such as researcher's video recording, computer illustrations and colors, slow typing, and the use of the laptop computers distracted some students from creating concept maps, although computer-based concept mapping had a strong positive effect on science concept learning.

Summary of Results

The results of the statistical analyses conducted to answer the first three research questions indicated that the 7th grade middle school students who collaboratively or individually generated computer-based concept maps significantly performed better on a comprehension test than those who did not generate computer-based concept maps. However, there was no significant difference between the individual and the collaborative groups on comprehension test scores. Additionally, the students who collaboratively generated concept maps created significantly higher quality concept maps than those who individually generated concepts maps.

The results of the qualitative analyses conducted to answer the fourth research question indicated that the attitudes toward concept mapping for science concept learning were positive. Most students agreed that concept mapping was a good technique for studying. Both the collaborative group students and the individual group students thought that creating concept maps using the computer program was helpful and useful to study science concepts. Their reasons could be summarized as follows: (a) students said that concept mapping helped them organize information leading to better understanding and the ability to answer questions easily; (b) concept mapping assisted them in memorizing the science concepts and helped them retain the learned concepts to prepare for an exam; and (c) computer assisted concept mapping was a useful technique for adding, deleting, revising and saving concept maps on computers. In summary, creating concept maps using the computer program, Inspiration™, provided students with a useful learning strategy and a positive learning experience.

An interesting finding was that the students in the collaborative group were more positively engaged in their studying than the students in the individual group. Only 52% of the individual group students thought that working by themselves was helpful and useful to study science concepts while 70% of the collaborative group students thought that working with a partner was helpful and useful to study science concepts. According to this finding, the researcher inferred that students' positive attitudes toward collaboration positively influenced the results on the quality of concept maps.

The control group students who did not generate concept maps expressed that studying alone was boring. Otherwise, most of the experimental group students showed positive attitudes toward doing the assigned work to create concept maps individually or collaboratively. However, several students in both experimental groups had a problem with slow typing, printing their work, and saving files on the computer. An interesting finding was that several students in both the experimental groups stated they had no interest in creating concept maps because they did not like to work with a computer or with a partner. Two students asked about changing their role from leader to monitor. Some students in the individual group asked whether they could study together. The researcher observed that students in the collaborative groups spent excessive amounts of time discussing and completing concept maps, and some students were distracted by their partners. Generally, the collaborative students were noisier than the individual group during study time because the collaborative students discussed with a partner. Because some students spent a lot of time picking up fancy graphics and colors while creating concept maps, all students were told to use three colors and no illustrations. But, some students still played with fancy colors and illustrations provided by Inspiration clipart. Therefore, factors such as computer illustration, colors, slow typing, and the use of the laptop computer distracted some students from effectively creating concept maps. Still, computer based concept mapping had a strong positive effect on science concept learning.

CHAPTER V

SUMMARY AND CONCLUSIONS

The findings of this study revealed that both collaboratively and individually generated computer-based concept mapping had positive effects on 7th grade middle school science concept learning. Also, the students who collaboratively generated concept maps created significantly higher quality concept maps than those who individually generated concepts maps.

In addition, this study provides insight for researchers and classroom teachers for the application of computer-based concept mapping and the importance of understanding conceptual structures for middle school science education. Collaboratively-generated concept mapping on computers can foster cognitive processes relevant for learning and high-quality knowledge construction.

This research supports previous research (Anderson-Inman & Ditson, 1999; Anderson-Inman & Horney, 1996; Anderson-Inman & Zeitz, 1993; Fischer, 1990; Hsieh & Cifuentes, 2006; Stoyanova & Kommers, 2001, 2002; Royer & Royer, 2004) that computer-based concept mapping promotes deep reflective thinking and thus aids in the construction of meaningful learning. Concept mapping tools empower learners to construct their own representations of knowledge rather than absorbing knowledge from others (Jonassen, Carr, & Yueh, 1998). Meaningful learning requires integrating new knowledge with existing knowledge and thus results in building more powerful knowledge structures. Making concept maps requires a student to identify key concepts and their relationships to one another in order to learn meaningfully (Novak, 2002).

In this study, the researcher demonstrated that concept mapping software, Inspiration™ allows students to construct concept maps for science learning and helps students capture their evolving creative ideas and organize them to promote meaningful learning. These findings extend the accumulating evidence of the effectiveness of computer-based student generated concept mapping on the improvement of students' concept understanding and furthers our understanding of collaborative learning in a computer-based environment. In addition, this study contributes to the research on computer-based concept mapping as a constructivist learning strategy.

Discussion

Within a constructivist framework, new knowledge is meaningfully constructed when learners establish connections among knowledge learned, previous experiences, and the context in which learners find themselves. In constructivist environments where students use concept-mapping tools, learners actively build their own knowledge and construct meaningful learning (Daley, 2002; Jonassen, 2000; Novak, 1998).

When students create concept maps with peers in collaboration, they discover, construct and become aware of their own cognitive structures by representing and explaining their concepts and ideas. Collaborative learning facilitates divergent ways for learners to think and prompts students to consider different perspectives of a problem. Also, collaborative learning stimulates critical and creative thinking (Stoyanova & Kommers, 2001).

According to Royer and Royer (2004), Inspiration™ is often misused as a tool for creating simple graphic organizers. Some teachers stress only the importance of adding decorative graphics instead of focusing on inserting linking words and creating valid propositions or cross links. Computer-based concept mapping provides various strategies that enhance the teaching and learning process (Anderson-Inman & Ditson, 1999). When students understand and master the strategy, concept mapping is a powerful metacognitive tool to promote meaningful learning of science concepts (Novak, 1990a, b; 2002). Therefore, the best concept mapping activities should be open ended, student-generated, and encourage revision and sharing. Concept mapping activities should focus on inserting linking words and creating valid propositions or cross-links to promote meaningful learning. Computer-based concept mapping is an effective tool for eliciting, representing and communicating knowledge in collaboration in a way that is meaningful and beneficial for all participants (Stoyanova & Kommers, 2001).

In this study, students who collaboratively generated concept maps in pairs were actively engaged in creating concept maps for science concept learning, and their performance significantly exceeded students who individually generated concept maps on the quality of concept maps. Comparing the individual group and the collaborative group on the quality of concept maps, the collaborative group's concept maps showed more valid propositions and relationships between concepts and links than the individual group's concept maps. The students who created concept maps with pairs made more complex maps that included concepts, subconcepts, and linkages that constructed propositions.

The positive effect of computer-based concept mapping on learning

The findings of this study provided further evidence that individually-generated concept mapping and collaboratively-generated concept mapping during study time positively influences science concept learning, at least for seventh graders.

Moreover, these findings support previous research (Anderson-Inman, & Horney, 1996; Boxtel, et al., 2002; Bruhn, et al., 1999; Cifuentes & Hsieh, 2003a, b; Fischer, et al., 1999, 2002; Hsieh & Cifuentes, 2006; Madrazo & Jordi, 2002) that found that visualization provides a useful cognitive strategy for retrieving information and concepts from previous learning. However, these findings only partially supported Brown's (2003) study that found that those students who collaboratively generated concept maps on paper outperformed students who individually generated concept maps in high school biology. Although he found a positive effect from collaborative concept mapping on paper, test scores for students who individually generated concept maps were not higher than those for students who did not generate concept maps.

In this study, on the other hand, the researcher found that both collaboratively and individually generated computer-based concept mapping had positive effects on 7th grade science concept learning. The researcher infers that the reason both collaboratively and individually generated computer-based concept mapping had positive effects on science concept learning was related to the positive effect of using the computer-based concept mapping tool, Inspiration™ software instead of paper-and-pencil form. According to the results of the learning strategy questionnaire, most of the experimental groups' students agreed that the computer-based concept mapping tool, Inspiration™ software was helpful, powerful and a benefit to learn science concepts.

In comparing hand drawn, paper-and-pencil concept mapping, and computer generated concept mapping, many studies support the claim that computer-based concept mapping has a positive effect on fostering knowledge representation and construction (Anderson-Inman & Ditson, 1999; Anderson-Inman & Horney, 1996; Anderson-Inman & Zeitz, 1993; Hsieh & Cifuentes, 2006; Royer & Royer, 2004). Computer-based concept mapping makes the learning process more accessible to students, and it helps alleviate the frustration felt by students while constructing concept maps using paper-and-pencil. Computer-based concept mapping using the Inspiration™ program encourages students to revise or change the maps and enables students to reflect on their understanding and construct meaningful learning.

Concept mapping in an electronic environment has become a powerful tool for visualizing and communicating and integrating in the science curriculum. Also, computer-based concept mapping helps students to make the structure of their knowledge more explicit by easily facilitating additions, deletions, and modifications of their knowledge representation. Computer-based concept mapping as a cognitive tool promotes deep reflective thinking and thus the construction of meaningful learning. Also, concept-mapping tools empower learners to construct their own representations of knowledge rather than absorbing knowledge from others. Cognitive tools are most effective when they are applied within a constructivist learning environment (Jonassen, Carr, & Yueh, 1998).

The process of visual representations facilitates both recall and comprehension (Gobert & Clement, 1999; Mayer, 1989; Mayer & Gallini, 1990). Based on findings in this study, the researcher concludes that concept mapping as a visualization tool promotes achievement of science concept learning and increases students' positive attitudes toward the content of study. Also, computer-based concept mapping enhances students' abilities to use knowledge and to draw scientifically valid inferences and conclusions.

In summary, this study showed that the groups who generated computer-based concept maps learned more meaningfully about science concepts and retained these concepts in memory better on the comprehension test than the group who did not generated concept maps. Computer-based concept mapping facilitated visual thinking and knowledge representation making concepts more accessible and less frustrating than paper based concept mapping.

The positive effect and impact of the use of collaboratively generated concept mapping on learning

Collaborative concept mapping facilitates the process of group negotiation of meaning and promotes a deeper mutual understanding between peers. Also, when interacting during concept mapping, sharing enables students to see the whole problem space as it is visualized by other group members. Peer collaboration enhances the process of critical reflection as well as creative thinking (Stoyanova & Kommers, 2001).

Collaborative learning using computer-based visualization tools has a potential to engage students in activities that facilitate the process of concept learning as follows:

verbalization and discussion of student's understanding of the concepts; collaborative reasoning with scientific concepts; the asking and answering of questions; the elaboration of conflicts; and the generation, comparison, and evaluation of explanation in groups (Boxtel, van der Linden, Roelofs, & Erkens, 2000).

The findings in this study supported Fischer, et al's (2002) assumption that collaborative knowledge construction is more effective than individual knowledge construction. This study demonstrated that the students who collaboratively generated concept maps significantly outscored those who individually generated concepts maps on the quality of concept maps. Also, both the experimental students' concept mapping on the computer during study time resulted in a significant positive effect on science concept learning. Although there was no significant difference between the individual and the collaborative groups in this group of participants on comprehension test scores, the collaboratively generated concept mapping group showed a tendency toward higher scores on the comprehension test.

According to the analysis of the video recording and observations in this study, the lack of a disciplined collaborative learning environment, the distraction of Inspiration™ software, and the lack of typing skill partially explained the lack of the effectiveness of computer-based concept mapping in the collaborative group.

The researcher inferred from the pilot study that the school environment might also partially explain the lack of effectiveness of computer-based concept mapping in the collaborative group. The school district in which the pilot study was conducted had limited technical facilities, many behavior problems among students, and most students had few opportunities to develop collaborative learning skills in their young school careers. On the other hand, the school district in which this study was conducted had better facilities, fewer behavior problems among students, and students with experience collaborating.

All participants learned concept mapping using Inspiration™ software for the first time in the context of both the pilot study and this study. This study, however, showed that the group who collaboratively generated computer-based concept maps significantly learned more about science concepts on the comprehension test than the group who did not generate concept maps. The pilot study showed that the group who collaboratively generated computer-based concept maps did not significantly outscore the control group on the comprehension test. Also, this study showed that the students who collaboratively generated concept maps significantly outscored those who individually generated concepts maps on the quality of concept maps.

In this case again, the reason that the collaborative group did not score significantly higher than the individual group on the comprehension test might have been the lack of a sufficiently disciplined, supportive collaborative working environment and the distraction of the computers and software.

The researcher observed that students in the collaborative groups spent excessive amounts of time discussing and completing concept maps, and some students were distracted by their group members. Cifuentes and Hsieh (2004) demonstrated that motivational problems among students, distraction of the computers and software, and the innate difficulty of learning the skill in a limited time contributed to the lack of the effectiveness of computer-based visualization. Also, Quinn, Mintzes, and Laws (2003) indicated that factors such as time limitation, subjectivity, student resistance, and peer resistance might also contribute to the disadvantage of concept mapping in collaborative groups.

When students have computer skills and well-organized collaboration, they can more easily construct, modify, or maintain their visualizations than they can on paper, and skilled teachers can monitor and evaluate student's understandings more effectively (Jonassen, Reeves, Hong, Harvey, & Karen, 1997; Reader & Hammond, 1994; Royer & Royer, 2004). When providing the appropriate training for students in group work, students become more responsive and active learners during group work (Ashman & Gillies, 1997).

In another school context, therefore, where students have technical skills and support, the atmosphere is more conducive to collaboration, and students have a history of collaborative experience in school, the finding may be more positive for collaboratively generated concept mapping.

Limitations of the Study

This study had several limitations. First, generalizability to a larger population is not recommended because this study had a quasi- and non-randomized experimental design. Second, the workshop materials and study essays used in this study were designed by the investigator and delivered by two science teachers to the participating students; therefore, the design of the materials and the quality of instruction might differ from that of other investigators. Third, all three groups' behaviors were contaminated by knowing that that they were part of the study. Fourth, because students were classified as either high or low achieving and each collaborative pair consisted of one high-achieving student and one low-achieving student, it’s impossible to know the effect that would be seen when including a classificaton of middle-achieving students.

Implications for Educational Practice

Given the positive effect of student-generated concept mapping using Inspiration™, students may be advised to use concept maps as a learning tool to creatively organize and integrate contents not only during study time in classrooms, but also for homework after school.

This research indicated that both individually and collaboratively generated concept mapping on science concept learning during study time is beneficial to the achievement of middle school students. Using concept maps as a learning strategy provides learners with a new metacognitive strategy in the computer-based learning environment for science concept learning. Also, through concept mapping training, when students understand how to create concept maps and master the Inspiration™ program, concept maps are powerful metacognitive tools for young students.

In addition, the qualitative findings indicate that some elements such as the researcher’s video recording, computer illustrations and colors, slow typing, and the use of the laptop computers distracted some students from creating concept maps during the days of the experiment.

If we can minimize negative elements in the environments and provide training in collaboratively generating concept maps with peers, perhaps students can learn science concepts more positively and meaningfully through computer-generated concept mapping. In another school context, therefore, where students have technical skills and support, the atmosphere may be more conducive to collaboration, and students may have a history of collaborative experience, the findings may be more positive for collaboratively generated concept mapping.

Furthermore, computer-based concept mapping can serve as the basis for a variety of strategies that enhance the teaching and learning process not only in the science curriculum, but also in other subject domains such as mathematics, history, and literature.

Implications for Future Research

Based on the results of this study, the following recommendations are suggested:

- Further research might investigate whether female and male students differentially affect learners' achievements on their science concept learning.
- Further research might investigate whether or not there is a peer learning effect and whether performance of pairs relates to individual student's achievement scores during collaboration.
- Further studies might be conducted to compare the effect of concept mapping for low-achieving students, middle-achieving students, and high-achieving students. In order to conduct such a study, concept mapping training in future studies should specifically prepare those participants to generate concept maps relevant to science content.

- It is possible that training on text interpretation during the three day workshop rather than training on concept mapping was what positively affected learning. Therefore, further studies might be conducted to determine the effect of training on text interpretation by creating a control group that does not receive training on how to interpret text and a control group that receives training on how to interpret text (without concept mapping). These groups could be compared to each other and to the experimental groups.
- Further research might investigate whether the quality of computer-generated concept maps improves differentially across individual or collaborative groups’ concept maps over the five days of the experiment.
- Further research might investigate whether individually or collaboratively computer-generated concept maps differentially affect learners with specific characteristics such as technical skills, access to technical support, and a history of collaborative experience in school.
- Given that some participants in this study were distracted by members of their group, both the classroom teachers of those students and the researcher think that training of structured collaboration work for students such as each member’s explicit role, goal, resource, interdependence and responsibility is necessary prior to treatments.
- A longer period of training that includes instruction in how to graphically represent other text structures and relationships, such as causal effect,

definition, enumeration, generalization, and classification, should be provided in future studies.

- The effectiveness of the use of concept mapping as a learning strategy may differ across developmental stages. Unsophisticated 7th graders were found to require large amounts of guidance from their teachers during study time in generating concept maps relevant to the content and in representing the conceptual structures adequately. Therefore, more research should be conducted to investigate the different impact of concept mapping on children's learning across the various developmental stages such as elementary, middle school, and high school level.
- Further studies might be conducted to compare the effect of workgroup size (i.e. pairs versus small groups) on the quality of concept maps. Possible qualitative factors might include propositions, hierarchical relationships among sub-concepts, cross links, and examples (Novak & Gowin, 1984). In order to conduct a study using quality of concept maps as a dependent variable, training in future studies should specifically prepare study participants to generate concept maps that include quality factors identified in concept mapping literature.
- It is suggested that future studies should explore the effectiveness of the use of individually-generated concept maps and collaboratively-generated concept maps as a study strategy in the hypertext Internet environment. Researchers may find a difference in the impact of linear reading of

conventional printed text in the face-to-face classroom environment and the non-linear reading of the electronically displayed, dynamic virtual environment.

- Further studies on the impact of the use of concept mapping as a study strategy in other content domains, such as history, literature, mathematics, or chemistry, should be explored. In this study, math and reading teachers showed high interest and positive attitudes when they observed students creating concept maps on science concept learning.

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APPENDIX A

TEACHER INFORMED CONSENT FORM

I understand that this study is part of a dissertation research project. My decision whether or not to give permission for my students' participation will not affect my current or future relations with Ms. Kwon and Texas A&M University. I can withdraw at any time. If I choose not to give permission for my students' participation in this study, all of their data will be removed and deleted.

I understand that I am being asked to give permission for my students' test scores, study notes, graphics, and video recording to be released along with approximately 150 other students participating in the curriculum "The comparative effect of individually-generated VS. collaboratively-generated visualization on science concept learning," conducted by So Young Kwon at Texas A&M University. Ms. Kwon plans to use this information to determine if my students learn interrelationships among concepts while creating concept maps. As part of the normal class curriculum, students participate in a workshop on creating concept maps of science concepts. They are tested on science concepts, and asked to describe how they studied for the test, not necessarily in that order. Test scores and graphics will be collected as units are completed. Ms. Kwon will be conducting the units. However, she will not be grading or scoring the work completed. There is no risk or benefit related to this study. This participation is voluntary and it will have no affect on my students' grade or class standing.

I understand that my students' grades will not be affected regardless of whether or not my students' information is released to Ms. Kwon. I understand that my students' names will not be used in any reports of the research. However, graphics that my students create may be used in reports of this research. I understand that the videotaping will be used only for this experiment. The tapes will be stored by the researcher for one year and then destroyed. After data is collected the videotapes will be destroyed.

I understand that this research study had been reviewed and approved by the Institutional Review Board-Human Subjects in Research, Texas A&M University. For research-related problems or questions regarding subjects' rights, I can contact the Institutional Review Board through Dr. Michael W. Buckley, Director of Support Services, Office of Vice President for Research at (979) 458-4067.

I may contact the researcher, Ms. So Young Kwon, at 207 Front St # D, College Station, Tx 77840, phone (979) 862-9377, email: soyoungk@neo.tamu.edu. I can also contact Dr. Lauren Cifuentes, at Mail Stop 4225, Texas A&M University, College Station, TX 77843-4225, phone (979) 845-7806, email: laurenc@tamu.edu.

I have read the above information. I have asked questions and have received answers to my satisfaction. I have been given a copy of this consent document for my records. By signing this document, I consent to participate in the study.

____ ____________________

Printed Name of Teacher Date

____ ____________________

Signature of Teacher Date

____ ____________________

Signature of Researcher Date

APPENDIX B

PARENT OR GUARDIAN INFORMED CONSENT FORM

I understand that this study is part of a dissertation research project. My decision whether or not to give permission for my child's participation will not affect my current or future relations with Ms. Kwon and Texas A&M University. I can withdraw my child at any time. If I choose not to give permission for my child's participation in this study, all of their data will be removed and deleted.

I understand that I am being asked to give permission for my child's test scores, study notes, graphics, and video recording to be released along with approximately 150 other students participating in the curriculum "The comparative effect of individually-generated VS. collaboratively-generated visualization on science concept learning," conducted by So Young Kwon at Texas A&M University. Ms. Kwon plans to use this information to determine if my child learns interrelationships among concepts while creating concept maps. As part of the normal class curriculum, students participate in a workshop on creating concept maps of science concepts. They are tested on science concepts, and asked to describe how they studied for the test, not necessarily in that order. Test scores and graphics will be collected as units are completed. Ms. Kwon will be conducting the units. However, she will not be grading or scoring the work completed. There is no risk or benefit related to this study. This participation is voluntary and it will have no affect on my child's grade or class standing.

I understand that my child's grades will not be affected regardless of whether or not my child's information is released to Ms. Kwon. I understand that my child's names will not be used in any reports of the research. However, graphics that my child's create may be used in reports of this research. I understand that the videotaping will be used only for this experiment. The tapes will be stored by the researcher for one year and then destroyed. After data is collected the videotapes will be destroyed.

I understand that this research study had been reviewed and approved by the Institutional Review Board-Human Subjects in Research, Texas A&M University. For research-related problems or questions regarding subjects' rights, I can contact the Institutional Review Board through Dr. Michael W. Buckley, Director of Support Services, Office of Vice President for Research at (979) 458-4067.

I may contact the researcher, Ms. So Young Kwon, at 207 Front St # D, College Station, Tx 77840, phone (979) 862-9377, email: soyoungk@neo.tamu.edu. I can also contact Dr. Lauren Cifuentes, at Mail Stop 4225, Texas A&M University, College Station, TX 77843-4225, phone (979) 845-7806, email: laurenc@tamu.edu.

I have read the above information. I have asked questions and have received answers to my satisfaction. I have been given a copy of this consent document for my records. By signing this document, I consent to provide permission for my child's information to be used in the study.

______________________________________ ____________________

Printed Name of Parent/Guardian Date

______________________________________ ____________________

Signature of Parent/Guardian Date

______________________________________ ____________________

Signature of Researcher Date

APPENDIX C

STUDENT ASSENT FORM

I understand that this study is part of a dissertation research project. My decision whether or not to participate will not affect my current or future relations with Ms. Kwon and Texas A&M University. If I decide to participate, I am free to refuse to answer any of the questions that may make me uncomfortable. Also, I may withdraw at any time. If I choose not to participate in this study, all of my data will be removed and deleted.

I understand that I am being asked, along with approximately 150 other students, to give permission for Ms. Kwon to use my test scores, study notes, graphics, and video recording from a special science unit in class. Ms. Kwon plans to use this information to see if I learn interrelationships among concepts while creating concept maps. As part of the normal class work, I will participate in a workshop on creating concept maps of science concepts. I will be tested on science concepts, and describe how I studied for the test (not necessarily in that order). Test scores and graphics will be collected as units are completed and are part of my normal science class work. Ms. Kwon will be conducting the units. However, she will not be grading or scoring the work completed. There is no risk or benefit related to this study. My participation is voluntary and it will have no affect on my grade or class standing.

I understand that my grades will not be affected regardless of whether or not my information is released to Ms. Kwon. I understand that my name will not be used in any reports of the research. However, graphics that I create may be used in reports of this research. I understand that the videotaping will be used only for this experiment. The tapes will be stored by the researcher for one year and then destroyed. After data is collected the videotapes will be destroyed.

I understand that this research study had been reviewed and approved by the Institutional Review Board-Human Subjects in Research, Texas A&M University. For research-related problems or questions regarding subjects’ rights, I can contact the Institutional Review Board through Dr. Michael W. Buckley, Director of Support Services, Office of Vice President for Research at (979) 458-4067.

I may contact the researcher, Ms. So Young Kwon, at 207 Front St # D, College Station, Tx 77840, phone (979) 862-9377, email: soyoungk@neo.tamu.edu. I can also contact Dr. Lauren Cifuentes, at Mail Stop 4225, Texas A&M University, College Station, TX 77843-4225, phone (979) 845-7806, email: laurenc@tamu.edu.

I have read the above information. I have asked questions and have received answers to my satisfaction. I have been given a copy of this consent document for my records. By signing this document, I consent to participate in the study.

______________________________	____________
Printed Name of Student	Date
______________________________	____________
Signature of Student	Date
______________________________	____________
Signature of Researcher	Date

APPENDIX D

LEARNING STRATEGY QUESTIONNAIRE FOR CONTROL GROUPS

1. To what extent had you been exposed before to the information in the handout about “Weathering”? (Please check one.)

    A. I knew none of the information.
    B. I knew some of the information.
    C. I knew a lot of the information.
    D. I knew all of the information.

2. To what extent had you been exposed before to the information in the handout about “The Nature of Soil”? (Please check one.)

    A. I knew none of the information.
    B. I knew some of the information.
    C. I knew a lot of the information.
    D. I knew all of the information.

3. To what extent had you been exposed before to the information in the handout about “Soil Erosion”? (Please check one.)

    A. I knew none of the information.
    B. I knew some of the information.
    C. I knew a lot of the information.
    D. I knew all of the information.

4. To what extent had you been exposed before to the information in the handout about “Erosion by Gravity”? (Please check one.)

    A. I knew none of the information.
    B. I knew some of the information.
    C. I knew a lot of the information.
    D. I knew all of the information.

5. To what extent had you been exposed before to the information in the handout about “Erosion by Glaciers”? (Please check one.)

   A. I knew none of the information.
   B. I knew some of the information.
   C. I knew a lot of the information.
   D. I knew all of the information.

6. Could you describe the steps that you took to prepare for the test?

LEARNING STRATEGY QUESTIONNAIRE FOR COLLABORATIVE GROUPS

1. To what extent had you been exposed before to the information in the handout about “Weathering”? (Please check one.)

   A. I knew none of the information.
   B. I knew some of the information.
   C. I knew a lot of the information.
   D. I knew all of the information.

2 To what extent had you been exposed before to the information in the handout about “The Nature of Soil”? (Please check one.)

   A. I knew none of the information.
   B. I knew some of the information.
   C. I knew a lot of the information.
   D. I knew all of the information.

3. To what extent had you been exposed before to the information in the handout about “Soil Erosion”? (Please check one.)

   A. I knew none of the information.
   B. I knew some of the information.
   C. I knew a lot of the information.
   D. I knew all of the information.

4. To what extent had you been exposed before to the information in the handout about “Erosion by Gravity”? (Please check one.)

   A. I knew none of the information.
   B. I knew some of the information.
   C. I knew a lot of the information.
   D. I knew all of the information.

5. To what extent had you been exposed before to the information in the handout about "Erosion by Glaciers"? (Please check one.)
   A. I knew none of the information.
   B. I knew some of the information.
   C. I knew a lot of the information.
   D. I knew all of the information.

6. How did you feel about making concept maps that showed interrelationships among concepts during study time?

7. Do you think it helped you learn the content? Why or why not?

8. When you created concept maps on a computer during study time, do you think that working with others helped you learn the content better than if you had worked by yourself? Why or why not?

9. Could you describe the steps that you took to prepare for the test?

10. Have you ever created concept maps before our workshop?
    a. Yes
    b. No

LEARNING STRATEGY QUESTIONNAIRE FOR INDIVIDUAL GROUPS

1. To what extent had you been exposed before to the information in the handout about “Weathering”? (Please check one.)

   A. I knew none of the information.
   B. I knew some of the information.
   C. I knew a lot of the information.
   D. I knew all of the information.

2. To what extent had you been exposed before to the information in the handout about “The Nature of Soil”? (Please check one.)

   A. I knew none of the information.
   B. I knew some of the information.
   C. I knew a lot of the information.
   D. I knew all of the information.

3. To what extent had you been exposed before to the information in the handout about “Soil Erosion”? (Please check one.)

   A. I knew none of the information.
   B. I knew some of the information.
   C. I knew a lot of the information.
   D. I knew all of the information.

4. To what extent had you been exposed before to the information in the handout about “Erosion by Gravity”? (Please check one.)

   A. I knew none of the information.
   B. I knew some of the information.
   C. I knew a lot of the information.
   D. I knew all of the information.

5. To what extent had you been exposed before to the information in the handout about “Erosion by Glaciers”? (Please check one.)
   A. I knew none of the information.
   B. I knew some of the information.
   C. I knew a lot of the information.
   D. I knew all of the information.

6. How did you feel about making concept maps that showed interrelationships among concepts during study time?

7. Do you think it helped you learn the content? Why or why not?

8. When you created concept maps on a computer during study time, do you think that working by yourself helped you learn the content better than if you had worked with others? Why or why not?

9. Could you describe the steps that you took to prepare for the test?

10. Have you ever created concept maps before our workshop?
    a. Yes
    b. No

APPENDIX E

COMPUTER USE SURVEY

Class: ____________ Name:_______________

I am:

a. Female
b. Male

My age is:

a. 12
b. 13
c. 14
d. Over 14.

1 How often do you use a computer AT SCHOOL?

A. Very frequently (generally daily)
B. Frequently (regularly, at least weekly)
C. Sometimes (when required)
D. Seldom (just a few times)
E. Never

2 When you use a computer AT SCHOOL, what is the average amount of time that you spend at the computer?

A. No time
B. Less than 1 hour
C. 1 to 2 hours
D. 3 to 4 hours
E. More than 4 hours

3 How many computer courses have you taken in the past?

A. None
B. 1 course
C. 2 courses
D. 3 courses
E. Over 3 courses

4 How often do you use a computer AT HOME?

A. Very frequently (daily)
B. Frequently (regularly, at least weekly)
C. Sometimes (when required)
D. Seldom (just a few times)
E. Never

5 When you use a computer AT HOME, what is the average amount of time that you spend at the computer?

A. No time
B. Less than 1 hour
C. 1 to 2 hours
D. 3 to 4 hours
E. More than 4 hours

6 How often do you create computer graphics (e.g. graphs, diagrams, maps, tables, trees) when you study the science textbooks?

A. Very frequently (daily)
B. Frequently (regularly, at least weekly)
C. Sometimes (when required)
D. Seldom (just a few times)
E. Never

7 How frequently have you used the computer for the following tasks?

(Circle one number for each task.)

Home/school	Never	Seldom (just a few times)	Sometimes (when required)	Somewhat Frequently (regularly, at least weekly)	Very Frequently (generally daily)
	1	2	3	4	5
Word Processing	1	2	3	4	5
WWW or Internet	1	2	3	4	5
E-mail	1	2	3	4	5
Chatting	1	2	3	4	5
Games	1	2	3	4	5
Spreadsheets	1	2	3	4	5
Presentations	1	2	3	4	5
Programming	1	2	3	4	5
Graphic or Drawing	1	2	3	4	5
Web Page Development	1	2	3	4	5

APPENDIX F

UNIT 1. WEATHERING - COMPREHENSION TEST

Identify the letter of the choice that best completes the statement or answers the question.

____1. All of the following cause mechanical weathering EXCEPT_______.

a. Ice
b. tree roots
c. burrowing animals
d. carbonic acid

____2. Chemical weathering is more rapid in a _____________climate.

a. warm, dry
b. warm, wet
c. cold, dry
d. cold, wet

____3. The difference between mechanical and chemical weathering is __________.

a. the length of time each takes to break up a rock
b. that only chemical weathering involves water
c. the way they affect the makeup of a rock
d. all of the above

____ 4. How do chemical weathering processes differ from mechanical weathering processes?

a. Chemical weathering processes break rocks into smaller pieces but physical weathering processes do not.
b. Chemical weathering processes affect igneous rocks but physical weathering processes do not.
c. Chemical weathering processes involve water but physical weathering processes do not.
d. Chemical weathering processes change the mineral composition of the rock but physical weathering processes do not.

____5. Ice wedging is brought about by _______.

a. carbonic acid freezing on rocks
b. water freezing and thawing
c. water and oxygen reacting
d. rocks colliding with each other

____6. In wet climates, granite weathers more slowly than ____________________.

a. Marble
b. Feldspar
c. Kaolinite
d. Calcite

____7. When water mixes with carbon dioxide gas in the air or soil, ______forms.

a. carbonic acid
b. lactic acid
c. calcite
d. oxygen

____ 8. Weathering breaks rock into smaller pieces (such as sand, silt and clay) called __________.

a. Soil
b. Fossil
c. Climate
d. Sediment

____9. Mechanical weathering is more rapid in a __________climate.

a. Dry
b. Cold
c. Hot
d. Humid

____10. The rate of weathering depends upon the area's _________.

a. Oxygen
b. Water
c. Soil
d. Climate

UNIT 2. THE NATURE OF SOIL - COMPREHENSION TEST

Identify the letter of the choice that best completes the statement or answers the question.

____ 1. Soil is a mixture of weathered rock, mineral fragment, water, air and _________.

a. Sand
b. decayed organic matter
c. Moss
d. Clay

____ 2. The layer of soil that contains the most organic material is called the _________horizon.

a. A
b. B
c. C
d. D

____ 3. Litter often covers the _________ horizon.

a. A
b. B
c. C
d. D

____ 4. The organic matter in humus is made of _________.

a. dead worms
b. Roots
c. Stems
d. all of the above

____ 5. _________affect the development of soil and cause different soils to have different characteristics.

a. The climate in the area
b. The slope of the land
c. Length of time the rock has been weathering
d. all of the above

___ 6. Mineral found in the B horizon were dissolved in water and carried there by a process called _________.

a. Oxidation
b. Leaching
c. Weathering
d. Littering

____ 7. The _____ horizon has smaller rock and mineral particles than the other layers.

a. A
b. B
c. C
d. D

____ 8. ___________is a factor that affects soil development.

a. Time
b. Slope
c. Types of rock
d. All of the above

____ 9. The B horizon is ______________________.

a. rockier than the C horizon
b. richer in humus than the A horizon
c. lighter than the A horizon
d. thicker than the C horizon

____ 10. The _____ horizon is the thickest soil horizon that contains only partly weathered rock without clay or humus.

a. A
b. B
c. C
d. D

UNIT 3. SOIL EROSION - COMPREHENSION TEST

Identify the letter of the choice that best completes the statement or answers the question.

____ 1. Soil erosion can be slowed by __________.

a. no-till farming
b. cutting trees from the middle of fields
c. plowing at least three times a year
d. farming on steeper slopes

____ 2. On steep slopes and mountains, __________helps reduce erosion by creating level areas for crops.

a. a shelter belt
b. strip cropping
c. Mulching
d. Terracing

____ 3. At construction sites, workers often reduce erosion by __________________.

a. covering exposed ground
b. spraying water on bare soil
c. Terracing
d. Both A and B

____ 4. __________turns and loosens soil, improving it for crops, but leaves soil vulnerable to erosion.

a. Grazing
b. No-till farming
c. Plowing
d. Terracing

____ 5. Soil erosion occurs __________________.

a. where animals eat away all the plants
b. when forests are removed
c. on steep slopes
d. all of the above

____ 6. When farmers leave plant stalks in the field to reduce soil erosion, it is called__________________.

a. contour farming
b. Plowing
c. no-till farming
d. Terracing

____ 7. When farm animals eat the glass on land until there is almost no ground cover, it is called__________________.

a. contour farming
b. Plowing
c. Overgrazing
d. no-till farming

____ 8. Planting along the natural slope of the land to reduce soil erosion is called_____________.

a. contour farming
b. Plowing
c. Overgrazing
d. no-till farming

____ 9. Farmers can reduce soil erosion by____________.

a. contour farming
b. planting shelter belts of trees
c. no-till farming
d. all of the above

____ 10. Plants don't grow as well when ________ has been lost.

a. Clay
b. Topsoil
c. parent rock
d. Slope

UNIT 4. EROSION BY GRAVITY - COMPREHENSION TEST

Identify the letter of the choice that best completes the statement or answers the question.

____ 1. Agents of__________ deposit sediments when they lose their energy of motion.

a. Deflation
b. Abrasion
c. Erosion
d. Plucking

____ 2. Agents of erosion include with ______________.

a. Water
b. Wind
c. Glacier
d. all of above

____ 3. The process that lays down sediment in a new location is ________.

a. Deposition
b. Abrasion
c. Erosion
d. Plucking

____ 4. _______ is very slow movement of sediment down a slope.

a. Creep.
b. Deposition
c. Slump
d. Mudflows

____ 5. Landslides, mudflows, slump, and creep are all examples of________ .

a. mechanical weathering.
b. runoff.
c. mass movement.
d. soil formation.

____ 6. Mass movement is caused by ____________ .

a. abrasion
b. gravity.
c. chemical weathering
d. erosion and deposition

____ 7. Mass movements do not include ____________.

a. Slump
b. Creep
c. Plucking
d. Rockfalls

____ 8. ________ is a thick mixture of water and sediments flowing downhill.

a. Creep
b. Deposition
c. Slump
d. Mudflows

____ 9. _______ are mass movements that can be a combination of mass movement.

a. Mudflows
b. Rockfalls
c. Landslides
d. Slump

____ 10. ________ happens when loose materials or rock layers slips down along a curved surface.

a. Mudflows
b. Rockfalls
c. Landslides
d. Slump

UNIT 5. WIND - COMPREHENSION TEST

Identify the letter of the choice that best completes the statement or answers the question.

____ 1. When people plant vegetation, they ______ erosion.

a. reduce
b. increase
c. start
d. do not affect

____ 2. Erosion caused by the sandblasting effect of windblown sediments is called _________.

a. deflation
b. abrasion
c. loess
d. outwash

____ 3. ____________ form(s) when sediments are blown against an obstacle and settle behind it.

a. Loess
b. Dunes
c. Eskers
d. Till

____ 4. Which one are windblown deposits of fine-grained sediments?

a. Loess
b. Dunes
c. Eskers
d. Outwash

____ 5. ______occurs when wind erodes only fine-grained sediments, leaving coarse sediments behind .

a. deflation
b. abrasion
c. loess
d. dunes

____ 6. A clump of grass, a small bush, or a rock can act as the obstacle around which a(n)__________ will start to form.

a. loess
b. dunes
c. eskers
d. till

____ 7. The polishing and pitting of rocks by windblown particles is called __________.

a. Deflation
b. Abrasion
c. Loess
d. Dunes

____ 8. Wind erodes Earth's surface by ___ __.

a. deflation
b. abrasion
c. sandstorms
d. All of above

____ 9. Put the following stages of dune formation using numbers one through five.

____	A mound of sand is formed.
____	Sediments settle behind the obstacle.
____	Wind blows sediment against an obstacle.
____	More and more sediments build up.

a. 4,2,1,3
b. 4,1,3,2
c. 4,2,3,1
d. 4,1,2,3

____ 10. The shapes and orientations of _____can provide clues about the prevailing wind directions.

a. Deflation
b. Abrasion
c. Loess
d. Dunes

APPENDIX G

UNIT 1 – WEATHERING

< Weathering >

The chemical and physical processes that break down rock on Earth's surface called **weathering**. Two different types of weathering - **Mechanical weathering** and **chemical weathering** - work together to shape Earth. Weathering breaks rock into smaller pieces, such as sand, silt and clay. These smaller, loose pieces are called **sediment**. These sediments change gradually into soil.

< Mechanical weathering >

Mechanical weathering is **the physical process** that breaks rocks into fragments without changing the rocks chemical compositions. Each fragment keeps the same characteristics as the original rock. **Growing plants, burrowing animals, and expanding ice wedging** are important agents of mechanical weathering.

For example, **tree roots** can grow beneath a sidewalk, cracking the concrete and pushing it up and also can grow into cracks in rock, breaking them apart.

Small animals mechanically weather rock when they burrow by breaking apart sediment and moving it to the surface.

Ice wedging occurs in cold climates where water enters cracks in rocks and freezes. When water enters freezes, it expands, causing the cracks to enlarge and the rock to break apart.

Mechanical weathering by plants, animals, and ice wedging reduces rocks to smaller pieces. These small pieces have more surface area than the original rock body.

< Chemical weathering >

Chemical weathering is the chemical reaction that dissolves minerals in rock or changes the composition of rocks into different minerals. **Natural acids, plant acids and oxygen** are important agents of chemical weathering.

For example, acidic water can dissolve rock or certain minerals within a rock. When water mixes with carbon dioxide, gas in the air or soil, a weak acid, called **carbonic acid**, forms.

Some plants cause chemical weathering by **secreting acids**.

Exposure to **oxygen** causes some rocks to weather, forming rustlike minerals. For instance, **oxidation** occurs when metallic materials are exposed to oxygen and water over a prolonged period of time.

< Effect of Climate >

Climate is the pattern of weather that occurs in a particular area over many years. Climate can affect the rate of weathering in different parts of the world. **Chemical weathering** is more rapid in **warm, wet climates**. **Mechanical weathering** is more rapid than chemical weathering in **cold climates**.

Rock type also can affect the rate of weathering in a particular climate. In a wet climate, for example, **marble** weathers more rapidly than **granite**.

UNIT 2 – THE NATURE OF SOIL

< Formation of Soil >

Soil is a mixture of rock **and mineral fragments, organic matter, air, and water**. Five different factors affect soil formation: **(a) climate, (b) slope of land, (c) types of rock, (d) types of vegetation, and (e) length of time that rock** has been weathering .

< Composition of Soil >

Composition of soil is the ingredient that makes up soil. Soil develops as rock is weathered and organic matter is added by organisms. Clay, silt, and sand are small particles of sediment.

Decaying, dark-colored plant and animal material is called **humus**. **Humus** serves as a source of nutrients for plants. Small spaces between soil particles may be filled with **air or water.**

< Soil Types >

Climate, parent rock, slope of the land, type of vegetation, and the time that rock has been weathering affect the development of soil and cause different soils to have different characteristics.

< Soil Profile >

Soil Profile is made up of different layers of soil. These different layers of soil are called horizons. Soil has **horizons** that differ in their color and composition. **The three soil horizons** are the A horizon, the B horizon, and the C horizon.

The A horizon is made up of **topsoil**, a crumbly, dark brown soil that is a mixture of humus, clay, and other minerals. **Topsoil** has more humus and fewer rock and mineral particles than the other layers. The A horizon might be covered with litter. **Litter** consists of leaves, twigs, and other organic materials that eventually can be changed to humus by decomposing organisms.

The B horizon, often called **subsoil**, usually consists of clay and other particles washed down from the A horizon, but little humus. It is lighter in color than the A horizon. **Leaching** is the removal of minerals that have been dissolved in water. The process of leaching removes materials from the upper layer of soil, the A horizon. Much of this material then is deposited in the B horizon.

The C horizon contains only partly weathered rock without clay or humus. It is often the thickest soil horizon and is the bottom horizon in a soil profile.

UNIT 3 – SOIL EROSION

Soil erosion or loss is important because plants do not grow as well **when topsoil is lost**. If topsoil is eroded, soil becomes much less fertile.

< Causes and Effects of Soil Erosion >

Many human activities disturb the natural balance between soil production and soil erosion. For example, (a) **Agricultural cultivation** or **increased farming** removes the plant cover, leaving soils open to wind and water erosion. (b) **Plowing** mechanically turns and loosens the soil, improving it for crops, but leaving soil vulnerable to erosion. (c) **Forest harvesting** removes forests, which increases erosion and particularly damages tropical rain forest soil. (d) **Overgrazing** results when animals graze until almost all ground cover disappears. (e) **Urban construction** clears land of vegetation and removes soil.

< Preventing Soil Erosion >

Soil is a resource that must be managed and protected. People can do several things to conserve soil.

(a) Manage crops – Farmers **plant shelter belts of trees** to break the force of the wind and **cover bare soils with decaying plants** to hold soil particles in place. In a dry area, instead of plowing under vegetation, many farmers **graze animals** on the vegetation.

With **no-till farming**, plant stalks are left in the field to provide cover for soil.

(b) Reduce erosion on slope – Contour farming reduces soil erosion by planting along the natural slope of land or the contours of slopes.

Terracing creates level areas or steep-sided flat areas for crops on the sides of hills and mountains.

(c) Reduce erosion at construction sites – Exposed ground is covered with mulch, mats, or plastic coverings. Water is sprayed onto bare soil to reduce wind erosion.

UNIT 4 – EROSION BY GRAVITY

< Erosion and Deposition >

Erosion is a process that wears away surface materials and moves them from one place to another. **Agents of erosion *drop the sediments*** they are carrying as they lose energy. This is called **deposition**. When sediments are eroded, they are not lost from Earth. They are just relocated.

Agents of erosion include **gravity, water, wind and glaciers.**

< Mass Movement >

A mass movement is any type of erosion that happens as **gravity** moves materials down a slope as one large mass.

Some mass movements are so slow that you hardly notice they're happening. Others happen quickly--possibly causing catastrophes.

Common types of mass movement include l**andslides, slumps, creeps, rockfalls, rock slides, and mudflows**.

(a) Landslides are mass movements that can be one of these types or a combination of these mass movements.

(b) Slumps are materials slipping down a curved surface as one large mass**.**

(c) Creeps occur when sediments slowly shift their positions downhill. Creeps are common in areas of freezing and throwing.

(d) **Rockfalls** happen when blocks of rock break loose from a steep slope and tumble through the air.

(e) Rock slides occur when layers of rock slip downslope suddenly.

(f) Mudflows are a thick mixture of water and sediments flowing downhill.

UNIT 5 – EROSION BY WIND

< Wind Erosion >

Wind erodes Earth's surface by (a) **deflation** and (b) **abrasion**.

Deflation occurs when wind erodes only fine-grained sediments, leaving coarse sediments behind. The pitting and polishing of rocks and grains of sediment by windblown sediment is called **abrasion.** Abrasion is similar to **sandblasting**. **Sandstorms and dust storms** also are parts of wind erosion.

< Reducing wind erosion >

The ways to slow or stop wind erosion is to **plant vegetation.** Plants with fibrous root systems, such as grasses, work best at stopping wind erosion.

< Deposition by Wind >

Wind deposits include (a) **loess and** (b) **dunes.**

Loess consists of fine-grained particles that are tightly packed.

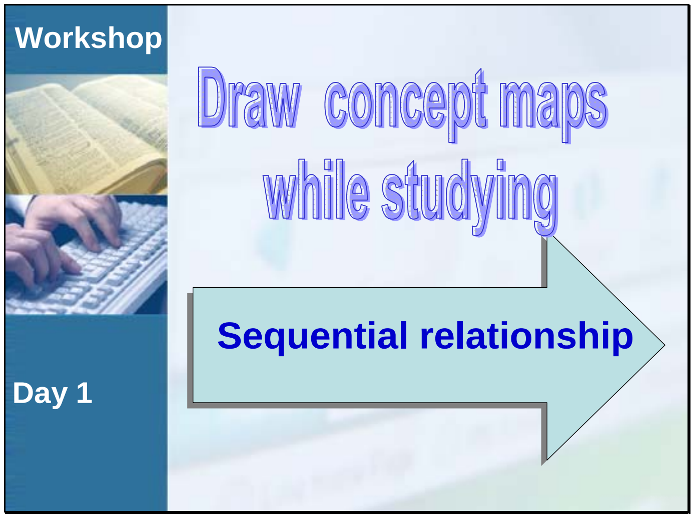
Dunes form when windblown sediments accumulate behind an obstacle such as a clump of grass, a small bush, or a rock. A dune is a mound of sediment drifted by the wind. Dunes are common landforms in desert regions. The shapes and orientations of dunes can provide clues about the prevailing wind directions in an area.

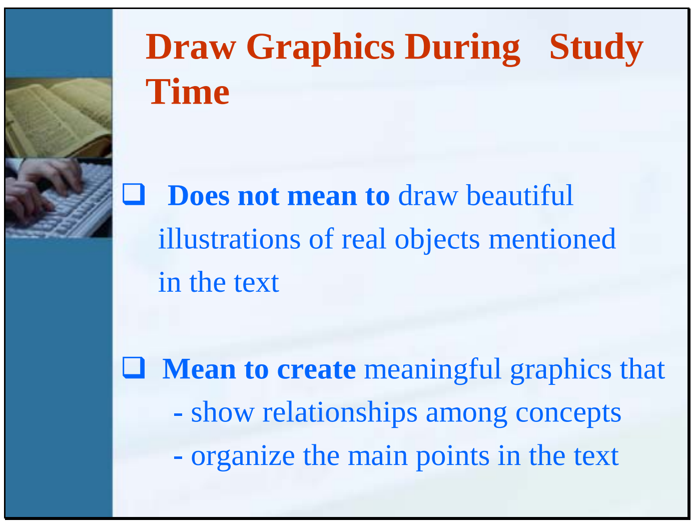
< How dunes form >

There are **four stages** of dune formation. First, wind blows sediment against an obstacle. Second, sediments settle behind the obstacle. Third, more and more sediment builds up. Finally, a mound of sand is formed.

APPENDIX H

WORKSHOP TRAINING – SEQUENTIAL STRUCTURE





Your Graphics Should …

- Organize the important ideas of the texts
- Show the relationships among concepts
- Be of appropriate quantity
- Be able to use for test review

Why draw graphics while studying?

- Good study strategy
  - Help you remember
  - Help you understand
  - Improve test scores
- Become independent and good learners

How to create meaningful conceptual graphics?

1. Read the science text briefly
2. Find the important paragraphs
3. Identify the text structures of those paragraphs (i.e. sequence, compare-contrast, categorical, etc.)
4. Use proper graphic organizers (flowcharts, tables, concept maps) to show the interrelationships among concepts

How to identify the text structures of science text?

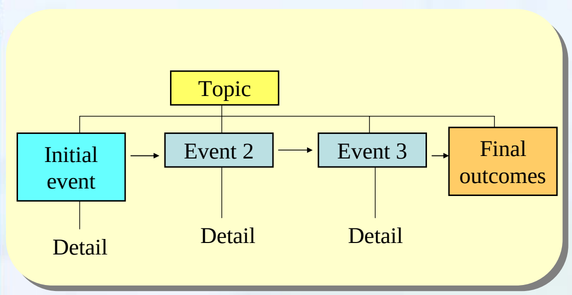
❑ **Sequential relationship:**

- Describe a continuous and connected series of events or the steps in a process.
- Signal words (clues): stages, process, phases, steps, etc.

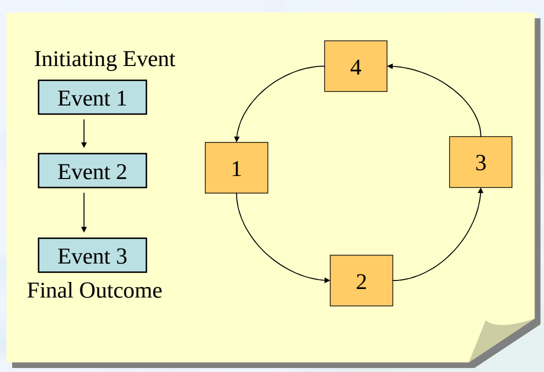
Use proper graphic organizers

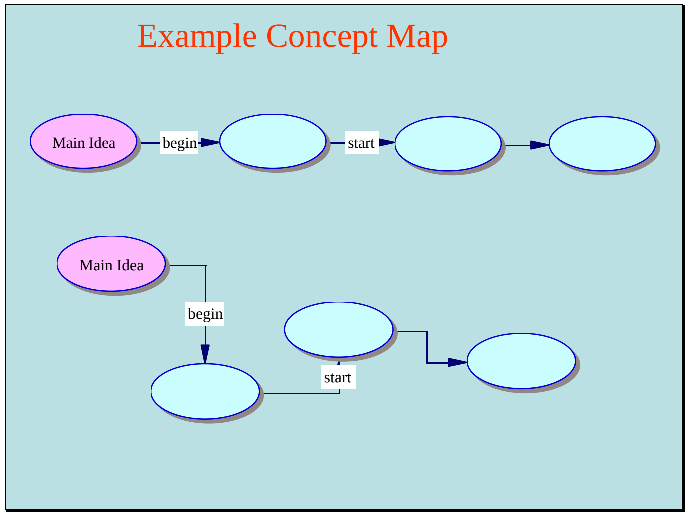
- **Sequential relationships:**

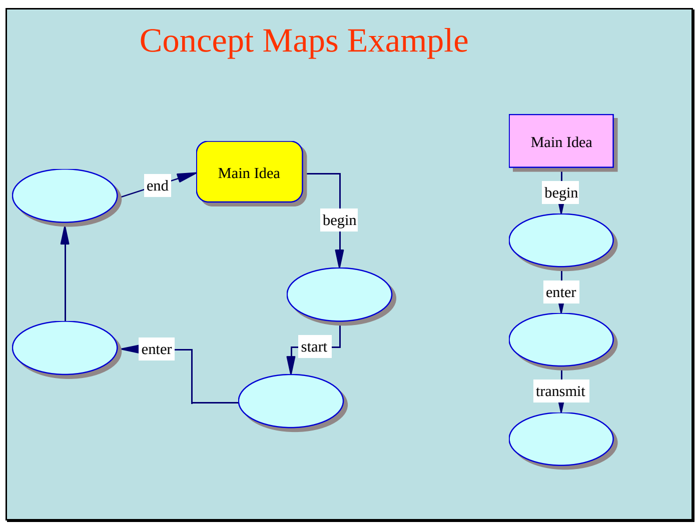
< flowchart >

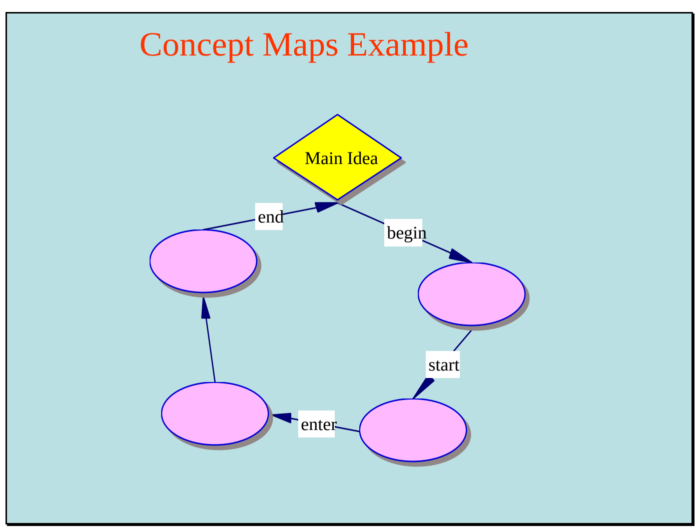


Sequential relationships:




Example Concept Map
Main Idea
begin
start
Main Idea
begin
start


Concept Maps Example
Main Idea
end
begin
start
enter
Main Idea
begin
enter
transmit

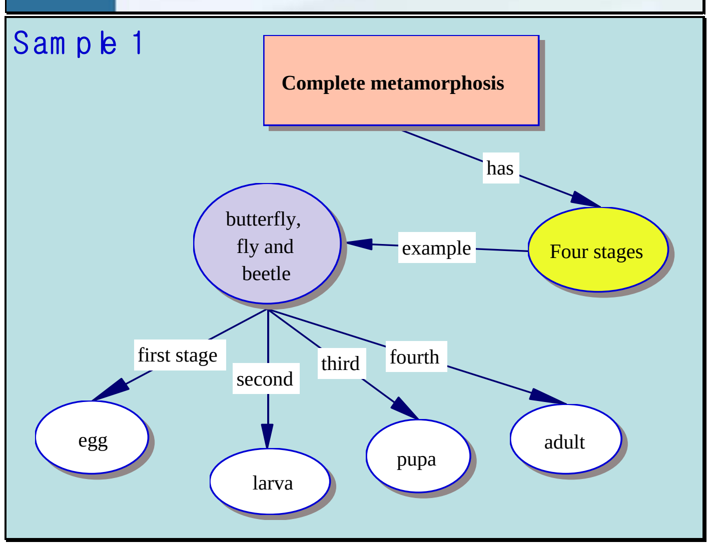

Concept Maps Example
Main Idea
end
begin
start
enter

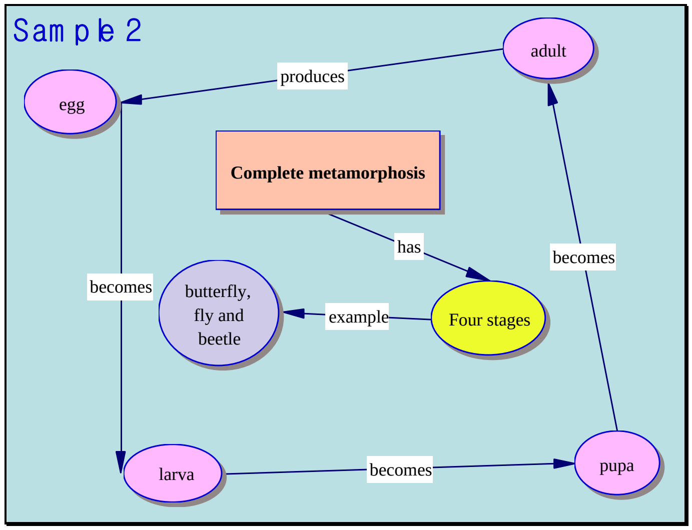
- **Let's see how the teacher draws conceptual graphics for sequential relationships.**
- **Then, it is Your Practice Time!**

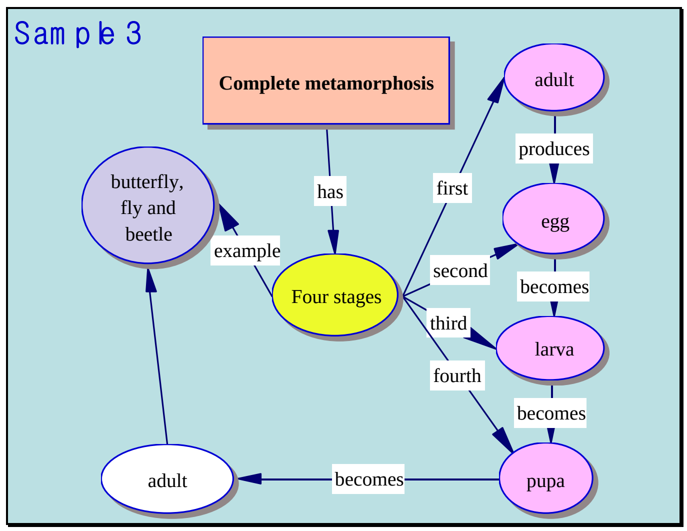
Sequential relationships:

Example 1

The life-history of the butterfly, fly and beetle is made of four stages, egg, larva, pupa, and adult. These insects show complete metamorphosis.





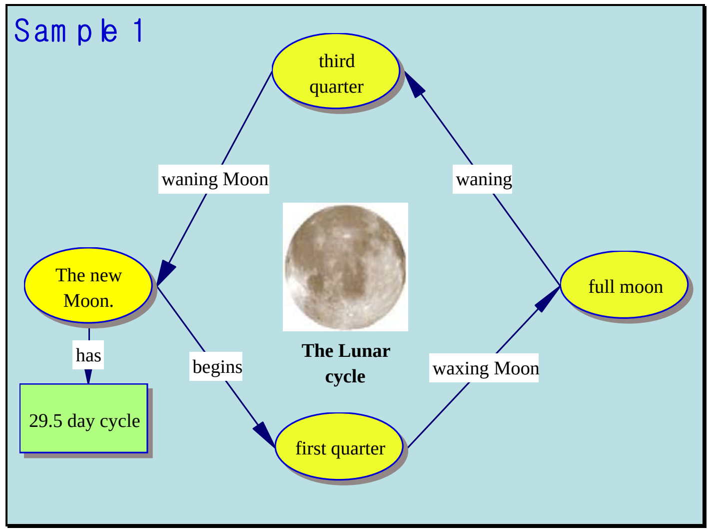


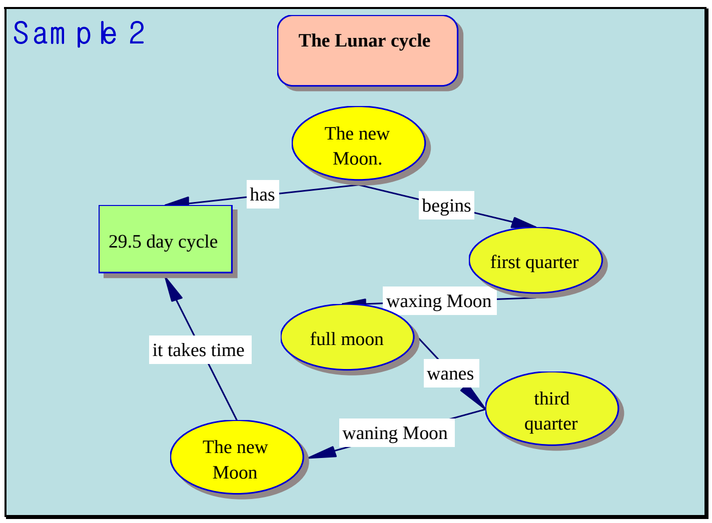
Sequential relationships:

Example 2

The Lunar cycle

A regular cycle in the Earth-moon system produces the phases of the moon. The lunar cycle begins with **the new moon**. Then, each night, the moon reflects sunlight from more and more of the moon's surface. The moon is said to "**wax**", or grow. When half of the moon' Earth-facing side is lit by the sun, the moon is said to be in its **first quarter**. Then a **full moon** occurs. After the full moon, the moon begins to **wane**, or decrease gradually in size. When just half of the moon's Earth-facing side is visible, the moon is in its **third quarter**. Then, 29.5 days after the last new moon, the moon can no longer be seen from the Earth.





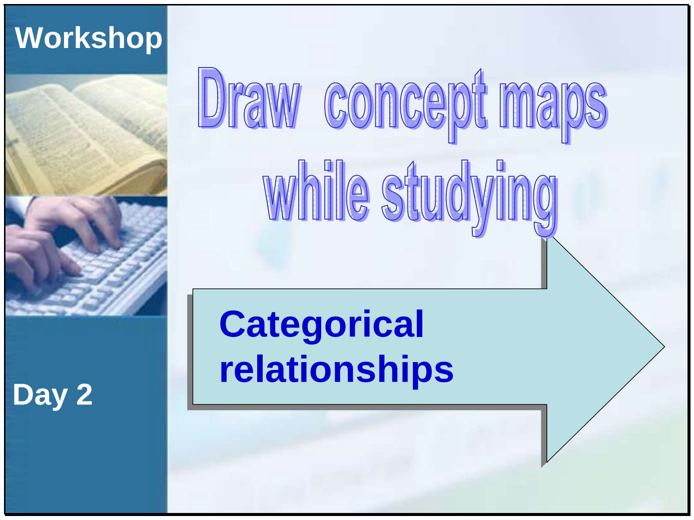
Let's Practice

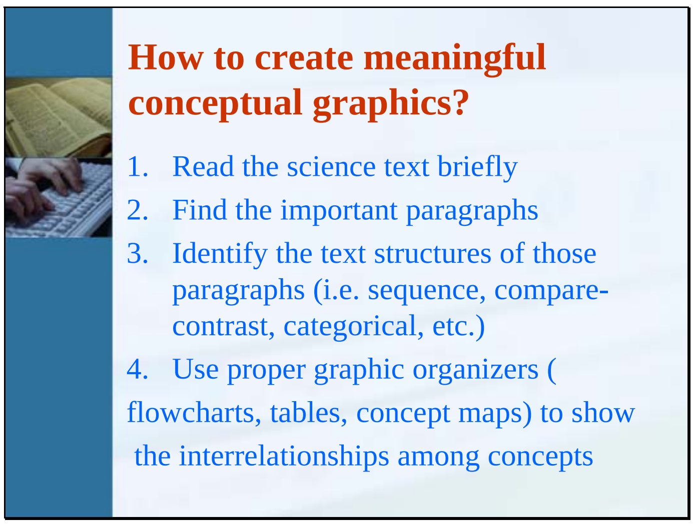
The Eye – An Organ System

The eye is the organ of sight. Light enters through the cornea and pupil, passes through the lens, and strikes the retina. The optic nerve then transmits signal to the brain.

APPENDIX I

WORKSHOP TRAINING – CATEGORICAL STRUCTURE





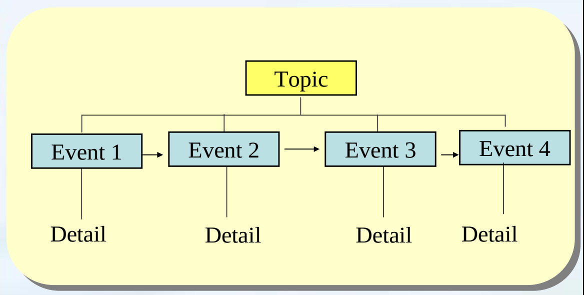
How to identify the text structures of science text?

❑ **Categorical relationships:**

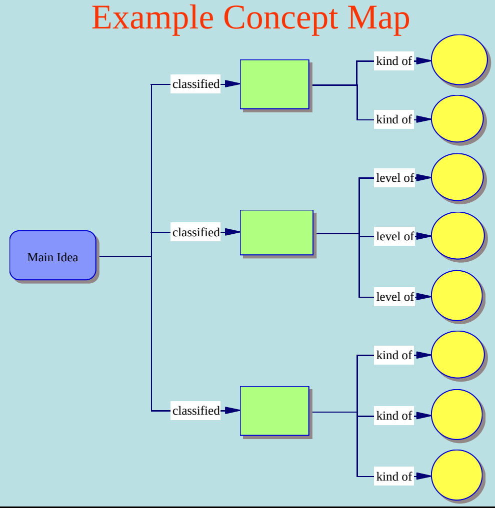
- Arrange or organize passage information according to type or category.
- Such passages begin with a topic that is divided according to the number of types or categories within the particular topic.
- Signal words (clues): classified, types of, kinds of, levels of… etc.

Use proper graphic organizers

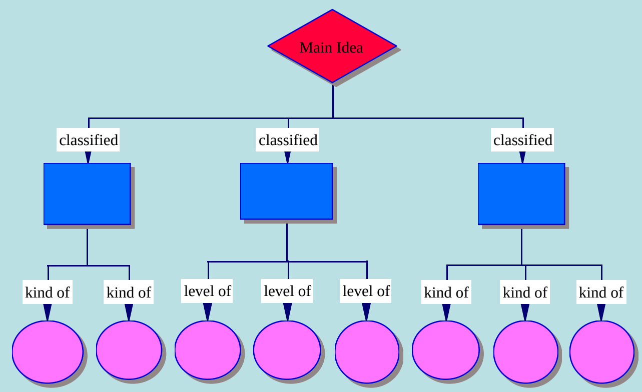
- categorical relationships:



Example Concept Map



Example Concept Map



- **Let's see how the teacher draws conceptual graphics for Categorical relationships.**

- **Then, it is Your Practice Time!**

Categorical Relationship:

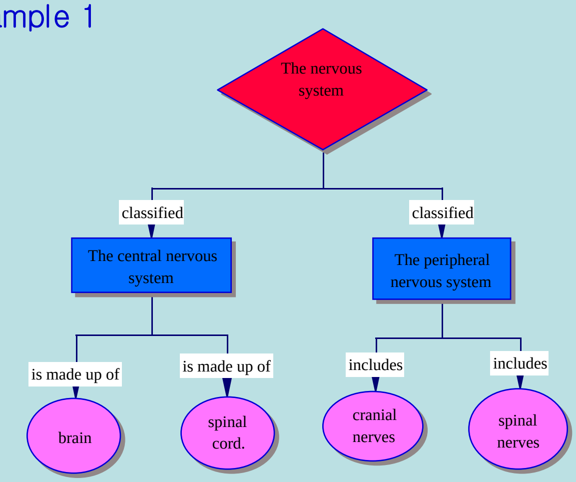
Example 1

The nervous system

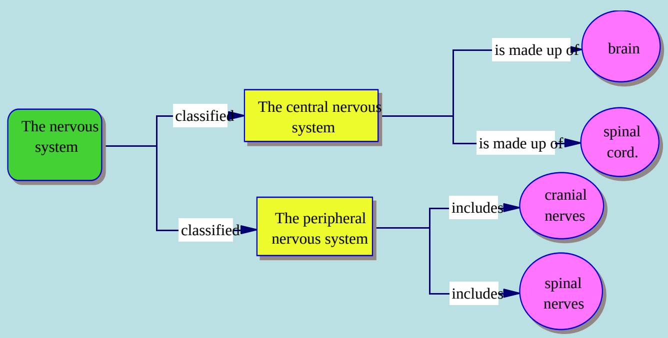
The central nervous system (CNS) is made up of the brain and spinal cord.

The peripheral nervous system is made up of all the nerves outside the CNS. These include the nerves in your head, called cranial nerves, and spinal nerves, which are nerves that come from your spinal cord.

Sample 1



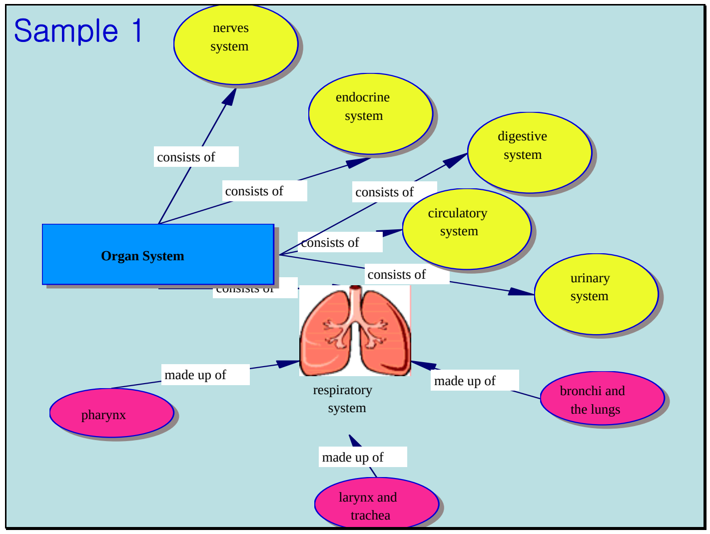
Sample 2

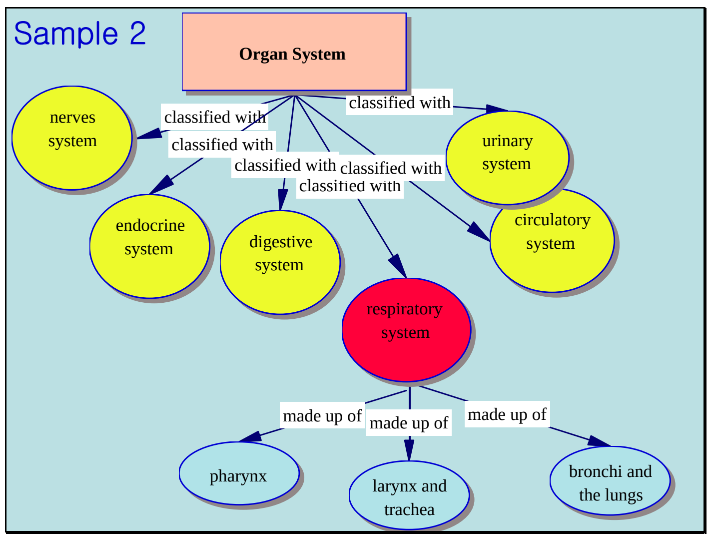


Categorical Relationship: Example 2

A group of organs that work together to do a certain job is called an **organ system** such as <u>nervous, endocrine, circulatory, respiratory, digestive, and urinary system.</u>

<u>Organs of the respiratory system are made up of pharynx, larynx and trachea, bronchi and the lungs.</u>





Let's Practice

<u>Muscle Tissue</u>

The three types of muscles are skeletal, smooth, and cardiac.

(a) Skeletal muscles

Skeletal muscles are the muscles that move bones. These muscles are voluntary muscles and have the striation.

Let's Practice

(b) Smooth muscles

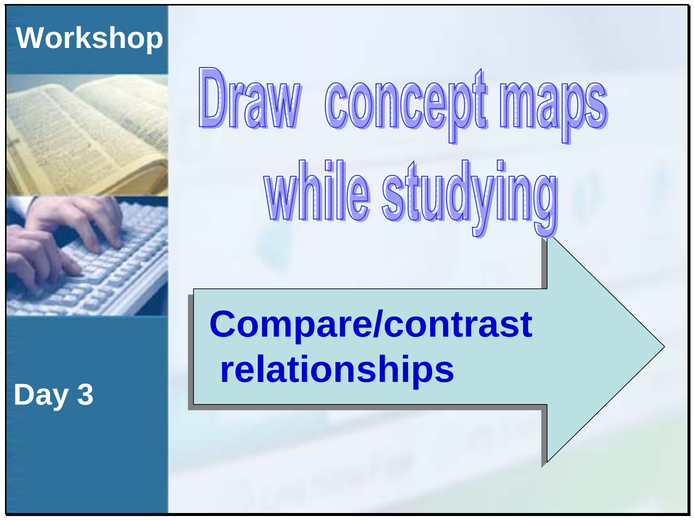
Smooth muscles are nonstriated, involuntary muscles that slowly contract and relax. Smooth muscles are found in your intestines, bladder, blood vessels, and other internal organs.

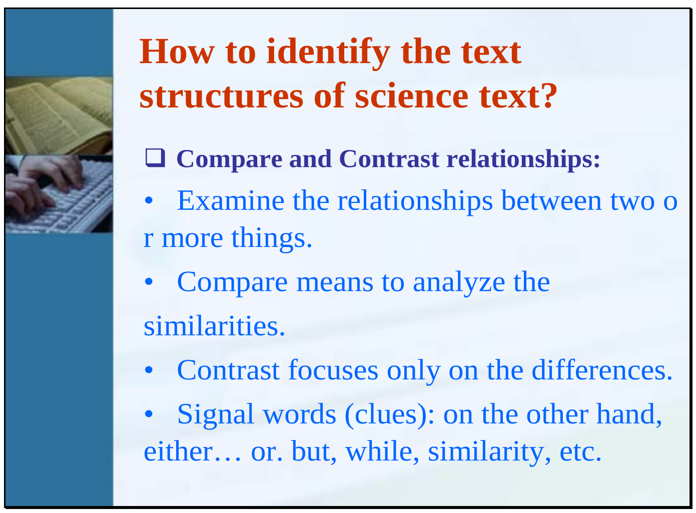
(c) Cardiac muscle

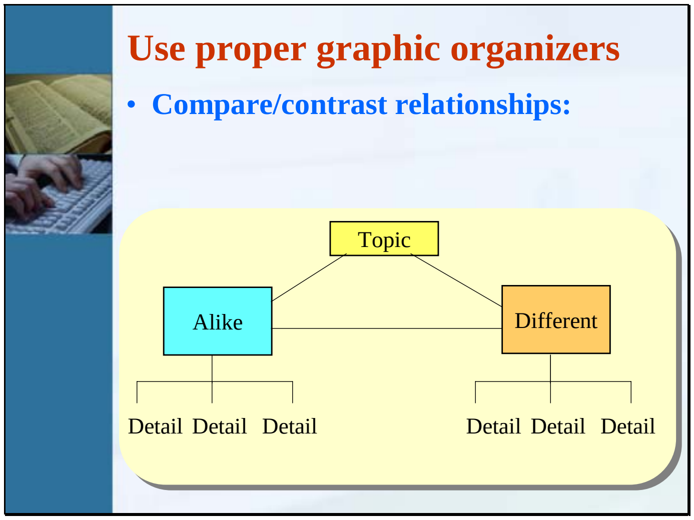
Cardiac muscle is found only in the heart. Like skeletal muscles, the cardiac muscle has striation but the heart is an involuntary muscle.

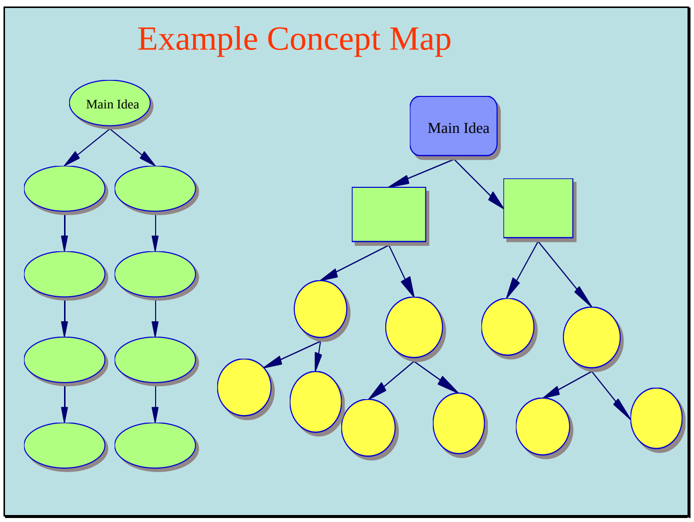
APPENDIX J

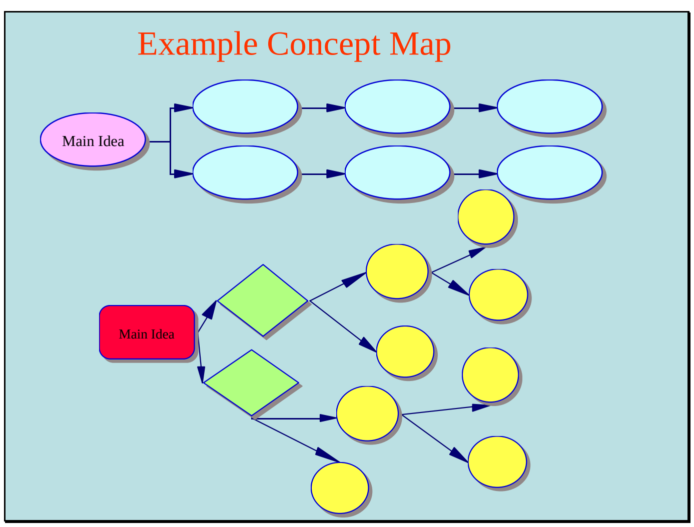
WORKSHOP TRAINING – COMPARE/CONTRAST STRUCTURE






Use proper graphic organizers
• Compare/contrast relationships:
Topic
Alike
Different
Detail Detail Detail
Detail Detail Detail


Example Concept Map
Main Idea
Main Idea


Example Concept Map
Main Idea
Main Idea

- **Let’s see how the teacher draws conceptual graphics for Compare/contrast relationships.**
- **Then, it is Your Practice Time!**

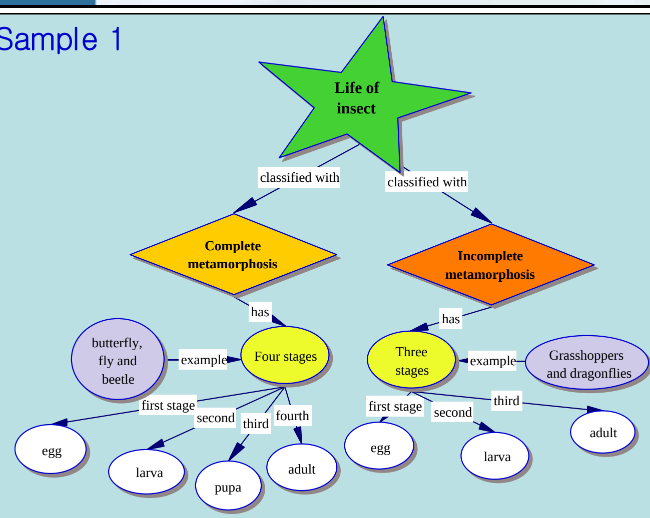
Compare/contrast relationships:

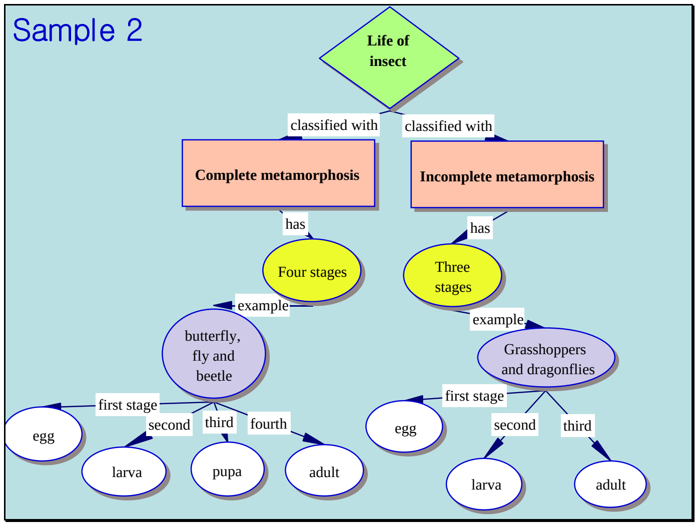
Example 1

The life-history of the butterfly, fly and beetle is made of four stage, egg, larva, pupa, and adult. These insects show complete metamorphosis.

Otherwise, the larva stage resembles a caterpillar or worm. In the pupa stage, the insect lives in its cocoon. Grasshoppers and dragonflies are examples of insects that go through incomplete metamorphosis in which insects show three stages, egg, larva, and adult. In the larva stage the insect looks like a small adult insect.

Sample 1





Compare/contrast relationships:

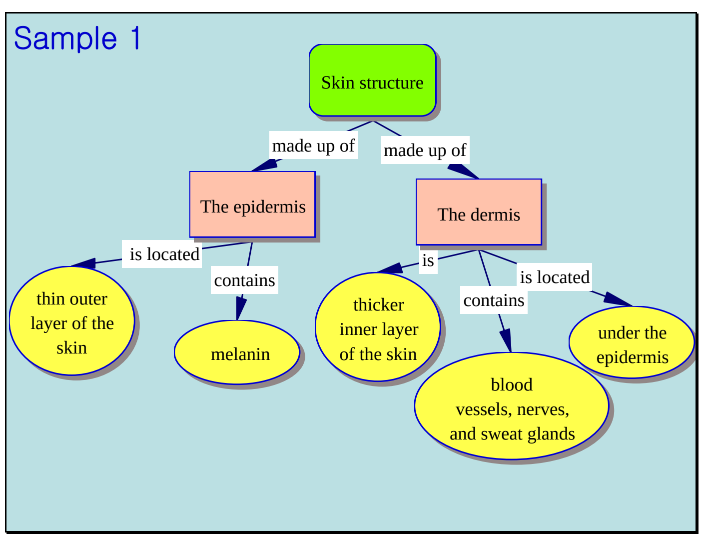
Example 2

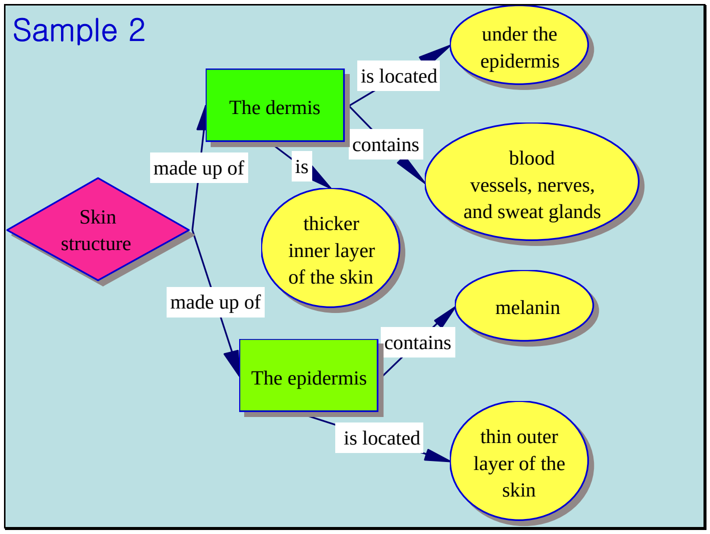
Skin Structure

Skin is made up of two layers of tissue – the epidermis and the dermis.

Epidermis is the thin outer layer of the skin. It contains melanin.

Dermis is the thicker inner layer of the skin under the epidermis. It contains many blood vessels, nerves, and sweat glands.





Let’s Practice

Joints

Joints are broadly classified as immovable or movable.

Immovable Joints

An immovable joint allows little or no movement. The joints of the bones in your skull and pelvis are classified as immovable joints.

Let’s Practice

Movable Joints

A movable joint allows the body to make a wide range of motions. There are several types of movable joints--pivot, ball and socket, hinge, and gliding.

Base of skull, shoulder, hip, elbow, knee, finger, wrist and ankle are examples of movable joints.

APPENDIX K

PROCEDURES FOR EXPERIMENTAL GROUPS

	Day 1 50 minutes treatment	Day 2 50 minutes treatment	Day 3 50 minutes treatment	Day 4 50 minutes treatment	Day 5 50 minutes treatment
Group	Task	Task	Task	Task	Task
Collab-orative Group	Maximum 10 minutes: Providing PowerPoint instruction on “Weathering” Maximum 30 minutes: Study the expository text on “Weathering” and **collaboratively** construct concept maps on computers with **a partner** during study time Maximum 10 minutes: 10 items multiple choice comprehension test	Maximum 10 minutes: Providing PowerPoint instruction on “The Nature of Soil” Maximum 30 minutes: Study the expository text on “The Nature of Soil” and **collaboratively** construct concept maps on computers with **a partner** during study time Maximum 10 minutes: 10 items multiple choice comprehension test	Maximum 10 minutes: Providing PowerPoint instruction on “Soil Erosion” Maximum 30 minutes: Study the expository text on “Soil Erosion” and **collaboratively** construct concept maps on computers with **a partner** during study time Maximum 10 minutes: 10 items multiple choice comprehension test	Maximum 10 minutes: Providing PowerPoint instruction on “Erosion by Gravity”. Maximum 30 minutes: Study the expository text on “Erosion by Gravity” and **collaboratively** construct concept maps on computers with **a partner** during study time. Maximum 10 minutes: 10 items multiple choice comprehension test	Maximum 10 minutes: Providing PowerPoint instruction on “Erosion by Winds” Maximum 30 minutes: Study the expository text on “Erosion by Winds” and **collaboratively** construct concept maps on computers with **a partner** during study time Maximum 10 minutes: 10 items multiple choice comprehension test
Individ-ual Group	Maximum 10 minutes: Providing PowerPoint instruction on “Weathering” Maximum 30 minutes: Study the expository text on “Weathering” and **individually** construct concept maps on computers during study time Maximum 10 minutes: 10 items multiple choice comprehension test	Maximum 10 minutes: Providing PowerPoint instruction on “The Nature of Soil” Maximum 30 minutes: Study the expository text on “ The Nature of Soil” and **individually** construct concept maps on computers during study time Maximum 10 minutes: 10 items multiple choice comprehension test	Maximum 10 minutes: Providing PowerPoint instruction on “Soil Erosion” Maximum 30 minutes: Study the expository text on “Soil Erosion” and **individually** construct concept maps on computers during study time Maximum 10 minutes: 10 items multiple choice comprehension test	Maximum 10 minutes: Providing PowerPoint instruction on “Erosion by Gravity” Maximum 30 minutes: Study the expository text on “Erosion by Gravity” and **individually** construct concept maps on computers during study time Maximum 10 minutes: 10 items multiple choice comprehension test	Maximum 10 minutes: Providing PowerPoint instruction on “Erosion by Winds” Maximum 30 minutes: Study the expository text on “Erosion by Winds” and **individually** construct concept maps on computers during study time Maximum 10 minutes: 10 items multiple choice comprehension test

PROCEDURES FOR CONTROL GROUPS

Day	Day 1 50 minutes treatment	Day 2 50 minutes treatment	Day 3 50 minutes treatment	Day 4 50 minutes treatment	Day 5 50 minutes treatment
Group	Task	Task	Task	Task	Task
Control Group	Maximum 10 minutes: Providing PowerPoint instruction on “Weathering” Maximum 30 minutes: Study the expository text on “Weathering” **independently** and follow their own learning strategies during study time Maximum 10 minutes: 10 items multiple choice comprehension test	Maximum 10 minutes: Providing PowerPoint instruction on “The Nature of Soil” Maximum 30 minutes: Study the expository text on “The Nature of Soil” **independently** and follow their own learning strategies during study time. Maximum 10 minutes: 10 items multiple choice comprehension test	Maximum 10 minutes: Providing PowerPoint instruction on “Soil Erosion” Maximum 30 minutes: Study the expository text on “Soil Erosion” **independently** and follow their own learning strategies during study time Maximum 10 minutes: 10 items multiple choice comprehension test	Maximum 10 minutes: Providing PowerPoint instruction on “Erosion by Gravity” Maximum 30 minutes: Study the expository text on “Erosion by Gravity” **independently** and follow their own learning strategies during study time Maximum 10 minutes: 10 items multiple choice comprehension test	Maximum 10 minutes: Providing PowerPoint instruction on “Erosion by Winds” Maximum 30 minutes: Study the expository text on “Erosion by Winds” **independently** and follow their own learning strategies during study time Maximum 10 minutes: 10 items multiple choice comprehension test

APPENDIX L

COMPUTER USE SURVEY RESULTS

Group Survey Questions	Control Group	Individual Group	Collaborative Group
Use computers at school			
Very frequently	18 %	19 %	18 %
Frequently	12 %	13 %	14 %
Sometimes	60 %	58 %	60 %
Seldom	10 %	8 %	6 %
Never	0 %	2 %	2 %
Time spent at school computers			
No time	3 %	1 %	5 %
Less than 1 hour	60 %	56 %	52 %
1 to 2 hours	25 %	32 %	30 %
3 to 4 hours	10 %	8 %	11 %
More than 4 hours	2 %	3 %	2 %
Numbers of computer courses taken			
None	50 %	48 %	52 %
1 course	32 %	34 %	33 %
2 courses	13 %	9 %	10 %
3 courses	3 %	6 %	3 %
Over 3 courses	2 %	3 %	2 %
Frequency –use of computer at home			
Very frequently	40 %	35 %	38 %
Frequently	33 %	36 %	33 %
Sometimes	12 %	10 %	12 %
Seldom	5 %	7 %	6 %
Never	10 %	12 %	11 %
Time spent at home computers			
No time	9 %	13 %	11 %
Less than 1 hour	45 %	47 %	44 %
1 to 2 hours	37 %	34 %	35 %
3 to 4 hours	6 %	4 %	7 %
More than 4 hours	3 %	2 %	3 %

Frequency – create computer graphics			
Very frequently	2 %	1 %	2 %
Frequently	3 %	5 %	3 %
Sometimes	40 %	36 %	41 %
Seldom	30 %	28 %	29 %
Never	25 %	30 %	25 %
Frequency – Word			
Very frequently	10 %	14 %	11%
Frequently	38 %	35 %	32 %
Sometimes	40 %	35 %	47 %
Seldom	10 %	13 %	9 %
Never	2 %	3 %	1 %
Frequency – Internet			
Very frequently	15 %	20 %	14 %
Frequently	38 %	35 %	39 %
Sometimes	40 %	37 %	40 %
Seldom	5 %	6 %	5 %
Never	2 %	2 %	2 %
Frequency – E-mail			
Very frequently	15 %	19 %	18 %
Frequently	8 %	10 %	13 %
Sometimes	25 %	23 %	24%
Seldom	15 %	13 %	15 %
Never	37 %	35 %	30 %
Frequency – Chatting			
Very frequently	8 %	5 %	3 %
Frequently	17 %	23 %	20 %
Sometimes	19 %	18 %	24 %
Seldom	25 %	20 %	19 %
Never	31 %	29 %	34 %
Frequency – Games			
Very frequently	38 %	42 %	40 %
Frequently	34 %	30 %	31 %
Sometimes	13 %	10 %	15 %
Seldom	8 %	13 %	10 %
Never	7 %	5 %	4 %

Frequency – Spreadsheets			
Very frequently	10 %	6 %	9 %
Frequently	7 %	15 %	8 %
Sometimes	26 %	30 %	26 %
Seldom	20 %	18 %	29 %
Never	37 %	31 %	28 %
Frequency – Presentations			
Very frequently	10 %	11 %	10 %
Frequently	12 %	11 %	11 %
Sometimes	25 %	26 %	26 %
Seldom	35 %	34 %	34 %
Never	18 %	18 %	19 %
Frequency – Programming			
Very frequently	1 %	0 %	0 %
Frequently	2 %	1 %	3 %
Sometimes	7 %	8 %	6 %
Seldom	19 %	20 %	24 %
Never	71 %	71 %	67 %
Frequency – Webpage			
Development	2 %	1 %	3 %
Very frequently	5 %	4 %	5 %
Frequently	3 %	2 %	4 %
Sometimes	25 %	27 %	24 %
Seldom	65 %	64 %	64 %
Never			

VITA

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- M.Ed., Elementary English Education as ESL, 2000, Chung-Ju National University of Education, South Korea.
- B.A., Education, 1998, Chung-Ju National University of Education, South Korea.

EXPERIENCE:

Graduate Assistant for Texas A&M University

Educational Media Service Center (EdMS), College Station, TX

- Assisted in Texas A&M Library-based instructional development operations including web design, graphic design, poster design, and brochure design.
- Provided technical training to librarians and performed management and development of web design/ Photoshop/ Flash MX / Illustration/ Director/ Authorware / Dreamweaver/ Camtasia Studio/ Premiere Pro/ Studio MX/ Media Studio Pro 7/ Sound Forge Studio/ Spin Panorama 2.0 and multimedia projects. [Available for detail project information in: http://people.tamu.edu/~soyoungk]
- Performed and delivered graphic design, web design, video production, and instructional design on various internal corporate presentations and external client-driven projects.

Teaching Experience

- Training and collaborating library staff, Texas A&M University, 2001-2005.
- Visiting Teacher, Navasota Junior High School, Navasota, TX, April-May 2005.
- Visiting Teacher, Hearne Junior High School, Hearne, TX, December 2004.
- Elementary School Teacher, TeaJun-Jayang, South Korea, 1998-2000.
- Teaching Graduate Assistant, Chung-Ju National University of Education, South Korea, graduate level, 1999.
- Teaching English as Bilingual at Private Institute, Tea-Jun, South Korea, 1998.