THE INSTRUCTIONAL EFFECTS OF PRIOR KNOWLEDGE AND THREE CONCEPT MAPPING STRATEGIES IN FACILITATING ACHIEVEMENT OF DIFFERENT EDUCATIONAL OBJECTIVES

A Thesis in
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by
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ABSTRACT

The purpose of this study was to explore the instructional effects of prior knowledge and three concept mapping strategies in facilitating achievement of different educational objectives. The three concept mapping strategies were concept matching, proposition identifying, and student-generated concept mapping. The instructional material used for the study was a 2,000-word expository text about the physiology and functioning of the human heart. The prior knowledge levels of the subjects were identified through a general physiology test. Achievement was measured by the identification, terminology, and comprehension tests and the total test. The criterion tests were designed to measure achievement of different educational objectives at factual, conceptual, and rules and principles levels and general academic performance of university undergraduate students.

The experimental population included 290 undergraduate students from a large comprehensive state university. The subjects completed the prior knowledge test, and participated in a 50-minute workshop on concept mapping one week prior to the experimental treatment. The experiment was conducted in a web-enhanced learning environment. The subjects browsed the given study website, interacted with the online learning material, and then, took the three criterion tests online and submitted the test results. The concept mapping activities were completed on paper. From four experimental treatments (T1: control, n = 42; T2: concept matching mapping, n = 50; T3: proposition identifying mapping, n = 44; and T4: student-generated concept mapping, n = 46), 182 sets of data were used for hypothesis testing by using MANOVA with the alpha level set at .05.
The findings include the following:

In examining the main effects of concept mapping, the three concept mapping strategies were found to be not equally effective in facilitating achievement of different educational objectives. Significant differences were found between concept matching mapping (T2) and the control group (T1) on all of the criterion tests. Significant differences were also found between student-generated concept mapping (T4) and the control group (T1) on the terminology and the total criterion tests. When comparing achievement of students receiving concept mapping strategies (T2, T3, and T4), insignificant differences were found to exist on all criterion measures.

Among the subjects identified as possessing low prior knowledge, concept matching mapping (T2) achieved significantly higher scores than the control on all of the criterion tests. Student receiving proposition identifying mapping strategy (T3) achieved significantly higher scores than the control group (T1) on the criterion test of terminology and on the total test. The student-generated concept mapping treatment (T4) achieved significantly higher score than the control (T1) on the terminology criterion test. Regarding the significant differences found on the terminology criterion test, concept matching mapping (T2) was the most effective and student-generated concept mapping (T4) was the least effective.

Among the subjects identified as possessing high prior knowledge, significant differences were found in achievement only between concept matching mapping (T2) and the control group (T1) on all of the criterion tests.

There was no significant interaction between levels of prior knowledge and concept mapping treatment types on any of the criterion tests in this study.
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Chapter 1

INTRODUCTION

Learning is a fascinating phenomenon that has been the target of study for many centuries. People study it from various perspectives and their endeavors have resulted in different theories about learning. Despite all of the differences, these learning theories share the same goal -- to better our understanding of what learning is, how the learning takes place, and, ultimately, how the learning can be enhanced and improved. This dissertation reflects my efforts to explore this fascinating phenomenon of learning. It is about the instructional effects of prior knowledge and three concept mapping strategies in facilitating achievement of different educational objectives.

Statement of Problem

Cognitive learning theory contends that learning is a potential change resulting from information processing (Walker, 1996). Information processing is the theoretical framework for describing the mental events that occur in humans as information in the form of stimulus is received, processed, and either stored for later use or lost (R. Gagne, 1985). How the information is processed during learning influences information retrieval and recall and, consequently, the ability of the learner to apply the information in his/her later use.

Ausubel (1968) proposed assimilation theory and advocated meaningful learning. Meaningful learning is a process in which learners purposefully relate the perceived new
information to an existing relevant aspect of their knowledge structures. Meaningful
learning, according to Ausubel (1968), occurs when a learner consciously links new
knowledge to what the learner already knows and makes that piece of information
“meaningful” to himself.

What a learner already knows prior to instruction is sometimes defined as prior
knowledge. Jonassen and Grabowski (1993) defined prior knowledge as the ability,
knowledge, and skills possessed by the learner before instruction. This prior knowledge is
stored in existing mental models or schemata and used in the interpretation and
assimilation of new knowledge (Anderson, 1984; Driver, 1988).

During learning, various learning strategies can be applied to assist information
processing. Concept mapping is one of them. “A concept map is a schematic device for
representing a set of concept meanings embedded in a framework of propositions”
(Novak & Gowin, 1984, 15). Concept maps are most commonly defined as graphic
representations of knowledge of a domain. A concept map consists of a set of nodes
representing concepts, objects, or actions connected by directional links that define the
relationships between and among those nodes (Alpert & Grueneberg, 2000). In concept
maps, concepts are arranged hierarchically so that the most inclusive, general concepts
appear at the top of the map, with less inclusive, subordinate concepts below (Jonassen &
Grabowski, 1993; Jonassen, Beissner, & Yacci, 1993; Novak, 1990a, 1998; Plotnick,
1997, 2001). Concept mapping in this dissertation is a learning strategy that helps
learners to learn through the use or creation of concept maps.

Novak (1990b) outlined four valuable ways that concept maps can be used to
improve learning and teaching in science classrooms: (1) as a learning strategy, (2) as an
instructional strategy, (3) as a tool in the instructional design process, and (4) as a means to assess the student’s understanding of science concepts.

Studies of concept mapping as a tool to facilitate learning are extensive and diverse. One group of the studies focuses on the effects of concept maps used in different formats. Examples include the instructor-provided concept map versus student-completed or student-generated concept map (Jo, 2001; Smith & Dwyer, 1995; Wang, 1995); individual concept mapping versus group concept mapping (Brown, 2000); and hand drawn versus computer generated concept maps (Sturm, 1996). The second group of studies compares and contrasts the effects of concept maps with those of other learning strategies. Examples for this group of studies are comparing and contrasting concept mapping with note-taking, outlining (Keng, 1996), post-questioning, and feedback (Naidu, 1991). The third group of concept map studies focuses on effects of concept maps when they are applied in specific learning domains and with specific groups of people. Examples in this group are the studies of concept mapping in science classrooms (Green, Ritchie, & Volk, 2000; Spaubling, 1989) and concept mapping with low-achieving inner-city seventh graders (Guastello, Beasley, & Sinatra, 2000) and with nursing students (Roop, 2002).

Among the extensive and diverse studies, research on the appropriate use of concept mapping strategies regarding their effectiveness and their relationship with students’ prior knowledge in facilitating the achievement of specific learning objectives is limited. It is necessary to implement an experiment to find out what type of concept mapping strategy is most effective and appropriate to use in order to achieve specific educational objective.
In general, concept map development consists of three important elements: the concepts, propositions and its hierarchical structure. By controlling and manipulating these variables in concept mapping, it is hypothesized that different levels of cognitive processes will be affected and therefore instigate different levels of information processing.

**Purpose of Study**

The purpose of this dissertation study is to explore the instructional effects of prior knowledge and three concept mapping strategies in facilitating achievement of different educational objectives. Specifically, the three concept mapping strategies are (1) concept matching mapping; (2) proposition identifying mapping, and (3) student-generated mapping. The learning material used in this study is a meaningful 2000-word expository text describing the human heart including its parts, locations and functions during systolic and diastolic phases. The learning material was developed by Dwyer (1965) together with the criterion tests for the purposes of measuring different educational objectives. The different educational objectives are (1) identifying parts and positions of an object; (2) defining and paraphrasing terms and concepts; and (3) differentiating and analyzing complex processes from a written text.

**Research Questions**

This study addresses the following questions:

**Q1:** Are different types of concept mapping strategies equally effective in facilitating student achievement of different educational objectives measured by the different criterion tests?
Q2: Are there any significant differences in achievement among students identified as possessing high and low prior knowledge receiving different treatments on the different criterion tests?

Q3: Is there a significant interaction between levels of prior knowledge and instructional treatment type on the different criterion tests?

Hypotheses

It is possible to answer the above research questions by testing the following hypotheses.

Ho 1: There are no significant differences in achievement among students receiving different concept mapping treatments on the criterion tests measuring different educational objectives.

Ho 2: There are no significant differences in achievement among students identified as possessing high and low prior knowledge receiving different concept mapping treatments on the criterion tests measuring different educational objectives.

Ho 3: There is no significant interaction between levels of prior knowledge and instructional treatment type on the criterion tests measuring different educational objectives.
Significance of the Study

Although concept maps are generally effective and robust as a tool to facilitate learning (Winn & Snyder, 1996), it cannot be assumed that all concept mapping strategies work equally well under all conditions in achieving all kinds of learning objectives. Dwyer (1978) points out that instruction and its assessment must be in alignment with instructional objectives if the instruction is meant to be effective and efficient and the assessment is meant to be valid. Beissner, Jonassen, and Grabowski (1994), in their discussion of the graphic techniques in learning, maintain that when different graphic techniques are used as learning tools, different cognitive processes are elicited, which result in different learning outcomes.

With different learning objectives to achieve, the effective uses of concept mapping should be those that instigate certain levels of cognitive processes as required to produce the desired learning outcomes. Prior research on concept mapping did not provide us with sufficient evidence in this regard. It is unclear which concept mapping strategies (concept matching, proposition identifying, and student-generated concept mapping strategies) should be used to be most effective and efficient in facilitating achievement of specific learning objectives, and what the relationships are between the selected concept mapping strategies and students’ prior knowledge level in instruction. Therefore, implementation of this study is significant in examining the critical relationships in using concept mapping strategies. Theoretically, the study will add empirical evidence to the effective use of concept mapping strategies and their relationships with students’ prior knowledge. For educational practice, the study results
will inform instructors and instructional designers about the effective and efficient uses of concept mapping strategies in their instructional designing and teaching.

**Generalizability**

The students who participated in this study were 290 undergraduate students from a statistics class and an educational psychology class in a large state university of the U.S. The students were in different majors. Most were in their first or second year of study at the university. They were all above 18 years of age. They were ordinary undergraduate students who shared many similarities in terms of learning experiences and cultural backgrounds with those undergraduate students in other comprehensive universities in the U.S. The content of instruction was an expository text describing the structure and functions of human heart. The generalization of the study was limited to types of concept mapping, educational objectives employed, and the type of students as specified above.

**Definition of Terms**

**Concept:** A perceived regularity in events or objects, or records of events or objects designated by a label (Novak, 1998). Concept represents a wide range of information from tangible objects to abstract ideas. In this dissertation, “concept” in concept maps is different from “CONCEPT” in learning hierarchical terminology. The “CONCEPT” in learning hierarchical terminology is always capitalized in this dissertation.
**Proposition:** The perceived relationship between/among the concepts in a concept map.

**Concept map:** A graphic representation of knowledge of a domain. It consists of a set of nodes representing concepts, objects, or actions connected by directional links that define the relationships between and among those nodes (Alpert & Grueneberg, 2000). In concept maps, concepts are arranged hierarchically so that the most inclusive, general concepts appear at the top of the map, with less inclusive, subordinate concepts below (Jonassen & Grabowski, 1993; Jonassen, Beissner, & Yacci, 1993; Novak, 1990a, 1998; Plotnick, 1997, 2001). Figure 1 is an example of a concept map.

*Figure 1. Example of concept map*

![Concept Map](image)

**Concept mapping strategy:** A learning strategy to help students achieve specific learning objectives by using concept maps.
**Concept matching mapping:** A strategy that helps students to achieve learning objectives by matching concepts that are missing from the given concept maps with those they identify in their reading materials and then filling in those missing concepts in the given concept maps.

**Proposition identifying mapping:** A strategy that helps students to achieve learning objectives by identifying and filling in the relationships (propositions) among the given concepts in concept maps according to the reading materials.

**Student-generated concept mapping strategy:** A strategy which helps students to achieve learning objectives by constructing concept maps that reflect their understanding of the learning material.

**Prior knowledge:** The ability, knowledge, and skills possessed by the learner before instruction (Jonassen & Grabowski, 1993).

**Achievement:** The results of learning measured by given criterion tests. In this study, it refers to the results of the criterion tests of identification, terminology, and comprehension and a total score of these criterion tests. Each criterion test measures achievement of learning at different levels. Identification test measures achievement of learning at factual level; terminology test measures achievement of learning at conceptual level; comprehension test measures achievement of learning at rules and principles level, and the total test score reflects the general academic performance of learners.
Summary

This study examines the instructional effects of prior knowledge and three concept mapping strategies on the achievement of different educational objectives. Prior research on concept mapping has not provided sufficient evidence to indicate which concept mapping strategies (concept matching, proposition identifying, and student-generated concept mapping strategies) should be used to be most effective in facilitating achievement of different educational objectives, nor has prior research revealed the relationships between these concept mapping strategies and students’ prior knowledge in facilitating specific learning objectives. Based on cognitive learning theory, different learning strategies instigate different levels of information processing and different levels of information processing result in different learning outcomes. Thus, it was hypothesized that different concept mapping strategies that instigate different levels of information processing would result in different levels of achievement and that different prior knowledge would also affect the processes and therefore, the results of learning, where different concept mapping strategies are applied. By conducting this experimental study, the researcher hoped to add empirical evidence to the appropriate uses of concept mapping strategies and reveal the relationships between the concept mapping strategies and students’ prior knowledge in facilitating specific learning objectives.
Chapter 2

REVIEW OF LITERATURE

This chapter provides the theoretical foundation on which this study is grounded. First, cognitive human information processing, levels of information processing, and schema theory are explored together with their implications for this study. Then, learning, prior knowledge, learning objectives, and learning strategies are discussed. The literature on concept mapping and relevant research on concept mapping as a tool to facilitate learning are also reviewed. Finally, a brief summary provides the theoretical justification for this study.

Human Information Processing

Cognitive theory seeks to understand internal processes of human learning: how information as stimuli is received, processed, stored in, and retrieved from memory. Most models of information processing can be traced to Atkinson and Shiffrin (1968) who offered a multistore, multistage concept of memory. According to Atkinson and Shiffrin (1968), when information is received by human information processing system, it must go through a series of transformations until it can be permanently stored in memory. This process is called information processing (Driscoll, 2000).
Multi-Store and Multi-stage Model of Information Processing

The multi-store and multi-stage model of information processes explains how information is processed by the three basic stages of memory system – sensory memory, short-term memory, and long-term memory (Driscoll, 2000). The whole process is monitored by executive control (Gredler, 2001). The executive control process shows that this information processing system is not only linear but also organized, dynamic and active. Figure 2 depicts a general structure and processes of human information processing.

Figure 2. Information processing model

According to this model of human memory, information processing consists of three stages: sensory memory, short-term (working) memory, and long-term memory (Gredler, 2001).
In sensory memory, a vast array of physical signals first impinges on the sensory system, primarily visual and auditory, from the stimuli sources. When the sensory receptors are activated by the stimuli, the information is then transmitted to the central nervous systems, where stimuli is briefly registered and selected for further processing. This is known as selective perception. Then, after the information is selected, it is transformed into recognizable patterns and retained briefly in short-term memory.

In the short-term memory, also known as a working memory (Atkinson & Shiffrin, 1968, 1971), the information is further processed. The working memory holds information for a very short period of time and with limited capacity. About seven plus or minus two chunks of information can be held in working memory (Miller, 1956). It is in the short-term or working memory that information is rehearsed, manipulated, transformed, interpreted and integrated with previously learned concepts (prior knowledge) stored in the long-term memory. If information is not meaningfully retained or rehearsed in the working memory, it will disappear from working memory in about 15 to 30 seconds (Gagne et al., 1992; Peterson & Peterson, 1959; Pettijohn, 1989). In other words, unattended information drops out of the system while the information meaningfully retained or rehearsed is encoded into some meaningful form and transferred to the long-term memory for permanent storage (Driscoll, 2001).

In the long-term memory, the information processed and encoded is permanently stored. Driscoll (2001) describes it as a permanent storehouse of information in an inactive state of previously learned concepts. Unlike the short-term memory, the long-term memory has unlimited capacity and information in long-term memory is not subject to decay (Smith & Ragan, 1999). The information stored in long-term memory is not
randomly scattered around in the “storehouse” but is organized so that information stored can be retrieved. The retrievability of information is related to the ways in which specific knowledge items are presented, and the organization of bodies of knowledge in the long-term memory, which is related to the ways the information is processed (the level or quality of information processing), and the number of times the information is processed in the short-term memory (Gredler, 2001).

Executive control manages the whole process of information processing. The executive control tracks the information, and decides whether the stimulus in the form of information is dropped out of the systems without further processing or needs attention and further processing. Executive control also determines the ways the information is processed, encoded in the short-term memory and the ways it is finally stored in the long-term memory (Gredler, 2001).

The implications of human information processing for this study include the following:

• The memory is an active organized processor of information and learning is an active process of information processing.

• Information processing can be manipulated and its results can be enhanced by the way the information in the form of the stimulus is presented to the sensory registers and working memory, by applying various strategies to facilitate information processing in the working memory, and by activating prior knowledge in the long-term memory.

• Learning strategies such as concept mapping could be used to facilitate information processing to achieve better learning outcomes because concept
mapping, depicting the connections among selected pieces of the information under processing through a graphic representation, helps to retain and elaborate the information in a meaningful way.

**Levels of Information Processing**

Another paradigm of information processing focuses more on the levels of information processing rather than the stages of information processing. Craik and Lockhart (1972) proposed that people can analyze stimuli at a number of different levels. The shallow level of information processing involves analysis in terms of physical or sensory characteristics while the deep levels require analysis in terms of meaning (Matlin, 1998). Empirical evidence supports that deep, meaningful kinds of information processing lead to more permanent retention than shallow, sensory kinds of information processing (Craik, 1979; Matlin, 1998; Treisman, 1979).

Upon the levels of information processing, Craik and Lockhart (1972) also proposed two kinds of rehearsal: maintenance rehearsal and elaborative rehearsal. Maintenance rehearsal merely repeats the kind of analysis that has been carried out whereas elaborative rehearsal involves a deeper, more meaningful analysis of the stimulus (Matlin, 1998).

Levels of processing encourage recall because of two factors: distinctiveness and elaboration (Craik & Lockhart, 1986). Distinctiveness means that a particular stimulus is different from all other memory traces while elaboration involves rich processing in terms of meaning (Craik, 1979). Elaboration is especially useful in enhancing memory
when similarities and relationship among items are emphasized. In other words, elaboration helps the synthesizing of information (Matlin, 1998).

The implications of levels of information processing for this study are as follows:

- Various learning strategies can affect the learning results by elaborating on the information being processed.
- Different concept mapping strategies with different degrees of elaboration would instigate different levels of information processing and therefore bring about different learning results.

Schema Theory

Schema theory is another paradigm often used to describe the concept of learning. “Schemata” refer to a person’s knowledge structure for a specific class of concepts (Gallini, 1989). It is defined as a “… data structure for representing the generic concepts stored in memory” (Rumelhart, 1980, 34). Schemata can also be viewed as packets of knowledge, and schema theory is a theory of how these packets are represented and how that representation facilitates the use of the knowledge in particular ways (Driscoll, 2000). Schemata work as building blocks of cognition. They are the fundamental elements on which all information processing depends (Roshan, 1997).

Winn and Snyder (1996) maintained that schemata share the following characteristics: “(1) It is an organized structure that exists in memory and in aggregate with all other schemata, contains the sum of our knowledge of the world (Paivio, 1974). (2) It exists at a higher level of generality, or abstraction, than our immediate experience with the world. (3) It consists of concepts that are linked together in propositions. (4) It is
dynamic, amenable to change by general experience or through instruction. (5) It provides a context for interpreting new knowledge as well as a structure to hold it” (p.117).

Schemata function in four dimensions in our mind. First, they categorize our experiences. If information is categorized, it can be searched more quickly and efficiently for relevant information. Second, they function to remember. When a schema for a certain object or event is created, and attached to a label, it can be retrieved and remembered through cuing labels. Third, schemata help comprehension. Comprehension indicates that what is going on is understood, including what to expect next. Finally, schemata function to help problem-solving ability. They help to make decisions and know what to do when a specific problem is encountered (Byrnes, 1996). These functions show that schemata influence information processing and the process of learning.

Existing schemata can be modified and new schemata can be acquired and constructed. Three different processes have been proposed to account for changes in existing schemata and the acquisition and construction of new schemata as a result of learning (Driscoll, 2000). They are accretion, tuning, and restructuring (Rumelhart & Norman, 1978; Rumelhart, 1980; Vosniadou & Brewer, 1987). Accretion is equivalent to fact learning because “… information is remembered that was instantiated within a schema as a result of text comprehension or understanding of some events” (Driscoll, 2000, 137). Tuning occurs when “… existing schemata evolve to become more consistent with experience” (Driscoll, 2000, 137). Rumelhart and Norman (1978) suggested that this process accounts for the minor schema modification that comes with new examples of concepts and principles. Restructuring involves “… the creation of entirely new schemata
which replace or incorporate old ones” (Driscoll, 2000, 137). Restructuring occurs through schema induction, in which a new schema is configured from repeated consistencies of experience (Driscoll, 2000).

Schema theory explains learning as an active process of information processing that leads to schema changes. Schema theory also explains how our knowledge is represented in our memory, how information is retrieved from the knowledge structure, and how new information is added to the structure. Schema theory assumes that during information processing, how stimuli in the form of information are selected, attained, interpreted, and integrated, and encoded and stored, depends on what we already know or our existing schemata in the long-term memory.

The implications for this study include:

• Prior knowledge is an important factor to be considered in any learning processes.
• Concept mapping can be used to activate prior knowledge to facilitate learning.
• Concept mapping can be used to anchor new knowledge.
• Different concept mapping strategies provide different types of facilitation in schemata modification, acquiring or construction.

**Exploration of Learning**

Based on the cognitive paradigms above, learning, prior knowledge, learning objectives, and learning strategies are discussed in this section.
Learning Defined

Gagné and Briggs (1979) defined learning as “… the set of cognitive processes that transforms the stimulation from the environment into the several phases of information processing” necessary for acquiring a new capacity (p. 43). Learning occurs when the stimulus is selected, processed, encoded, stored, and retrieved. Various learning strategies can facilitate this process so that better results of learning or learning outcomes can be achieved.

Ausubel (1968) mentioned two kinds of learning in his assimilation theory of learning: meaningful learning and rote learning. In meaningful learning, learners consciously and explicitly tie new knowledge to relevant concepts or propositions already possessed (Fisher, et al., 1990; Okebukola, 1990). Meaningful learning occurs when a learner can connect new knowledge to a preexisting cognitive framework (Snead, 2000). Rote learning results when new knowledge is arbitrarily incorporated into cognitive structure. Rote learning is verbatim, involving externally dictated stimulus-response associations (Cliburn, 1986).

Ausubel (1968) believes that three conditions must exist for meaningful learning to occur: (a) the learner must sense a relationship among the concepts to be learned; (b) the learner must possess specific relevant ideas to which this new material can be related; and (c) the learner must actually intend to relate these new ideas to ideas already possessed.
Learning and Prior Knowledge

Prior knowledge is the experience and knowledge a person brings to a learning situation, which greatly influences how the learning material is comprehended, interpreted, and recalled (Elliott, 1993). Prior knowledge is commonly defined as the ability, knowledge, and skills possessed by the learner before instruction (Jonassen & Grabowski, 1993). The description of schema theory and meaningful learning above clearly indicates the important role prior knowledge plays in learning. The prior knowledge is stored in existing mental models or schemata and used in the interpretation and assimilation of new knowledge (Anderson 1984; Driver 1988). Driscoll (2000) also maintained that the prior knowledge that learners bring to the learning environment dictates to a large extent what they will take away from it in terms of new knowledge, concepts added to their cognitive structure or details elaborating schemata. Ausubel (1968) explicitly indicated the importance of prior knowledge in learning and instruction by stating that it is the most important single factor influencing learning.

Effects of prior knowledge on learning achievement are critical as most of learning theories and instructional design models do consider prior knowledge as a key element in learning processes (Elliott, 1993). Researchers (Dwyer & Dwyer, 1990, Elliott, 1993) maintain that prior knowledge plays a significant part in how learners interact with the learning material and perform on various learning tasks as measured by different criterion tests.
Learning Objectives

A learning objective is a description of intended learning results. An objective, according to Mager (1984,) is “… a description of a performance you want learners to be able to exhibit before you consider them competent” (p. 5). In terms of difficulty levels, learning objectives exists on a continuum from simple to complex.

Many educational psychologists use different labels to describe the difficult level of cognitive performance. Bloom, Engelhart, Furst, Hill, and Krathwhol (1956) offered a comprehensive taxonomy that categorizes cognitive performance into six major groups arranged from simple to complex. They are knowledge, comprehension, application, analysis, synthesis, and evaluation. Gagné (1977) offered learning hierarchy that explains ordered relationship of intellectual skills and states that prerequisite skills must be acquired before the learner can perform learning tasks that are based on those prerequisite skills. The labels Gagné (1977) used for these interdependence skills are association and chains, discriminations, concepts, rules, and higher-ordered rules. Merrill (1983) offered his Performance-Content Matrix for Classifying Learning Outcomes, which represents the essence of his Component Display Theory. In his Component Display Theory, he categorized the performance with remember, use and find and the content with fact, concept, procedure, rule, and principle.

Dwyer (1978) identified basic performances that college students over a wide variety of disciplines are generally expected to perform in a course study. He maintained that “…students were expected to: (a) learn terminology and facts basic to the course content, (b) identify locations and/or positions, (c) construct and/or understand relationships, and (d) engage in problem solving activities” (p. 44). Dwyer (1978)
emphasized the consistency and congruency of learning objectives, instruction, and assessment in educational programs. Based on his categorization of student performance, he developed a set of criterion tests measuring different educational objectives.

The categorization of learning and performance indicates that achievement of learning should be evaluated at different levels. It offers a concrete foundation based on which learning objectives are developed, decisions about instructional sequence are made, and learning results are assessed.

**Learning Strategies**

Any internally or externally mediated cognitive process that facilitates the transfer of information to be learned from short-term memory into long-term memory can be defined as a learning strategy (Bruning, 1983). Learning strategies are used to rehearse, organize, and elaborate information to make it more meaningful. Some commonly used strategies include underlining, repetition, outlining, categorizing, concept mapping, mental imaging, forming analogies, inserting questions, paraphrasing, analyzing key points, and note taking (Kenny & Schroeder, 1994). All of these strategies are not equally effective in facilitating achievement of different learning objectives. In other words, which learning strategy is appropriate depends upon many factors such as learning objectives to be achieved, individual differences of the learners, and levels of prior knowledge, and learning conditions and learning environment, etc.
Summary

Learning is an active process of information processing. Various learning strategies can be applied to facilitate information processing which results in schema modification and creation. Prior knowledge plays a very important role in learning. The concept of learning hierarchy (Gagné, 1977) and the taxonomy by Bloom et al. (1956) indicate that learning tasks exist on a continuum from the very simple to the very complex according to the cognitive efforts required to complete the task. So do the learning objectives to be achieved in learning and in instruction. It cannot be assumed that all learning strategies are equally effective under all conditions to achieve all kinds of learning objectives. With different learning objectives to achieve, appropriate uses of learning strategies should be those that facilitate achievement of specific learning objectives for specific learners.

Concept Mapping

First, the term “concept” is widely used in many ways to describe learning. Novak (1998) defined “concept” as a perceived regularity in events or objects, or records of events or objects designated by a label. It is believed that to learn a concept, the learner must see the meaning in the regularity of the events (Novak, 1998). According to this assumption and based on Ausubel’s assimilation theory (1963) of cognitive learning, Novak and his colleagues developed the concept mapping technique, first as a research tool to represent a learner’s prior knowledge, and later as a tool to facilitate meaningful learning (Heinze-Fry & Novak, 1990; Novak & Gowin, 1984).
Defining Concept Maps

“A concept map is a schematic device for representing a set of concept meanings embedded in a framework of propositions” (Novak & Gowin, 1984, p. 15). Concept maps are most commonly defined as two dimensional diagrams that consist of concepts or nodes linked by labeled lines to show relationships and inter-relationships between those selected concepts. In concept maps, concepts are arranged hierarchically so that the most inclusive, general concepts appear at the top of the map, with less inclusive, subordinate concepts below (Jonassen & Grabowski, 1993; Jonassen, Beissner & Yacci, 1993; Novak, 1990a, 1998; Plotnick, 1997, 2001). Concept maps “…are a representation of meaning or ideational frameworks specific to a domain of knowledge, for a given context of meaning” (Novak, 1990b, 29).

Concept Mapping and Learning

Learning is a continuous process of building, expanding, and modifying old concepts over time as new relationships are introduced and linked with previous concepts (Ausubel et al., 1968). Cognitive processing theory supports that for information to be retained, it must be attended to and encoded into long-term memory by the learner in the act of linking new information to existing information thus creating a series of perceptual networks or schema (Gredler, 2001). Concept mapping fosters this process because it helps the learner to make sense of concepts by relating new concepts with prior existing concepts in the memory and then organizing them hierarchically to form an integrated, coherent framework of the material learned. This is believed to promote meaningful learning (Novak, 1990a).
Concept mapping fosters meaningful learning by helping learners identify, clarify, and organize the abstract concepts and relationships among information being processed through visually presenting them in an almost tangible format. Concept mapping fosters meaningful learning by instigating active interactions of learners with the information being processed and by linking what is being processed in the working (or short-term) memory to what they have already known (their prior knowledge) in the long-term memory. Concept mapping fosters meaningful learning by elaborating and organizing the information being processed to ensure that schema modification and creation are easier and happen in an organized fashion. Concept mapping fosters meaningful learning by helping learner process the information effectively through dual coding. Dual coding uses both verbal and nonverbal (or graphic) representations to strengthen the cues to the specific information being processed and increases the possibility of information recall (Clark & Paivio, 1991; Paivio, 1986). The graphic cues in concept maps include boxes for concepts and labeled links for propositions, and its structure that represents the perception of a given knowledge domain.

One of the greatest strengths of concept mapping is that they insist that learners deal explicitly and consciously with what is normally an implicit activity (Taricani, 2002). Concept mapping, as a learning strategy, enhances comprehension, and memory, and promotes meaningful learning.

General Effects of Concept Mapping

Since the early work of Novak, much research has been conducted to empirically test this cognitive strategy of concept mapping, mostly in science domain. Novak and
Musonda (1991) reported a 12-year longitudinal study of using science concept mapping as a tool to represent students’ knowledge structures based on transforming data gathered through clinical interviews held before and after instruction. Their data showed the lasting impact of early instruction in science and the value of concept maps as a representational tool for cognitive development changes. Horton and colleagues (1993) investigated the effectiveness of concept mapping as an instructional tool based on 19 studies that published significant results during 1985-1992. Their meta-analysis showed that generally concept mapping had positive effects on both students achievement and attitudes. In general, concept mapping has been reported to be an effective learning strategy in a variety of educational settings and disciplines, with various populations (Jo, 2001; Lambiotte, Dansereau, Cross, & Reynolds, 1989; Wang, 1995; West, Farmer, & Wolf, 1991).

Research on Concept Mapping

Studies of concept mapping as a tool to facilitate learning are extensive and diverse with subjects from kindergarten through college undergraduate education (Helton, 1994). One group of the studies focused on the effects of concept maps used in different formats. Examples include the instructor-provided concept map versus student completed or generated concept map (Jo, 2001; Smith & Dwyer, 1995; Wang, 1995), individual concept mapping versus group concept mapping (Brown, 2000), and hand drawn versus computer generated concept maps (Sturm, 1996). The second group of studies compared and contrasted the effects of concept mapping with those of other learning strategies such as note-taking, outlining (Keng, 1996), post-questioning and
feedback (Naidu, 1991). The third group of studies focused on effects of concept mapping when they were applied in a specific area or knowledge domains with specific group of people. Researchers from this group studied concept mapping in the science classroom (Green, Ritchie, & Volk, 2000; Spaubling, 1989) and concept mapping with low-achieving inner-city seventh graders (Guastello, Beasley, & Sinatra, 2000) and with nursing students (Roop, 2002). In general, the research provides empirical evidence that concept mapping is a useful learning strategy (Wang, 1995). Since this study is about different concept mapping strategies in facilitating learning achievement, similar studies of concept mapping are reported below.

Wachter (1993) investigated the effects of hierarchical concept maps on fourth grade students’ reading comprehension and retention of text content. She randomly divided 120 students into three groups: a complete concept map group in which students studied the map before reading (Group 1); a partial concept map group in which student got the same concept map but with some information deleted from the map (Group 2) and a control group in which no map was provided (Group 3). A partial concept map differed from a complete concept map only in that several concepts were randomly deleted and replaced with geometric figures surrounding blank space. Students in the partial concept map group were required to fill in the information while reading. Students read the same passage and were tested by an immediate written free recall, a delayed written free recall, and a delayed multiple choice test. The results were that students in both concept map groups recalled significantly more content units for both immediate and delayed written free recall than students in the control group. In addition, students in both concept map groups significantly outperformed the control group on the multiple choice test. As for
type of concept map, insignificant difference was found between students in the complete concept map group and students in the partial concept map group on three measures. Therefore, the research concluded that when concept maps are presented first, they significantly aid reading comprehension and information retention regardless of the type of concept map.

Smith and Dwyer (1995) studied the effectiveness of two concept mapping strategies (instructor-prepared and learner-generated) in facilitating student achievement of different types of educational objectives. They randomly assigned 81 college-level students to the three instructional treatment groups. Subjects were required to interact with their respective treatment and to take individual criterion tests. Results revealed insignificant results between the instructor-prepared concept map treatment and the learner-generated concept map treatment. Implications are that even though concept mapping strategies are physically and procedurally different, they may be functionally identical in terms of facilitating achievement.

Wang (1995) conducted a study to examine the main and interactive effects of different formats of concept maps (whole maps vs. stacked maps) and learner involvement in concept mapping (instructor-completed maps vs. student-completed maps) on learning. Sixty undergraduates were randomly given one of four versions of the learning material consisting of a lesson on “children, death, and grief” and one type of concept map (complete whole map, incomplete whole map, complete stacked maps, or incomplete stacked maps). Subjects who received incomplete maps were asked to provide the information that was missing from their maps. The findings indicated that providing students with whole concept maps as a learning aid facilitated significantly better
awareness of lesson structure than did providing a set of stacked concept maps. Moreover, providing students with unfinished concept maps and having them complete the concept maps resulted in significantly better recall of the specific information presented in the concept map than did providing students with the instructor-completed maps. One of the major limitations of this study was the limited number of subjects involved in the study (60 subjects for four treatment groups).

Jo (2001) investigated the effects of the two types of concept mapping -- concept map-as-process (concept maps constructed by students) versus concept map-as-product (concept maps provided for students) -- on college students’ comprehension of expository text. In addition to the two concept map groups, a contrast group was involved in this study to confirm the overall effectiveness of concept mapping. The subjects involved in this study were 132 students from two large lecture sections in the course, “Introduction to Educational Technology” at Florida State University. One of the two sections was randomly assigned to the concept map-as-process condition. Then, the students from the other section were randomly assigned to either the concept map-as-product or the contrast group. For the students in the concept map-as-process condition, concept mapping training was provided before the treatments. The results showed significant differences for both measures between the performance of the concept map-as-process group and the concept map-as-product group. The differences were both favorable to the concept map-as-process group as predicted. Interestingly, however, although there was insignificant difference between the concept map-as-product group and the contrast group, the concept map-as-product group performed more poorly than the contrast group, which is opposite to the prediction.
Taricani (2002) conducted a study to examine the effect of blending both feedback and concept map generation on learning terminology and learner comprehension. The participants in the study were 150 freshmen students. They were systematically assigned into five treatment groups: (1) the control (no concept map generated and no feedback); (2) totally learner-generated concept map without feedback; (3) totally learner-generated concept map with feedback; (4) partially learner-generated concept map with feedback; and (5) partially generated concept map without feedback. The findings in the study indicated that (a) students who used the concept mapping were not significantly different from those who did not use concept mapping on the criterion tests; (b) those who did not receive feedback (totally generated and partially generated maps) did significantly better than those with feedback on the comprehension test; (c) those working with partially generated maps with feedback did significantly better on the terminology test items that matched on the learner generated items than those that matched the researcher generated ones; and (d) there was a significant difference between science and non-science majors on the terminology test, with the science majors doing significantly better.

The above studies examined the ways concept mapping strategies were used in facilitating learning. Smith and Dwyer (1995) and Jo (2001) both explored the effects of student-generated (processes) concept map and instructor provided (product) concept map while Watcher (1993), Wang (1995) and Taricani (2002) examined the effects of partially completed and student-generated concept mapping. Although these studies bear some similarities with this dissertation study, they are different in the following ways.
First, this study examines the instructional effects of prior knowledge and concept mapping strategies according to specific learning objectives. The researcher believes that with different learning objectives to achieve, different concept mapping strategies should be applied. Concept mapping strategies are not limited to student-generated (partial and complete) or instructor provided mapping strategies.

Second, within the partially complete concept mapping strategies (Taricani, 2002; Wang, 1995; Watcher, 1993) in which students were required to complete the concept maps, the task in completing concept maps was to fill in those randomly deleted pieces of information. Depending on which pieces of information were deleted in a concept map, the difficulty level of concept mapping task can be really varied. In other words, partially complete concept mapping with some pieces of information randomly deleted is loosely defined and their experimental results were hard to compare. In this study, the concept matching mapping strategy and proposition identifying strategy are similar in form with those partially complete concept maps. However, this study identifies the variables in construction of concept mapping: identifying concepts, identifying propositions, and identifying structures, and purposefully tests the instructional effects of students’ prior knowledge and concept mapping when those identified variables are manipulated. By controlling and manipulating these variables in concept mapping, it is hypothesized that different levels of cognitive process will be affected and result in different levels of information processing.
Summary

Although concept maps as a tool to facilitate learning are generally effective and robust (Winn & Snyder, 1996), it cannot be assumed that all concept mapping strategies work equally well under all conditions to achieve all kinds of learning objectives. Beissner, Jonassen, and Grabowski (1994), in their discussion of the graphic techniques in learning, pointed out that when different graphic techniques are used as learning tools, different cognitive processes are elicited, which results in different learning outcomes.

The effective uses of concept mapping should be oriented towards instigating certain levels of cognitive processes as required to produce the desired learning outcomes. Prior research on concept mapping has not provided us with sufficient evidence of how different concept mapping strategies (concept matching, proposition identifying, and student-generated concept mapping strategies) should be used to be most effective and efficient in facilitating achievement of different educational objectives. Therefore, it is significant to implement this study to examine these critical relationships in using concept mapping strategies. From a theoretical perspective, the study will add empirical evidence to the effective uses of concept mapping strategies and reveal the important relationships between the concept mapping strategies and students’ prior knowledge in facilitating achievement of different educational objectives. From the educational practice standpoint, the study will inform instructional designers and teachers about the effective and efficient uses of concept mapping strategies in their instructional design and teaching practice.
Chapter 3

METHODOLOGY

This chapter describes the methodology applied in this study. Instrumentation, which covers the learning material, and criterion measures used in this study, are first described. Then two pilot studies conducted prior to the major study and the major study are also described. The descriptions of two pilot studies reveal how the progressive efforts were built towards the major dissertation study.

Learning Material

The learning material used in this study was a meaningful 2,000-word expository text describing the human heart, including its parts, locations and functions during systolic and diastolic phases (see Appendix A.2). The material was developed by Dwyer (1965). Dwyer (1965) identified basic performances that college students over a wide variety of disciplines were generally expected to perform in a course study. He maintained that “…students were expected to: (a) to learn terminology and facts basic to the course content, (b) identify locations and/or positions, (c) construct and/or understand relationships, and (d) engage in problem solving activities” (1978, 44). Based on findings from his research, Dwyer (1965) developed the learning material and the criterion tests in order to assess students’ achievement on the educational objectives derived from those basic academic performances above. Although this study was implemented in an online
learning environment, the learning material and the criterion of tests were used without any modification in their contents.

**Prior Knowledge Test of Physiology**

The prior knowledge test of physiology consisted of 36 multiple-choice question items (see Appendix A.3). The first 30 items were taken from *Reviewing Biology* (Hall, 1985). The remaining six items were developed by Dwyer (1965). The objective of the prior knowledge test was to determine the level of general knowledge the subjects of the major study had about human physiology. According to the test results, the subjects were divided into high prior knowledge and low prior knowledge groups to explore the instructional effects of three concept mapping strategies on students of different prior knowledge levels.

**Criterion Measures of Achievement**

The criterion tests in the study were the tests of identification, terminology, and comprehension, and a total criterion test. These criterion tests were developed by Dwyer (1965) (see Appendix A.4). In the development of the learning material and these criterion measures, Dwyer (1978) validated the contents for both the learning material and its criterion tests according to his findings of four basic types of performance that college students were generally expected to perform in a course study. Each test consisted of 20 multiple-choice questions for the purpose of measuring different educational
objectives. The total criterion test combined the three individual tests (60 multiple-choice questions) as one dependent measurement.

According to Dwyer (1978), the identification test measured students’ ability to identify parts or position of certain parts of an object. It required students to identify the numbered parts of a drawing of a heart. The terminology test measured students’ knowledge of specific terms, and definitions relevant to the learning material. The comprehension test measured students’ comprehension of the learning material about the human heart, its parts, and their functions as a system. The total criterion test assessed students’ overall achievement in learning the material.

The criterion tests enjoyed fairly good reliability. Average Reliability coefficients from a random sampling for the criterion tests were .81 for the identification test, .83, for the terminology test, .77 for the comprehension test and .92 for the total test (Dwyer, 1978). The reliability of these criterion tests used in this study are reported in the next chapter.

**Pilot Studies**

Two pilot studies were conducted prior to the major study. The purposes of the two pilot studies were:

1. To identify items of low achievement in learning the material in order to develop appropriate concept mapping strategies for the major study to target those potentially difficult areas;

2. To identify potential problems in the design and in the implementation of the study;

3. To improve the experimental treatments of concept mapping strategies; and
4. To prepare the researcher for the implementation of the major study.

The First Pilot Study

The first pilot study was conducted in the fall of 2001. The subjects in the first pilot study were 16 undergraduate students from an information science and technology class in a large state university of the U.S. They got three extra points out of 100 course credits for participating in this study.

The study consisted of three phases: pre-treatment concept map workshop, experimental treatment, and data analysis and report. The pre-treatment concept map workshop, conducted one week prior to the experimental treatment, provided a 35-minute training session on concept mapping in small groups of two to five. Altogether, 16 students participated in the concept map workshops. The workshops were conducted in an informal learning environment, such as around a table in a library common room. The workshop offered the subjects a brief introduction into what concept maps were, how concept maps could help people study, and the ways to create concept maps. See Appendix B.1 for the training procedures and materials.

In the experimental treatment phase, 12 subjects, who were randomly assigned to one of the four treatment groups, actually participated in this phase. The study was conducted in the university computer lab with Internet access. The subjects were given a Blackboard.com course site, and a login name with a password. The subjects were required to login into the course site and interact with the learning material at their own pace to understand its contents (see Appendix C.1). The subjects in the control group received no mapping activities and they took the criterion tests of terminology and
comprehension immediately after they finished reading of the learning material. The subjects in other treatment groups read the learning material and completed concept mapping activities followed by the two criterion tests (terminology and comprehension). In phase three, data analysis and report, item analyses were conducted to identify the difficulty level of each test item in the two criterion tests.

At the completion of the first pilot study, the following decisions were made for the second pilot study in order to improve the study.

- The number of subjects should be greatly increased in order to produce valid data for analysis and to prepare the researcher for the implementation of the major study with similar magnitude.
- The workload of concept mapping treatments in the first pilot study was too much for the subjects to complete. Impatience of the subjects was observed towards the end of the study. The concept mapping treatments needed to be improved to make it more effective and efficient.
- Since the number of the subjects who completed the first pilot study was so small, the researcher decided to conduct item analysis again in the second pilot study.
- The identification test would be used to assess students’ achievement in the second pilot study to provide a fuller picture of students’ performance in learning with concept mapping strategies.

**The Second Pilot Study**

The second pilot study was done in 2002. Subjects for this study were 146 undergraduate students from a statistics class in a large state university of the U. S. Out of
146 subjects, 105 subjects completed the study. Students received 3 extra credits out of 100 course credits for participating in this study. The second study consisted of three phases: pre-treatment concept map workshop, experimental treatment, and data analysis and report.

In pre-study training, one week prior to the experimental treatment, six workshops on concept mapping were conducted in groups of 10 - 38 students in an ordinary university classroom with an overhead projector for presentation. Printed handouts were given to the students during the workshop. Each workshop lasted for about 45 minutes. See Appendix B.2 for the training procedures and materials.

In the experimental treatment phase, the subjects were randomly assigned to one of the four treatment groups. The study was conducted at the same time in two university computer labs with Internet access. Both labs were of the same size, and equipped with the same type of computers, desks, chairs, and other facilities. Written instruction for the study (see Appendix C.2) was given to every subject at the entrance of the labs. Following the written instructions, the subjects browsed the course web site, interacted with the learning material at their own pace to understand its contents, and then immediately took the tests of identification, terminology, and comprehension online.

In phase three, data analysis and report, item analyses were conducted to identify the difficulty level of each test item and Analysis of Variance (ANOVA) was used for data analysis using the Statistic Package for Social Sciences (SPSS) version 10.0. Table 3.1 presents the number of subjects in each treatment, and the mean scores and standard deviations achieved by the students on each criterion test.
Table 3.1

Descriptive Statistics for the Second Pilot Study

<table>
<thead>
<tr>
<th>Treatments</th>
<th>n</th>
<th>Identification</th>
<th>Terminology</th>
<th>Comprehension</th>
<th>Total Test</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>M</td>
<td>SD</td>
<td>M</td>
<td>SD</td>
<td>M</td>
</tr>
<tr>
<td>Treatment 1</td>
<td>29</td>
<td>7.10</td>
<td>8.38</td>
<td>6.86</td>
<td>22.34</td>
</tr>
<tr>
<td>Treatment 2</td>
<td>27</td>
<td>11.67</td>
<td>11.85</td>
<td>11.00</td>
<td>34.52</td>
</tr>
<tr>
<td>Treatment 3</td>
<td>24</td>
<td>10.00</td>
<td>10.25</td>
<td>9.42</td>
<td>29.67</td>
</tr>
<tr>
<td>Treatment 4</td>
<td>25</td>
<td>11.52</td>
<td>11.68</td>
<td>8.36</td>
<td>31.56</td>
</tr>
</tbody>
</table>

Maximum score possible = 20. Total test = Identification + Terminology + Comprehension

The reliability tests on the identification, terminology, and comprehension criterion tests were conducted using SPSS 10.0. Table 3.2 reports the reliability analysis results.

Table 3.2

Reliability of Each Criterion Test in the Second Pilot Study

<table>
<thead>
<tr>
<th>Identification</th>
<th>Terminology</th>
<th>Comprehension</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Alpha</td>
<td>.8018</td>
<td>.7685</td>
<td>.7318</td>
</tr>
</tbody>
</table>

One-way analysis of variance (ANOVA) was conducted on SPSS 10.0 program to analyze the data collected with alpha level set at .05. The results revealed that there were significant differences among treatment groups on all criterion tests as indicated in Table 3.3.
Table 3.3

ANOVA Results for the Second Pilot Study

<table>
<thead>
<tr>
<th></th>
<th>Sum of Square</th>
<th>df</th>
<th>Mean Square</th>
<th>F</th>
<th>Sig</th>
</tr>
</thead>
<tbody>
<tr>
<td>Identification test</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Between Treatments</td>
<td>376.60</td>
<td>3</td>
<td>125.354</td>
<td>5.450</td>
<td>.002</td>
</tr>
<tr>
<td>Within Treatments</td>
<td>2322.930</td>
<td>101</td>
<td>22.999</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>2698.990</td>
<td>104</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Terminology test</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Between Treatments</td>
<td>216.054</td>
<td>3</td>
<td>72.018</td>
<td>4.156</td>
<td>.008</td>
</tr>
<tr>
<td>Within Treatments</td>
<td>1750.175</td>
<td>101</td>
<td>17.328</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>1966.229</td>
<td>104</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Comprehension test</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Between Treatments</td>
<td>253.092</td>
<td>3</td>
<td>84.364</td>
<td>5.250</td>
<td>.002</td>
</tr>
<tr>
<td>Within Treatments</td>
<td>1623.042</td>
<td>101</td>
<td>16.070</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>1876.133</td>
<td>104</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total Test</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Between Treatments</td>
<td>2268.871</td>
<td>3</td>
<td>756.290</td>
<td>5.561</td>
<td>.001</td>
</tr>
<tr>
<td>Within Treatments</td>
<td>13736.786</td>
<td>101</td>
<td>136.008</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>16005.657</td>
<td>104</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Post hoc tests (Scheffe) were run in SPSS to identify the specific differences among treatment groups. The post hoc test revealed significant differences between Treatment 1 (the control) and Treatment 2 (the concept matching mapping) on all criterion tests; there were significant differences between Treatment 1 (the control) and Treatment 4 (the student-generated mapping) on the identification test and terminology test and total tests. The results also indicated that there were no significant differences between Treatment 1 (the control) and Treatment 3 (the proposition identifying mapping) on all criterion tests and no significant differences existed among Treatment 2 (the concept matching mapping), Treatment 3 (the proposition identifying mapping), and
Treatment 4 (the student-generated mapping) on all criterion tests. Table 3.4 presents the results of the post hoc test.

Table 3.4
*Post Hoc Test (Scheffe) for the Second Pilot Study*

<table>
<thead>
<tr>
<th>Dependent Variable</th>
<th>(I) Groups</th>
<th>(J) Groups</th>
<th>Mean Difference (I-J)</th>
<th>Std Error</th>
<th>Sig*</th>
<th>95% Confidence Interval</th>
</tr>
</thead>
<tbody>
<tr>
<td>Identification</td>
<td>Control</td>
<td>Concept matching</td>
<td>-4.56*</td>
<td>1.28</td>
<td>.007</td>
<td>-8.21 - .92</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Proposition identifying</td>
<td>-2.90</td>
<td>1.32</td>
<td>.195</td>
<td>-6.66 .87</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Student-generated mapping</td>
<td>-4.42*</td>
<td>1.31</td>
<td>.013</td>
<td>-8.14 -.70</td>
</tr>
<tr>
<td>Terminology</td>
<td>Control</td>
<td>Concept matching</td>
<td>-3.47*</td>
<td>1.11</td>
<td>.025</td>
<td>-6.64 -.31</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Proposition identifying</td>
<td>-1.87</td>
<td>1.15</td>
<td>.452</td>
<td>-5.14 1.40</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Student-generated mapping</td>
<td>-3.30*</td>
<td>1.16</td>
<td>.043</td>
<td>-6.53 -7.06</td>
</tr>
<tr>
<td>Comprehension</td>
<td>Control</td>
<td>Concept matching</td>
<td>-4.14*</td>
<td>1.07</td>
<td>.003</td>
<td>-7.19 -1.09</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Proposition identifying</td>
<td>-2.25</td>
<td>1.11</td>
<td>.156</td>
<td>-5.70 .59</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Student-generated mapping</td>
<td>-1.50</td>
<td>1.09</td>
<td>.601</td>
<td>-4.61 -1.61</td>
</tr>
<tr>
<td>Total Tests</td>
<td>Control</td>
<td>Concept matching</td>
<td>-12.17*</td>
<td>3.12</td>
<td>.003</td>
<td>-21.04 -3.31</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Proposition identifying</td>
<td>-7.32</td>
<td>3.22</td>
<td>.167</td>
<td>-16.47 1.83</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Student-generated mapping</td>
<td>-9.22*</td>
<td>3.18</td>
<td>.044</td>
<td>-18.26 -.17</td>
</tr>
</tbody>
</table>

* The mean difference is significant at the .05 level.

Table 3.5 summarizes the significant differences found in student achievement among the criterion tests in the second pilot study.
Table 3.5

**Significant Differences in the Second Pilot Study**

<table>
<thead>
<tr>
<th>Treatment 2 vs. Treatment 1</th>
<th>Identification</th>
<th>Terminology</th>
<th>Comprehension</th>
<th>Total Test</th>
</tr>
</thead>
<tbody>
<tr>
<td>T2 &gt; T1</td>
<td>T2 &gt; T1</td>
<td>T2 &gt; T1</td>
<td></td>
<td>T2 &gt; T1</td>
</tr>
<tr>
<td>Treatment 3 vs. Treatment 1</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Treatment 4 vs. Treatment 1</td>
<td>T4 &gt; T1</td>
<td>T4 &gt; T1</td>
<td>T4 &gt; T1</td>
<td>T4 &gt; T1</td>
</tr>
</tbody>
</table>

T 1: Control
T 2: Concept matching mapping
T 3: Proposition identifying mapping
T 4: Student-generated concept mapping
X = No significances found between this group and the other groups.

Item analysis was conducted to identify the difficult items on the criterion tests. Table 3.6 displayed the item analysis results. The item difficulty was calculated by using the data from the control group who did not use any concept mapping strategies in the second pilot study. The item difficulty level was the number of correct choices on a test item divided by the number of subjects in the control group.
Table 3.6

*Item Difficulty of the Three Criterion Tests in the Second Pilot Study*

<table>
<thead>
<tr>
<th>Identification Test</th>
<th>Terminology Test</th>
<th>Comprehension Test</th>
</tr>
</thead>
<tbody>
<tr>
<td>Items</td>
<td>Item Difficulty</td>
<td>Items</td>
</tr>
<tr>
<td>1</td>
<td>.179</td>
<td>21</td>
</tr>
<tr>
<td>2</td>
<td>.464</td>
<td>22</td>
</tr>
<tr>
<td>3</td>
<td>.552</td>
<td>23</td>
</tr>
<tr>
<td>4</td>
<td>.179</td>
<td>24</td>
</tr>
<tr>
<td>5</td>
<td>.448</td>
<td>25</td>
</tr>
<tr>
<td>6</td>
<td>.185</td>
<td>26</td>
</tr>
<tr>
<td>7</td>
<td>.576</td>
<td>27</td>
</tr>
<tr>
<td>8</td>
<td>.620</td>
<td>28</td>
</tr>
<tr>
<td>9</td>
<td>.357</td>
<td>29</td>
</tr>
<tr>
<td>10</td>
<td>.564</td>
<td>30</td>
</tr>
<tr>
<td>11</td>
<td>.321</td>
<td>31</td>
</tr>
<tr>
<td>12</td>
<td>.586</td>
<td>32</td>
</tr>
<tr>
<td>13</td>
<td>.250</td>
<td>33</td>
</tr>
<tr>
<td>14</td>
<td>.551</td>
<td>34</td>
</tr>
<tr>
<td>15</td>
<td>.214</td>
<td>35</td>
</tr>
<tr>
<td>16</td>
<td>.214</td>
<td>36</td>
</tr>
<tr>
<td>17</td>
<td>.463</td>
<td>37</td>
</tr>
<tr>
<td>18</td>
<td>.413</td>
<td>38</td>
</tr>
<tr>
<td>19</td>
<td>.250</td>
<td>39</td>
</tr>
<tr>
<td>20</td>
<td>.179</td>
<td>40</td>
</tr>
</tbody>
</table>

At the completion of the second pilot study, following modification decisions were made for the major study.

- The concept mapping activities in Treatment 2 (concept matching mapping) and Treatment 3 (proposition identifying mapping) were modified to help learners...
understand specific information in the learning material, which would assist them
to make correct choices on those low achieving test items as identified in the item
analysis of the second pilot study.

- Ten items of great difficulty in each criterion test were selected as target items for
the major study. The crucial information in the learning material that would lead
students to make correct choices of those targeted items was also identified. The
concept mapping activities in Treatment 2 (concept matching mapping) and
Treatment 3 (proposition identifying mapping) would help learners process the
identified specific information in the learning material. Table 3.7 shows the
selected items and their difficult level based on the item analysis results from the
second pilot study.

Table 3.7

<table>
<thead>
<tr>
<th>Identification Test</th>
<th>Terminology Test</th>
<th>Comprehension Test</th>
</tr>
</thead>
<tbody>
<tr>
<td>Items</td>
<td>Item Difficulty</td>
<td>Items</td>
</tr>
<tr>
<td>---------</td>
<td>-----------------</td>
<td>---------</td>
</tr>
<tr>
<td>1</td>
<td>.179</td>
<td>21</td>
</tr>
<tr>
<td>4</td>
<td>.179</td>
<td>25</td>
</tr>
<tr>
<td>6</td>
<td>.185</td>
<td>26</td>
</tr>
<tr>
<td>9</td>
<td>.357</td>
<td>28</td>
</tr>
<tr>
<td>11</td>
<td>.321</td>
<td>29</td>
</tr>
<tr>
<td>13</td>
<td>.250</td>
<td>32</td>
</tr>
<tr>
<td>15</td>
<td>.214</td>
<td>33</td>
</tr>
<tr>
<td>16</td>
<td>.214</td>
<td>36</td>
</tr>
<tr>
<td>19</td>
<td>.250</td>
<td>37</td>
</tr>
<tr>
<td>20</td>
<td>.179</td>
<td>40</td>
</tr>
</tbody>
</table>
• Treatment 2 (concept matching mapping) in the major study would require the subjects to fill in only those concepts that would help them process the information related to the selected items in the criterion tests. Other concepts, which are not directly related to the selected test items, would be given in the concept maps.

• Treatment 3 (proposition identifying mapping) in the second pilot study was a combination of concept matching and proposition identifying since the subjects in this treatment were required to fill both concepts and propositions missing from the concept maps. For the major study, this treatment would require subjects to fill in only those propositions that would help them process the information of the learning material related to those selected items in the criterion tests. All the concepts of concept maps would be given in this treatment.

• No graphic hints would be given in Treatment 4 (student-generated concept mapping) to make it “purely” student-generated. This treatment in both pilot studies had offered subjects some graphic hints for concept mapping.

• In the previous pilot studies, subjects were told to study the learning material and then, complete concept mapping activities before taking the criterion tests. In implementation of the major study, concept mapping activities would be given to the subjects at the beginning of the study. They would be told to use concept mapping activities as a learning strategy to study the learning material.

• In order to ensure only the data from those subjects who went through the experimental treatment seriously were used for data analysis, the data collected in the major study would be screened with the following criteria: (a) the time the
subjects spent in the treatment and (b) the quality of the concept mapping activities.

- A prior knowledge test of physiology would be incorporated in the major study in order to explore the instructional effects of three concept mapping strategies and their relationship with students’ prior knowledge levels.

- Multivariate analysis of variance (MANOVA) would be used for data analysis, as the major study would incorporate independent factor of prior knowledge in its design, which was different from the two pilot studies.

The Major Study

The major study was implemented in the fall of 2002. The description of the major study includes subjects, experimental instruments, experimental procedure, and data analysis method. The prior knowledge test of physiology and the criterion tests used in this study were described at the beginning of this chapter.

Subjects

Subjects for the major study were recruited from an educational psychology and a statistics class at a large state university in the U.S. Altogether, 290 undergraduate students participated in the major study. They completed the physiology pretest and participated in the concept map workshop in a formal classroom environment one week prior to the experimental treatments (see Appendix B.3). Among 290 students, 270
completed the actual study. All of the participants were either in their first year or second year at the university. They got extra class credit for their participation in this study.

**Experimental Treatments**

In the major study, there were four experimental treatments: the control, concept matching mapping, proposition identifying mapping, and student-generated mapping (see Appendix C.3).

**Treatment 1: Control**

The subjects in this treatment were required to interact with the learning material at their own pace and then to take the online criterion tests immediately after they finished their study. No concept mapping strategies were used in this treatment.

**Treatment 2: Concept Matching**

The subjects in this treatment (concept matching) were required to interact with the learning material at their own pace while using the concept matching mapping strategy to help them learn the learning material. They took the online criterion tests after they finished their reading of the learning material and concept mapping activity. The major modification of this mapping strategy was that the blanks where students were required to fill in the missing concepts were targeted difficulty areas in the learning material identified through item analyses in previous two pilot studies. Figure 3 is an example of the concept matching mapping activity in Treatment 2.
Figure 3. Sample mapping activities for Treatment 2

**Direction:** Please complete the concept map by filling in the concepts according to the learning material Part 2 & 3.

**Concept Map of Heart Structure**

**Symbols Used**

**Left is the right half of the heart.**
**Right is the left half of the heart.**

Human Heart is divided by Septum

- Right Half of Heart
- Left Half of Heart
- Upper Chamber
- Lower Chamber
- Right Auricle

- is divided into
- is divided into
- is divided into
- is divided into
- is divided into
- is called
- is called
- is called
- is called
- through
- linked to

No direct communication & function simultaneously

**Treatment 3: Proposition Identifying Mapping**

In the previous two pilot studies, concept mapping activities in this treatment required subjects to fill out both concepts and propositions. In this major study, the concept mapping activities required subjects to fill out only some of those propositions, which were related to the targeted difficulty areas in the learning material identified through item analyses in the previous two pilot studies. The subjects in this treatment were required to interact with the learning material at their own pace while using proposition identifying mapping to help them learn the learning material. They took the online criterion tests after they finished study and the concept mapping activity. Figure 4 is an example of the proposition identifying mapping activity in Treatment 3.
**Figure 4. Sample mapping activities for Treatment 3**

**Direction:** Please complete the concept map by filling in link words according to the learning material Part 2 & 3.

**Concept Map of Heart Structure**

- **Left is the right half of the heart.**
- **Right is the left half of the heart.**

**Symbols Used**

- Heart Chambers
- Valves

**Treatment 4: Student-generated Mapping**

The modification made in this treatment was to give student a blank page instead of some hints on graphics as in the previous pilot studies. The subjects in this treatment were required to interact with the learning material at their own pace and to generate their own concept maps depicting their understanding of the learning material during their study. They took the online criterion tests after they finished the concept mapping activity. Figure 5 is an example of the student-generated concept mapping activity in Treatment 4.
**Experimental Procedure**

The whole study consisted of three phases similar to the procedures of the pilot studies described above. Figure 6 illustrates the design and procedures of the study.
Figure 1. Design and procedure of the major study
Phase 1: The main tasks included (a) collecting the Informed Consent Forms from the subjects (see Appendix A.1), (b) administering prior knowledge test, (c) conducting a series of concept map workshops, and (d) assigning subjects to different treatment groups. The prior knowledge test, which consisted of 36 multiple-choice questions on human physiology, was administered before conducting the concept mapping workshop in an ordinary classroom environment. The workshops were conducted one week prior to the second phase. Usually, the concept mapping workshops lasted about 45 to 50 minutes. In the workshop, the researcher briefly explained concept mapping and its uses for learning by using an overhead projector in the classroom. Lecture outlines were given to all participants in the workshop. After the researcher explained the nature, uses, and procedures of concept mapping, participants were required to do some concept mapping activities by themselves. Brief feedback was provided to all participants in the workshop through overhead projector slides. The complete concept mapping workshop materials are provided in Appendix B.3. All participants with prior knowledge test scores were assigned to one of the four treatments by using stratified randomization.

Phase 2: The main tasks included (a) logistical preparation for the study, which covered designing and developing the study website, and locating and training the helpers for the study, and (b) implementation of the study. The study was conducted at the same time in two university computer labs with Internet access. Both labs were of the same size, and equipped with the same types of computers, desks, chairs, and other facilities. The subjects were informed prior to the study which group they were in and a concept mapping activity packet for each group (see Appendix C.3) was given to the subjects at
the door of the computer labs. The concept mapping activity packet informed subjects of the rules and regulations for this study, gave the subjects a study website URL, and offered the directions for this study. The subjects were required to interact with the learning material at their own pace. Subjects in Treatment 1 (the control) took the online criterion tests immediately after they finished their study. Subjects in other treatments were asked to use concept mapping to help them study the learning material during the process. When they finished their study and completed the concept mapping activities, the subjects turned in their concept mapping activity packet and then took the online criterion tests of identification, terminology, and comprehension and submitted their test results online. The pre-programmed function of the site collected all test data for later analysis.

**Phase 3:** The main tasks included data analysis and study report. The data analysis went through following stages: (a) data sorting, (b) data analyzing, and (c) data interpreting. The justification of data analysis method is presented at the end of this chapter and detailed results of the data analysis and interpretations of the results are reported in chapter 4.

**Data Analysis Method**

Multivariate analysis of variance (MANOVA) was used for data analysis. The Statistical Package for the Social Sciences (SPSS) version 11.5 was used to run MANOVA. According to Stevens (1986), MANOVA is “… a generalization of analysis of variance that permits testing for mean differences of more than one nominal independent variables on multiple interval/ratio dependent measures simultaneously” (p.
This study has two nominal independent variables: prior knowledge and concept mapping strategies and four interval/ratio dependent variables: four criterion tests, which are moderately correlated (Tabachnick & Fidell, 2001). To accomplish sound statistical analysis of the data in this study, MANOVA is usually used to increase statistical power and to control false positive results (Huck, 2000; Stevens, 1986; Tabachnick & Fidell, 2001).

**Summary**

This chapter described the design of the major study. It included the instrumentation, which covers the learning material, and criterion measures used in this study, the subjects and experimental treatments, implementing procedures, and data analysis methods. Two pilot studies conducted prior to the major study and the major study were also described to show the progressive efforts towards the major study. The two pilot studies prepared the researcher for the major study and also provided critical information that allowed the major study to be modified and improved. Suggestions from the dissertation committee members and peer students were incorporated in the modification of instructional treatments.
Chapter 4

DATA ANALYSIS AND RESULTS

The purpose of this study is to explore the instructional effects of prior knowledge and three concept mapping strategies in facilitating student achievement of different educational objectives. This chapter reports the results of data analysis and hypothesis testing in order to answer the research questions proposed in chapter 1.

Briefing on the Data

Among 290 subjects recruited for the major study, 270 actually completed the entire process which included taking the prior knowledge test, participating in the concept mapping training workshop, going through the experimental treatment, and taking online criterion tests. The study was implemented in a web-enhanced learning environment where the instructions and criteria tests were online. They were programmed in such a way that students’ data were directly imported into the database by using a CGI script to avoid possible human typing errors. According to the data collected, five subjects’ data were missing either because they failed to submit or chose not to submit their test results.

Motivation was an influential factor in learning efforts. In this study, the subjects got extra course credits for only participating in the study rather than for the quality of their performance. The lack of motivation was clearly revealed by the observed impatience of some subjects and poor quality of concept mapping results in this study. In
order to examine the real effects of concept mapping strategies, two major criteria were considered to screen the data for analysis: The time the subject spent in the study and the quality of concept mapping activities. The process of data screening is to make sure that only data from those subjects who went through the treatment seriously were used in data analysis and hypothesis testing.

As described in the previous chapter, subjects in this study needed to login on to a study web site, study a 2,000-word text, complete concept mapping activities, and take three sets of 20-item test online. Considering the number of tasks the subjects were required to perform and the time needed to complete the tasks, it was decided that the data from those subjects who spent less than half of the mean study time of his/her treatment group would be excluded from data analysis. The study time started when the subjects logged in to the study web site and ended when the subjects submitted their test results. Table 4.1 reports the descriptive statistics on the time each treatment spent in the study.

Table 4.1.
Descriptive Statistics on the Time for Each Treatment in the Major Study (in Minutes)

<table>
<thead>
<tr>
<th>Treatment</th>
<th>n</th>
<th>Mean</th>
<th>SD</th>
<th>Min</th>
<th>Max</th>
</tr>
</thead>
<tbody>
<tr>
<td>Treatment 1: Control</td>
<td>62</td>
<td>12.74</td>
<td>4.50</td>
<td>3.25</td>
<td>21.01</td>
</tr>
<tr>
<td>Treatment 2: Concept mapping</td>
<td>71</td>
<td>27.06</td>
<td>7.36</td>
<td>14.00</td>
<td>47.25</td>
</tr>
<tr>
<td>Treatment 3: Proposition identifying mapping</td>
<td>67</td>
<td>24.58</td>
<td>5.82</td>
<td>11.5</td>
<td>39.50</td>
</tr>
<tr>
<td>Treatment 4: Student-generated concept mapping</td>
<td>65</td>
<td>39.27</td>
<td>11.31</td>
<td>11.00</td>
<td>63.45</td>
</tr>
</tbody>
</table>

Treatment 1: Control  
Treatment 2: Concept matching mapping  
Treatment 3: Proposition identifying mapping  
Treatment 4: Student-generated concept mapping
The quality of concept mapping activity was used to screen the data for analysis. There were two sub-criteria: (1) incomplete concept mapping activity, and (2) quality of student-generated mapping. The incomplete concept mapping activity criterion excluded the data from those subjects in Treatment 2 and Treatment 3 who failed to complete three of five of concept mapping activities. Additionally, the partially completed concept maps in which three or more concepts or propositions were not filled in as required on a single map were regarded as one incomplete concept mapping activity.

Treatment 4 was the student-generated concept mapping. The concept maps generated by them were used to screen the data for analysis. The incomplete concept mapping activity criterion was also applied to this treatment. The data from those subjects who did not generate two or more required concept maps were excluded from data analysis. In addition, if two out of five concept maps generated by the subjects were of poor quality and did not in any way represent the content of the learning materials, his/her data were excluded from analysis.

Data screening also found that the subjects, who did not complete mapping activities in Treatment 2, 3, and 4, spent less than the half of the group mean time in the study. Paired sample T test was used to see if the data screening affected the division of prior knowledge. The pair sample T test results showed no significant differences on the prior knowledge level in each treatment prior to and after data screening. After the screening of the data, 182 sets of data were used for analysis.
Hypothesis Test and Descriptive Statistical Data

SPSS 11.5 was used for the data analysis. The statistic assumptions for MANOVA were checked and met. The checked assumptions (Stevens, 1986; Tabachnick & Fidell, 2001) in this study included:

- The observations are independent;
- Multiple interval/ratio dependent variables and multiple nominal independent variables are of linear relationships;
- The value for the I/R dependent variables follow a multivariate normal distribution of each group of the nominal independent variable;
- The nominal independent variables are fairly similar in their group sizes (largest /smallest ≤ 1.5).

The test of the null hypotheses was performed on four levels of achievement as measured by (1) identification test, (2) terminology test, (3) comprehension test, and (4) the total test, which combined the above three criterion tests. Their reliability and the reliability of prior knowledge test were moderately high (Issac & Michael, 1997) and fairly consistent across all of the measures used in the study as shown in Table 4.2.
Table 4.2.
*Reliability of the Criterion Tests in the Major Study*

<table>
<thead>
<tr>
<th>Variables</th>
<th>Test of Prior Knowledge</th>
<th>Identification Test</th>
<th>Terminology Test</th>
<th>Comprehension Test</th>
<th>Total Test</th>
</tr>
</thead>
<tbody>
<tr>
<td>Treatment 1</td>
<td>0.7104</td>
<td>0.6519</td>
<td>0.7317</td>
<td>0.6561</td>
<td>0.8623</td>
</tr>
<tr>
<td>Treatment 2</td>
<td>0.6973</td>
<td>0.7994</td>
<td>0.7191</td>
<td>0.7597</td>
<td>0.8976</td>
</tr>
<tr>
<td>Treatment 3</td>
<td>0.7087</td>
<td>0.7419</td>
<td>0.5696</td>
<td>0.5959</td>
<td>0.8293</td>
</tr>
<tr>
<td>Treatment 4</td>
<td>0.6948</td>
<td>0.7456</td>
<td>0.7651</td>
<td>0.6408</td>
<td>0.8744</td>
</tr>
<tr>
<td>Overall</td>
<td>0.7311</td>
<td>0.7537</td>
<td>0.7349</td>
<td>0.7088</td>
<td>0.8812</td>
</tr>
</tbody>
</table>

Treatment 1: Control, \( n = 42 \). Treatment 2: Concept matching mapping strategy, \( n = 50 \). Treatment 3: Proposition identifying mapping strategy, \( n = 44 \). Treatment 4: Student-generated concept mapping strategy, \( n = 46 \). Treatment Overall = Treatment 1 + Treatment 2 + Treatment 3 + Treatment 4, \( n = 182 \).

The observed means on the ten selected items in each criterion test were used for hypothesis testing. However, statistical results for 20 test items in the criterion tests are also reported here. Table 4.3 summarizes the means and standard deviations of different treatments on those 10 selected items for all criterion tests.

Table 4.3.
*Descriptive Statistics of the Major Study (10 Selected Test Items)*

<table>
<thead>
<tr>
<th>n</th>
<th>M</th>
<th>SD</th>
<th>M</th>
<th>SD</th>
<th>M</th>
<th>SD</th>
<th>M</th>
<th>SD</th>
<th>M</th>
<th>SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>T 1</td>
<td>42</td>
<td>21.93</td>
<td>3.79</td>
<td>3.64</td>
<td>2.17</td>
<td>3.40</td>
<td>2.39</td>
<td>3.17</td>
<td>2.23</td>
<td>10.21</td>
</tr>
<tr>
<td>T 2</td>
<td>50</td>
<td>22.14</td>
<td>4.11</td>
<td>5.34</td>
<td>2.79</td>
<td>5.74</td>
<td>2.59</td>
<td>5.16</td>
<td>2.38</td>
<td>16.24</td>
</tr>
<tr>
<td>T 3</td>
<td>44</td>
<td>22.36</td>
<td>3.69</td>
<td>4.48</td>
<td>2.42</td>
<td>4.82</td>
<td>2.45</td>
<td>4.34</td>
<td>2.20</td>
<td>13.64</td>
</tr>
<tr>
<td>T 4</td>
<td>46</td>
<td>22.46</td>
<td>3.99</td>
<td>4.57</td>
<td>2.41</td>
<td>5.15</td>
<td>2.75</td>
<td>4.15</td>
<td>1.72</td>
<td>13.87</td>
</tr>
</tbody>
</table>

T 1: Control T 2: Concept matching mapping T 3: Proposition identifying mapping T 4: Student-generated concept mapping

* The maximum score for the Test of Prior knowledge is 36.
* The maximum score for each dependent criterion test is 10 and the maximum score for total test is 30.
Table 4.4 summarizes the means and standard deviations of different treatments on the 20 criterion test items.

Table 4.4.
Descriptive Statistics of the Major Study (20 Test Items)

<table>
<thead>
<tr>
<th></th>
<th>Test of Prior Knowledge</th>
<th>Identification Test</th>
<th>Terminology Test</th>
<th>Comprehension Test</th>
<th>Total Score</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>n</td>
<td>M (SD)</td>
<td>M (SD)</td>
<td>M (SD)</td>
<td>M (SD)</td>
</tr>
<tr>
<td>T 1</td>
<td>42</td>
<td>21.93 (3.79)</td>
<td>9.29 (4.09)</td>
<td>8.33 (4.19)</td>
<td>7.52 (3.98)</td>
</tr>
<tr>
<td>T 2</td>
<td>50</td>
<td>22.14 (4.11)</td>
<td>12.30 (4.60)</td>
<td>12.36 (4.05)</td>
<td>11.82 (4.54)</td>
</tr>
<tr>
<td>T 3</td>
<td>44</td>
<td>22.36 (3.69)</td>
<td>10.11 (4.59)</td>
<td>10.91 (3.48)</td>
<td>10.16 (3.41)</td>
</tr>
<tr>
<td>T 4</td>
<td>46</td>
<td>22.46 (3.99)</td>
<td>11.00 (4.39)</td>
<td>11.59 (4.20)</td>
<td>10.15 (3.65)</td>
</tr>
</tbody>
</table>

T 1: Control  T 2: Concept matching mapping
T 3: Proposition identifying mapping  T 4: Student-generated concept mapping

* The maximum score for the Test of Prior knowledge was 36.
* The maximum score for each dependent criterion test was 20.

Test of Null Hypothesis One

**Ho 1:** There are no significant differences in achievement among students receiving different concept mapping treatments on the criterion tests measuring different educational objectives.

MANOVA results from SPSS 11.5 found significant differences among all four treatments on the four dependent criterion tests in the study (P = 0.003, df = 9, Pillais Trace F = 2.841). Following the checklists for MANOVA offered by Tabachnick and Fidell (2001), univariate F values for each criterion test were checked. Univariate test results
indicated significant F values for each criterion test. Table 4.5 summarizes the results of MANOVA.

Table 4.5.  
**MANOVA Results of the Major Study (10 Selected Test Items)**

<table>
<thead>
<tr>
<th>Dependent Variables</th>
<th>Multivariate: F Ho: df = 9</th>
<th>Univariate F df = 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Treatment Group Effect Pillais Trace</td>
<td>2.841 (p=.003)</td>
<td>3.583 (p=.015)</td>
</tr>
<tr>
<td>Identification Test</td>
<td></td>
<td>6.702 (p&lt;.001)</td>
</tr>
<tr>
<td>Terminology Test</td>
<td></td>
<td>6.570 (p&lt;.001)</td>
</tr>
<tr>
<td>Comprehension Test</td>
<td></td>
<td>7.637 (p&lt;.001)</td>
</tr>
<tr>
<td>Total Test</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Post hoc tests were conducted on SPSS to investigate specific significant differences among all the treatments on each criterion measure (Huck, 2000). The next section reports post hoc test results on each criterion test.

**Identification Test**

Univariate test showed significant differences among the four treatments on the identification test ($F = 3.583, df = 3, p = .015$). The post hoc test of pairwise comparison indicated specific significant differences exist among these four treatments, which are summarized in Table 4.6.
Table 4.6.
Pairwise Comparison of Identification Test

<table>
<thead>
<tr>
<th>(I) Treatments</th>
<th>(J) Treatments</th>
<th>Mean Difference (I – J)</th>
<th>Sig.*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control</td>
<td>Concept matching</td>
<td>-1.70*</td>
<td>.015</td>
</tr>
<tr>
<td></td>
<td>Proposition identifying</td>
<td>-.83</td>
<td>.489</td>
</tr>
<tr>
<td></td>
<td>Student-generated mapping</td>
<td>-.92</td>
<td>.388</td>
</tr>
<tr>
<td>Concept matching</td>
<td>Control</td>
<td>1.70*</td>
<td>.015</td>
</tr>
<tr>
<td></td>
<td>Proposition identifying</td>
<td>.86</td>
<td>.420</td>
</tr>
<tr>
<td></td>
<td>Student-generated mapping</td>
<td>.77</td>
<td>.506</td>
</tr>
<tr>
<td>Proposition identifying</td>
<td>Control</td>
<td>.83</td>
<td>.489</td>
</tr>
<tr>
<td></td>
<td>Concept matching</td>
<td>-.86</td>
<td>.420</td>
</tr>
<tr>
<td></td>
<td>Student-generated mapping</td>
<td>-.77</td>
<td>.999</td>
</tr>
<tr>
<td>Student-generated mapping</td>
<td>Control</td>
<td>.92</td>
<td>.388</td>
</tr>
<tr>
<td></td>
<td>Concept matching</td>
<td>-.77</td>
<td>.506</td>
</tr>
<tr>
<td></td>
<td>Proposition identifying</td>
<td>.09</td>
<td>.999</td>
</tr>
</tbody>
</table>

Based on observed means. * The mean difference is significant at the .05 level.

On the identification test, the mean of Treatment 2 (M = 5.34), concept matching mapping, was significantly higher than that of Treatment 1, the control (M = 3.64), with a mean difference of 1.70 out of 10 maximum possible score.

**Terminology Test**

Univariate test showed significant differences among the four treatments on the terminology test (F = 6.702, df = 3, p < .001). The post hoc test of pairwise comparison found specific significant differences among these four treatments as shown in Table 4.7.
Table 4.7.
Pairwise Comparison of Terminology Test

<table>
<thead>
<tr>
<th>(I) Treatments</th>
<th>(J) Treatment</th>
<th>Mean Difference $(I - J)$</th>
<th>Sig. *</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control</td>
<td>Concept matching</td>
<td>-2.34*</td>
<td>.000</td>
</tr>
<tr>
<td></td>
<td>Proposition identifying</td>
<td>-.141</td>
<td>.091</td>
</tr>
<tr>
<td></td>
<td>Student-generated mapping</td>
<td>-1.75*</td>
<td>.019</td>
</tr>
<tr>
<td>Concept matching</td>
<td>Control</td>
<td>2.34*</td>
<td>.000</td>
</tr>
<tr>
<td></td>
<td>Proposition identifying</td>
<td>.92</td>
<td>.388</td>
</tr>
<tr>
<td></td>
<td>Student-generated mapping</td>
<td>.59</td>
<td>.738</td>
</tr>
<tr>
<td>Proposition identifying</td>
<td>Control</td>
<td>1.41</td>
<td>.091</td>
</tr>
<tr>
<td></td>
<td>Concept matching</td>
<td>-.92</td>
<td>.388</td>
</tr>
<tr>
<td></td>
<td>Student-generated mapping</td>
<td>-.33</td>
<td>.943</td>
</tr>
<tr>
<td>Student-generated mapping</td>
<td>Control</td>
<td>1.75*</td>
<td>.019</td>
</tr>
<tr>
<td></td>
<td>Concept matching</td>
<td>-.59</td>
<td>.783</td>
</tr>
<tr>
<td></td>
<td>Proposition identifying</td>
<td>.33</td>
<td>.943</td>
</tr>
</tbody>
</table>

Based on observed means  * The mean difference is significant at the .05 level.

The means for Treatment 2, concept mapping, and Treatment 4, student-generated mapping, were significantly higher than that of Treatment 1, the control, on the terminology test. The mean difference between Treatment 2 (M = 5.74) and Treatment 1 (M = 3.40) was 2.34 and the mean difference between Treatment 4 (M= 5.15) and Treatment 1 (M = 3.40) was 1.75 out of 10 maximum possible score. There was no significant difference between Treatment 3 (M = 4.82), proposition identifying mapping and Treatment 1, with a mean difference of .53 out of 10 maximum possible score.

Comprehension Test

Univariate test showed that there were significant differences among the four treatments on the comprehension test (F = 6.570, df = 3, p < .001). The post hoc test of
pairwise comparison revealed specific significant differences among these four treatments as summarized in Table 4.8.

Table 4.8.
*Pairwise Comparison of Comprehension Test*

<table>
<thead>
<tr>
<th>(I) Treatments</th>
<th>(J) Treatments</th>
<th>Mean Difference (I – J)</th>
<th>Sig.*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control</td>
<td>Concept matching</td>
<td>-1.99*</td>
<td>.000</td>
</tr>
<tr>
<td></td>
<td>Proposition identifying</td>
<td>-.17</td>
<td>.098</td>
</tr>
<tr>
<td></td>
<td>Student-generated mapping</td>
<td>-.99</td>
<td>.208</td>
</tr>
<tr>
<td>Concept matching</td>
<td>Control</td>
<td>1.99*</td>
<td>.000</td>
</tr>
<tr>
<td></td>
<td>Proposition identifying</td>
<td>.82</td>
<td>.256</td>
</tr>
<tr>
<td></td>
<td>Student-generated mapping</td>
<td>1.01</td>
<td>.237</td>
</tr>
<tr>
<td>Proposition identifying</td>
<td>Control</td>
<td>1.71</td>
<td>.098</td>
</tr>
<tr>
<td></td>
<td>Concept matching</td>
<td>-.82</td>
<td>.339</td>
</tr>
<tr>
<td></td>
<td>Student-generated mapping</td>
<td>-.19</td>
<td>.982</td>
</tr>
<tr>
<td>Student-generated mapping</td>
<td>Control</td>
<td>.99</td>
<td>.208</td>
</tr>
<tr>
<td></td>
<td>Concept matching</td>
<td>-1.01</td>
<td>.159</td>
</tr>
<tr>
<td></td>
<td>Proposition identifying</td>
<td>.19</td>
<td>.982</td>
</tr>
</tbody>
</table>

Based on observed means. * The mean difference is significant at the .05 level.

The only significant difference on this criterion test was between Treatment 2 (M = 5.16), concept matching and Treatment 1 (M = 3.17), the control, with a mean difference of 1.99 out of 10 possible maximum score.

**Total Test**

Univariate test showed significant differences among the four treatments on the total test (F = 7.637, df = 3, p < .001). The post hoc test of pairwise comparison indicated specific significant differences among these four treatments as summarized in Table 4.9.
Table 4.9.  
*Pairwise Comparison of Total Test*

<table>
<thead>
<tr>
<th>(I) Treatments</th>
<th>(J) Treatments</th>
<th>Mean Difference (I – J)</th>
<th>Sig.*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control</td>
<td>Concept matching</td>
<td>-6.03*</td>
<td>.000</td>
</tr>
<tr>
<td></td>
<td>Proposition identifying</td>
<td>-3.42</td>
<td>.078</td>
</tr>
<tr>
<td></td>
<td>Student-generated mapping</td>
<td>-3.66*</td>
<td>.048</td>
</tr>
<tr>
<td>Concept matching</td>
<td>Control</td>
<td>6.03*</td>
<td>.000</td>
</tr>
<tr>
<td></td>
<td>Proposition identifying</td>
<td>2.60</td>
<td>.229</td>
</tr>
<tr>
<td></td>
<td>Student-generated mapping</td>
<td>2.37</td>
<td>.299</td>
</tr>
<tr>
<td>Proposition identifying</td>
<td>Control</td>
<td>3.42</td>
<td>.078</td>
</tr>
<tr>
<td></td>
<td>Concept matching</td>
<td>-2.60</td>
<td>.229</td>
</tr>
<tr>
<td></td>
<td>Student-generated mapping</td>
<td>-.23</td>
<td>.998</td>
</tr>
<tr>
<td>Student-generated mapping</td>
<td>Control</td>
<td>3.66*</td>
<td>.048</td>
</tr>
<tr>
<td></td>
<td>Concept matching</td>
<td>-2.37</td>
<td>.299</td>
</tr>
<tr>
<td></td>
<td>Proposition identifying</td>
<td>.23</td>
<td>.998</td>
</tr>
</tbody>
</table>

Based on observed means. * The mean difference is significant at the .05 level.

The post hoc test indicated that there were significant differences among the treatments. The mean of Treatment 2 (M = 16.24), concept matching mapping, was 6.03 significantly higher than that of Treatment 1 (M = 10.21), out a maximum possible score of 30. Significant difference also existed between the mean of Treatment 4 (M = 13.87), the student-generated mapping, and Treatment 1 (M = 10.21), the control, on the total test with a difference of 3.36 out of 30 maximum scores. Table 4.10 Summarizes the significant differences found in post hoc tests by treatments.
Table 4.10.  
*Significant Differences in the Major Study (10 Selected Test Items)*

<table>
<thead>
<tr>
<th>Identification</th>
<th>Terminology</th>
<th>Comprehension</th>
<th>Total Test</th>
</tr>
</thead>
<tbody>
<tr>
<td>Treatment 2</td>
<td>T 2 &gt; T 1</td>
<td>T 2 &gt; T 1</td>
<td>T 2 &gt; T 1</td>
</tr>
<tr>
<td>Treatment 3</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Treatment 4</td>
<td>X</td>
<td>T 4 &gt; T 1</td>
<td>T 4 &gt; T 1</td>
</tr>
</tbody>
</table>

T 1: Control     T 2: Concept matching mapping  
T 3: Proposition identifying mapping  T 4: Student-generated concept mapping  
X = No significances found between this group and the other groups.  
Alpha = .05.

The researcher also examined the instructional effects of different treatments on the 20 test items. MANOVA results indicated significant differences among the treatments (p < .001, df = 9, Pillais Trace F = 4.465). Univariate tests revealed significances found on each criterion test. Table 4.11 summarized the MANOVA results for those selected item.

Table 4.11.  
*MANOVA Results of the Major Study (20 Test Items)*

<table>
<thead>
<tr>
<th>Dependent Variables</th>
<th>Multivariate: F</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Ho: df = 9</td>
</tr>
<tr>
<td>Treatment Group Effect Pillais Trace</td>
<td>4.465 (p&lt;.001)</td>
</tr>
<tr>
<td>Identification Test</td>
<td>3.910 (p=.010)</td>
</tr>
<tr>
<td>Terminology Test</td>
<td>8.461 (p&lt;.001)</td>
</tr>
<tr>
<td>Comprehension Test</td>
<td>9.158 (p&lt;.001)</td>
</tr>
<tr>
<td>Total Test</td>
<td>8.333 (p&lt;.001)</td>
</tr>
</tbody>
</table>

The post hoc tests also revealed the specific significant differences among treatments on the criterion tests as summarized in Table 4.12.
### Table 4.12.

**Significant Differences in the Major Study (20 Test Items)**

<table>
<thead>
<tr>
<th>Identification</th>
<th>Terminology</th>
<th>Comprehension</th>
<th>Total Test</th>
</tr>
</thead>
<tbody>
<tr>
<td>Treatment 2</td>
<td>T 2 &gt; T 1</td>
<td>T 2 &gt; T 1</td>
<td>T 2 &gt; T 1</td>
</tr>
<tr>
<td>Treatment 3</td>
<td>X</td>
<td>T 3 &gt; T 1</td>
<td>T 3 &gt; T 1</td>
</tr>
<tr>
<td>Treatment 4</td>
<td>X</td>
<td>T 4 &gt; T 1</td>
<td>T 4 &gt; T 1</td>
</tr>
</tbody>
</table>

T 1: Control  
T 2: Concept matching mapping  
T 3: Proposition identifying mapping  
T 4: Student-generated concept mapping  
X = No significances found between this group and the other groups.  
Alpha = .05.

With all of these significant differences among students receiving different concept mapping treatments both on the ten selected test items and on the 20-item criterion tests, Null Hypothesis One was rejected. Detailed interpretations of the data analysis results are presented and discussed in chapter 5.

**Test of Null Hypothesis Two**

**Ho 2:** *There are no significant differences in the achievement on the criterion tests among students identified as possessing high and low prior knowledge receiving different concept mapping treatments.*

The design of this study also identified subjects in each treatment as subjects possessing high prior knowledge and low prior knowledge based on the scores of prior knowledge test of physiology administered one week prior to the actual treatment. Table 4.13 reports the descriptive statistics of the prior knowledge test of physiology. The reliability coefficient of the prior knowledge test of physiology was .7311 as reported in Table 4.2.
Table 4.13.  
Descriptive Statistics for the Prior Knowledge Test

<table>
<thead>
<tr>
<th>n</th>
<th>Mean</th>
<th>Median</th>
<th>Mode</th>
<th>Std. D</th>
<th>Min</th>
<th>Max</th>
<th>Total Score</th>
</tr>
</thead>
<tbody>
<tr>
<td>182</td>
<td>22.23</td>
<td>22.00</td>
<td>23.00</td>
<td>3.88</td>
<td>14.00</td>
<td>35.00</td>
<td>36.00</td>
</tr>
</tbody>
</table>

The distribution of the prior knowledge test results was pretty normal with grand mean of 22.23 out a maximum possible score of 36. The minimum score was 14 and the maximum score was 35 out of 36 maximum score for the prior knowledge test. The median of the prior knowledge test (M = 22) was used to categorize the subjects. The subjects whose prior knowledge test score was above 22 were identified as possessing high prior knowledge while those subjects whose score was 22 and below were identified as possessing low prior knowledge. Table 4.14 presents the descriptive statistics based on this categorization of the subjects regarding their prior knowledge levels.
Table 4.14.  
*Descriptive Statistics for Each Treatment with Prior Knowledge Levels*

<table>
<thead>
<tr>
<th></th>
<th>Test of Prior Knowledge</th>
<th>Identification Test</th>
<th>Terminology Test</th>
<th>Comprehension Test</th>
<th>Total Test</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>n</td>
<td>M</td>
<td>SD</td>
<td>M</td>
<td>SD</td>
</tr>
<tr>
<td>T 1</td>
<td>HPK</td>
<td>19</td>
<td>25.05</td>
<td>2.97</td>
<td>4.47</td>
</tr>
<tr>
<td></td>
<td>LPK</td>
<td>23</td>
<td>19.35</td>
<td>2.03</td>
<td>2.96</td>
</tr>
<tr>
<td>T 2</td>
<td>HPK</td>
<td>21</td>
<td>25.81</td>
<td>3.28</td>
<td>6.90</td>
</tr>
<tr>
<td></td>
<td>LPK</td>
<td>29</td>
<td>19.48</td>
<td>2.11</td>
<td>4.21</td>
</tr>
<tr>
<td>T 3</td>
<td>HPK</td>
<td>22</td>
<td>25.09</td>
<td>2.61</td>
<td>5.27</td>
</tr>
<tr>
<td></td>
<td>LPK</td>
<td>22</td>
<td>19.64</td>
<td>2.34</td>
<td>3.68</td>
</tr>
<tr>
<td>T 4</td>
<td>HPK</td>
<td>22</td>
<td>25.68</td>
<td>2.86</td>
<td>5.59</td>
</tr>
<tr>
<td></td>
<td>LPK</td>
<td>24</td>
<td>19.50</td>
<td>2.16</td>
<td>3.63</td>
</tr>
</tbody>
</table>

T 1: Control       T 2: Concept matching mapping  
T 3: Proposition identifying mapping   T 4: Student-generated concept mapping  
HPK: High Prior Knowledge       LPK: Low Prior Knowledge

* The maximum score for the Test of Prior Knowledge is 36.
* The maximum score for each dependent criterion test is 10 and the maximum score for total test is 30.

This table shows that subjects identified as possessing high prior knowledge outperformed the subjects identified as possessing low prior knowledge in each treatment on all criterion tests. The test of Null Hypothesis Two was conducted with both subjects identified as possessing high and low prior knowledge.

MANOVA results from SPSS 11.5 found significant differences among all four treatments on the four dependent criterion tests for the subjects identified as possessing low prior knowledge. (P < .001, df = 9, Pillais Trace F = 2.791). The univariate test indicated significant differences among all criterion tests as summarized in Table 4.15.
MANOVA was also used to explore the data for those subjects identified as possessing high prior knowledge in this study. The MANOVA results from SPSS 11.5 revealed significant differences among all four treatments on the four dependent criterion tests with the subjects identified as possessing high prior knowledge (P < .019, df = 9, Pillais Trace F = 2.236). The univariate test indicated significant differences among all criterion tests. The results of multivariate and univariate tests for each criterion test were summarized in Table 4.16.

Table 4.15.  
**MANOVA Results for Subjects Possessing Low Prior Knowledge**

<table>
<thead>
<tr>
<th>Dependent Variables</th>
<th>Multivariate: F</th>
<th>Univariate: F</th>
</tr>
</thead>
<tbody>
<tr>
<td>Treatment Group Effect Pillais Trace</td>
<td>2.791 (p &lt; .001)</td>
<td></td>
</tr>
<tr>
<td>Identification Test</td>
<td>2.690 (p = .041)</td>
<td></td>
</tr>
<tr>
<td>Terminology Test</td>
<td>7.574 (p &lt; .001)</td>
<td></td>
</tr>
<tr>
<td>Comprehension Test</td>
<td>6.303 (p = .001)</td>
<td></td>
</tr>
<tr>
<td>Total Test</td>
<td>7.460 (p &lt; .001)</td>
<td></td>
</tr>
</tbody>
</table>

Table 4.16.  
**MANOVA Results for Subjects Possessing High Prior Knowledge**

<table>
<thead>
<tr>
<th>Dependent Variables</th>
<th>Multivariate: F</th>
<th>Univariate: F</th>
</tr>
</thead>
<tbody>
<tr>
<td>Treatment Group Effect Pillais Trace</td>
<td>2.236 (p = .019)</td>
<td></td>
</tr>
<tr>
<td>Identification Test</td>
<td>2.848 (p = .043)</td>
<td></td>
</tr>
<tr>
<td>Terminology Test</td>
<td>3.848 (p = .013)</td>
<td></td>
</tr>
<tr>
<td>Comprehension Test</td>
<td>4.467 (p = .006)</td>
<td></td>
</tr>
<tr>
<td>Total Test</td>
<td>4.185 (p = .008)</td>
<td></td>
</tr>
</tbody>
</table>
Post hoc tests performed revealed specific significant differences among the treatments for both groups of subjects identified as possessing low and high prior knowledge as shown in Table 4.17.

Table 4.17.  
Summary of Significant Differences among Subjects Possessing High and Low Prior Knowledge (10 Test Items)

<table>
<thead>
<tr>
<th>Prior Knowledge</th>
<th>Identification</th>
<th>Terminology</th>
<th>Comprehension</th>
<th>Total Test</th>
</tr>
</thead>
<tbody>
<tr>
<td>T 2</td>
<td>HPK T 2 &gt; T 1</td>
<td>T 2 &gt; T 1</td>
<td>T 2 &gt; T 1</td>
<td>T 2 &gt; T 1</td>
</tr>
<tr>
<td></td>
<td>LPK T 2 &gt; T 1</td>
<td>T 2 &gt; T 1</td>
<td>T 2 &gt; T 1</td>
<td>T 2 &gt; T 1</td>
</tr>
<tr>
<td>T 3</td>
<td>HPK X</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td></td>
<td>LPK X</td>
<td>T 3 &gt; T 1</td>
<td>X</td>
<td>T 3 &gt; T 1</td>
</tr>
<tr>
<td>T 4</td>
<td>HPK X</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td></td>
<td>LPK X</td>
<td>T 4 &gt; T 1</td>
<td>X</td>
<td>X</td>
</tr>
</tbody>
</table>

T 1: Control       T 2: Concept matching mapping  
T 3: Proposition identifying mapping   T 4: Student-generated concept mapping  
HPK: High Prior Knowledge       LPK: Low Prior Knowledge  
X = No significances found between this group and the other groups  
Alpha =.05.

With the significant differences found among all treatments on the criterion tests, Null Hypothesis Two was rejected.

Test of Null Hypothesis Three

**Ho 3:** There is no significant interaction between levels of prior knowledge and instructional treatment type on the criterion tests measuring different educational objectives.
MANOVA on the prior knowledge and concept mapping treatment reported no significant interaction between these two independent variables in this study as shown in Table 4.18. Null Hypothesis Three was retained.

Table 4.18.
MANOVA Results of Prior Knowledge and Concept Mapping

<table>
<thead>
<tr>
<th>Source</th>
<th>df</th>
<th>F</th>
<th>Sig</th>
</tr>
</thead>
<tbody>
<tr>
<td>Prior knowledge</td>
<td>3</td>
<td>14.661</td>
<td>.000</td>
</tr>
<tr>
<td>Concept mapping treatments</td>
<td>9</td>
<td>4.465</td>
<td>.000</td>
</tr>
<tr>
<td>Interaction*</td>
<td>9</td>
<td>.421</td>
<td>.942</td>
</tr>
</tbody>
</table>

* Design: Intercept + Concept mapping treatment + Concept mapping treatment x Prior Knowledge

Summary

This chapter reports the results of data analysis and hypothesis testing in order to answer the research questions proposed in chapter 1. MANOVA was used to accomplish the task and the entire analysis process was conducted using SPSS version 11.5. The results showed that Null Hypothesis One (Ho 1) and Null Hypothesis Two (Ho 2) were rejected because of the significant differences found among the treatments on criterion tests while Hypothesis Three (Ho 3) was retained. A detailed interpretation of the hypothesis testing will be reported in the next chapter.
Chapter 5

CONCLUSIONS

Overview of the Study

This study examined the instructional effects of prior knowledge and three different concept mapping strategies in facilitating achievement of different educational objectives. Specifically, this study tried to determine

a) If the three concept mapping strategies are equally effective in facilitating achievement of different educational objectives, and;

b) If the three concept mapping strategies are equally effective in facilitating achievement of different educational objectives among subjects identified as possessing high and low prior knowledge, and;

c) If there is a significant interaction between levels of prior knowledge and instructional treatment type on the different criterion tests.

The learning material and the criterion tests for measuring different educational objectives used in this study were developed by Dwyer (1965).

The study was implemented in October 2002 with 290 subjects recruited from an educational psychology and a statistics class at a large state university in the U.S. Of 290 participants, 270 completed the entire study process, 265 sets of data were collected and 182 were used for data analysis and hypothesis testing. The ten selected items in each criterion measure were used in the hypothesis testing. The following null hypotheses were tested.
**Ho 1:** There are no significant differences in achievement among students receiving different concept mapping treatments on the criterion tests measuring different educational objectives.

**Ho 2:** There are no significant differences in achievement among students identified as possessing high and low prior knowledge receiving different concept mapping treatments on the criterion tests measuring different educational objectives.

**Ho 3:** There is no significant interaction between levels of prior knowledge and instructional treatment type on the criterion tests measuring different educational objectives.

The hypothesis testing resulted in rejecting Null Hypotheses One and Two and retaining Null Hypothesis Three.

**Interpretation and Discussion of Hypothesis Testing**

The answers to the research questions in the study were explored through the testing of the above hypotheses. The hypotheses were tested at four different levels to determine hypothesis retention or rejection as indicated in Table 5.1. Following interpretation and discussion of the data analysis results are presented according to the concept mapping treatments at these four levels.
Table 5.1.
Learning Hierarchy, Levels of Performance and Criterion Measures

<table>
<thead>
<tr>
<th>Learning Hierarchy</th>
<th>Levels of Performance</th>
<th>Criterion Measures</th>
</tr>
</thead>
<tbody>
<tr>
<td>Factual</td>
<td>Identifying parts and position of an object relating to the learning material</td>
<td>Identification</td>
</tr>
<tr>
<td>Conceptual</td>
<td>Defining terms and rephrasing concepts relating to the learning material</td>
<td>Terminology</td>
</tr>
<tr>
<td>Rules &amp; Principles</td>
<td>Comprehending complex procedures and processes of how a system works</td>
<td>Comprehension</td>
</tr>
<tr>
<td>Overall</td>
<td>General academic performance of undergraduates for a course study in a university</td>
<td>Total Tests</td>
</tr>
</tbody>
</table>

Null Hypothesis One

Treatment 1: Control

Treatment 1, which did not use any concept mapping strategy in this study, provided the context for comparing the instructional effects of prior knowledge and the three concept mapping strategies. The achievement scores on all four criterion tests for the control were pretty low. The lowest achievement score was on the comprehension test with a group mean of 3.17 for the ten selected items (maximum score of 10) and 7.52 for the 20 test item criterion test (maximum score of 20). This indicated that the learning material itself and the criterion tests were fairly difficult for the subjects in the control group.

Treatment 2: Concept matching

Among the concept mapping treatments, Treatment 2, concept matching, used the simplest and most straightforward mapping activity to facilitate learning. Subjects in this treatment were required to fill in some of the missing concepts in the given concept maps
that represented the contents of their learning material. The missing concepts were those that were directly associated with the information in the learning material that would help the subjects answer correctly those ten selected difficult items in the criterion tests. Prior to the study, the researcher anticipated that this treatment would significantly outperform all other treatments in the test of identification, since this concept matching mapping strategy focused learners’ attention on the factual information of those key concepts in the learning material, which were crucial if the learner wanted to answer questions correctly in the criterion test of identification.

Data analysis found that significant differences existed between Treatment 2 and Treatment 1, the control, on all criterion tests of the ten selected items. This finding is consistent with those of researchers (Chularut, 2001; Jegede et al., 1990; Okebukola 1990; Pankratius, 1990; Wachter, 1993), who report a significant difference in achievement between students using concept mapping and those not using concept mapping. Although concept matching mapping was designed to focus subjects’ attention primarily on interacting with factual information of those key concepts in the learning material, this meaningful and active interaction instigated by concept matching helped the students process not only the factual information of those key concepts but also comprehend other dimensions of the content (other than the factual information of those key concepts) in the learning material. Pankratius (1990) pointed out that students benefit most from concept maps that reveal the connections between concepts by using labeled words. Concept matching, by labeling all important propositions among the selected concepts in a map, well framed all the key concepts in the learning material. According to
Novak and Gowin (1984) it is the connectedness between and among individual concepts in concept mapping that facilitates meaningful learning.

This finding is also in alignment with the concept of learning hierarchy (Gagné, 1977). In explaining the phases in the learning hierarchy, Dwyer (1978) stated that the more facts that a person is familiar within a content area, the better prepared the person is to relate and combine those factual information into concepts, and the more concepts a person possesses, the easier it is for the person to form generalizations, rules and principles. Dwyer’s explanation of the phases of the learning hierarchy can be borrowed to explain the reason why Treatment 2, concept matching, which focuses on facilitating learning at a factual level, can eventually facilitate learning at the CONCEPT, and rules and principles levels. Concept matching, simple and straightforward, directs learners’ attention to processing the factual information of those key concepts in the learning material and results in distinctive encoding and deeper processing of factual information (Craik & Lockhart, 1972; Driscoll, 2000). The distinctively encoded and deeper processed factual information provides good foundations for understanding concepts, and well-understood concepts support comprehension of the complex content of the learning material and application of rules and principles.

The insignificant differences among the three concept mapping treatments (Treatments 2, 3, and 4) are discussed at the end of this section.

**Treatment 3: Proposition identifying**

Treatment 3, proposition identifying, required subjects to identify the propositions between given concepts and fill in the missing link words or phrases on given maps. It
was designed to instigate interaction between learners and their learning material by focusing their attention on the relationships or propositions among those key concepts and to facilitate learning at a conceptual level. It was predicted that proposition identifying mapping would be more effective in facilitating achievement at the conceptual level as measured by the criterion test of terminology than other treatments. Data analysis for this treatment found no significant differences on the ten selected items. These findings are consistent with those of researchers (Fraser & Edwards, 1987; Lehman, Carter, & Kahle, 1985; Sherris & Kahle, 1984) who report insignificant differences on achievement between the concept mapping and the control. However, significant differences were found between Treatment 3 and Treatment 1 on 20 test items on the terminology and comprehension tests.

The proposition identifying mapping strategy, which was designed to instigate interaction between learners and learning material by focusing their attention on the relationships -- propositions -- among those key concepts in the learning material, was not effective in facilitating learning of factual information. One possible reason for this result might be the selective characteristics of information processing. If information is not meaningfully attended during information processing in the working memory, it is soon lost from the system (Driscoll, 2000; Gagne et al. 1992; Gredler, 2001). Since proposition identifying mapping oriented the subjects’ attention during information processing on those missing propositions between concepts in the given concept maps, the subjects might fail to see the factual information of those key concepts although they were presented in the given maps. Their minds were busy working at the conceptual level to figure out what relationships among those selected concepts were in a given map. This
result of proposition identifying mapping provides evidence that different learning
strategies would instigate different levels of information processing and result in different
levels of achievement.

However, on the criterion tests of terminology, and comprehension (20 test
items), proposition identifying mapping does affect learning and makes a significant
difference when comparing achievement scores with those of the control group. This is in
accordance with reports of those researchers (Chularut, 2001; Jegede et al. 1990;
Okebukola 1990; Pankratius, 1990; Wachter, 1993) who found significant differences in
achievement between concept mapping and the control. By focusing learners’ attention
on the relationships among those key concepts in the learning material, proposition
identifying mapping is effective in facilitating learning at the conceptual level and
consequently learning at the rules and principles level. Proposition identifying mapping
forces the subjects to explicitly identify the relationships among those key concepts in
their learning material. This procedure demands that the subjects process the specific
information at a deeper level and consequently results in better comprehension of the
contents of their learning material compared with the subjects in the control. As Chularut
(2001) put it, the procedure of mapping demands that the students have a good
understanding of the attributes of concepts and interrelationships (propositions) of
concepts. This result for proposition identifying mapping on achievement once again
provides evidence that well-understood concepts support application of the rules and
principles (Dwyer, 1978).
**Treatment 4: Student-generated mapping**

Student-generated concept mapping was designed to facilitate learning at the rules and principles level. It was projected that the student-generated concept mapping would instigate meaningful interaction with the learning material and facilitate achievement on the comprehension test. However, since generating concept maps requires students to identify and select key concepts to map, and clarify the relationships (propositions) among those selected key concepts, and eventually to reorganize those concepts and propositions to represent their understanding of the learning material, it was also predicted that student-generated mapping would facilitate learning at factual and conceptual levels as measured by the identification test and terminology test, respectively. Data analysis results found only significant differences between Treatment 4 and Treatment 1, Control, on the criterion test of terminology and the total test (10 selected test items), and on the criterion tests of terminology, comprehension, and total test (20 test items).

There was no significant difference between Treatment 4, the student-generated concept mapping and Treatment 1, the control, in achievement as measured by the identification test. One explanation for this result could be that student-generated concept mapping is very demanding, requiring the subjects to identify all of the important concepts and propositions among the concepts in their learning material and then determine the structure of the concept map according to their understanding of the contents and map it out explicitly. This process requires the subjects to think in multiple directions and to switch back and forth between different levels of abstractions (Okebukola, 1990). Therefore during this process of mapping, the factual information is
certainly not the focus of the subjects while they are busy sorting out the propositions among the concepts and constructing a concept map to represent their understanding of the content. Consequently, it did not make significant differences in achievement at the factual level as measured by the criterion test of identification when compared with the control.

However, the student-generated concept mapping was effective in facilitating achievement at the conceptual level according to the test of terminology on the ten selected test items. As a result, it made a significant difference in the general academic achievement as measured by the total test when compared with the control. On the criterion tests of 20 test items, the student-generated concept mapping also made significant differences on achievement as measured by the terminology, comprehension and total tests when compared with the control. The results of student-generated mapping are supported by the findings from those researchers (Chularut, 2001, Jegede et al. 1990, Okebukola, 1990; Pankratius, 1990, Wachter, 1993) who report significant differences in achievement between concept mapping and the control.

A possible explanation could be that the student-generated concept mapping helps the students interact with the learning material by not only identifying the key concepts and propositions but also explicitly recognizing the meaningful and internal structure of the content that holds it as a complete unit in the learning material. This meaningful interaction instigated by the student-generated concept mapping and the efforts to explore the internal structure and completeness of the information being processed during the mapping process enhance learning at both conceptual level and rules and principles level. Pankratius (1990) suggested that mapping is most effective when students create their
own maps throughout this learning process and that the degree of involvement in constructing concept mapping is clearly the major factor in students’ achievement.

Discussion

Study results indicate that different concept mapping strategies have different effects in facilitating achievement of different educational objectives. Figure 7 presents graphically the achievement of each treatment on the criterion tests of ten selected tests items, Figure 8 represents the achievement of each treatments on the criterion tests of 20 test items in the major study, and Figure 9. the achievement on the criterion tests for each treatment in the second pilot study.

Figure 1. Achievement on the criterion tests for each treatment (10 test items)
Figure 8. Achievement on the criterion tests for each treatment (20 test items)

![Graph showing achievement scores for each treatment (Identification, Terminology, Comprehension, Total Test) for different levels of criterion measures.]

Figure 9. Achievement on the criterion tests for each treatment in the second pilot study

![Graph showing achievement scores for each treatment (Identification, Terminology, Comprehension, Total Test) for different levels of criterion measures.]

It must be mentioned at this point that the experimental effects of concept mapping strategies in the major study on achievement as measured by the criterion tests were very similar to those of the second pilot study described in chapter 3. The similarity in the experimental effects indicated the consistency of concept mapping strategies in facilitating learning. Figure 9, which presents graphically the achievement of each treatment on the criterion tests in the second pilot study, is almost the same as Figure 8.

In this study, insignificances were also interesting results of data analysis. Many factors might have contributed to the insignificant results among the three concept mapping strategies. For Treatment 3, proposition identifying mapping, one of the possible factors might be that the treatment was difficult and confusing to some of the subjects. Concepts, according to Novak (1998), are perceived regularity in events or objects, or records of events or objects designated by labeling words. The perceived regularity is defined by the attributes of the concepts, which are framed by the propositions among those concepts. This explains why Novak and Gowin (1994) maintain that concept mapping facilitates meaningful learning by illustrating the connectedness between and among individual concepts and concept mapping can serve as a learning tool to help learners organize their cognitive frameworks into more powerful integrated patterns with those labeled propositions. Pankratius (1990) stated that students benefit most from maps that reveal the connections between concepts using labeled word. Proposition identifying mapping, removing those critical propositions in the given concept maps, might easily confuse the subjects.

Concepts without propositions are not well defined and are ambiguous. Different people might perceive these concepts without propositions in their own ways according
to their understanding of the learning material as they are required to identify the propositions among these concepts. In proposition identifying mapping, the subjects might perceive those given concepts very differently from what a map provider expected them to see. According to Stewart (1979), there could be “… numerous valid propositions that could be generated to link two nodes” (p. 400). The ambiguity in given maps with deleted propositions as those in Treatment 3 could easily confuse the subjects and cause negative effect on learning. This assumption is consistent with that of Jo (2001) who found the negative results in achievement with the instructor-provided concept map treatment when compared with the control. So, in devising proposition identifying concept mapping, it is advisable to be extra cautious when removing some of the propositions from the concept maps.

Additionally, the fact that subjects were not familiar with proposition identifying mapping and student-generated mapping might be another explanation for those insignificant differences among the three concept mapping treatments. Student-generated mapping as stated above is a very demanding metacognitive strategy that takes a relatively long time, and requires sustained efforts and fairly good concept mapping skill, if it is meant to be effectively used in facilitating learning. If subjects were struggling with frustration to map out the complex maps for the learning material, they could not deeply or meaningfully process the information as they shifted their focus onto the construction of the concept map. Both the concept maps generated by the subjects and the observations made in this study indicated the lack of concept mapping skills among the subjects. As a result, the student-generated concept mapping may have failed to facilitate achievement significantly in this study.
Schau and Mattern (1997) argued that asking students to draw a totally user-generated map imposes a high cognitive demand to extract meaningful representations of their knowledge. “This demand may have caused the students to focus more heavily on the map than on actually understanding the material and establishing mental connections” (Taricani, 2002, 97). Snead (2000) asserted that a lack of familiarity with the concept mapping strategy and inadequate preparation for the use of the concept mapping strategy is likely a factor for the insignificant differences. The subjects in this study, who received only a 50-minute workshop training on concept mapping prior to the study, were certainly not sufficiently prepared with the concept mapping strategies. Successful use of concept mapping requires practice and a willingness of people to be open to a great deal of trial and error and ambiguity (Novak, 1990a). Concept mapping is most effective when accompanied with comprehensive training, instructor guidance, and long-term practice (Roop, 2002).

To sum up, the three concept mapping strategies are not equally effective in facilitating achievement of different educational objectives. Extra considerations should be given to learners’ mapping ability before deciding which type of concept mapping would be used in order to achieve maximum effects on learning.

**Null Hypothesis Two**

**Ho 2:** There are no significant differences in achievement among students identified as possessing high and low prior knowledge receiving different concept mapping treatments on the criterion tests measuring different educational objectives.
Hypothesis testing found significant differences among students identified as possessing high and low prior knowledge receiving different concept mapping treatments on the criterion tests measuring different educational objectives and this null hypothesis was rejected.

The main effects of concept mapping in this study were as anticipated: Higher achievement scores for high prior knowledge subjects across all treatments on all criterion tests. The main effects of prior knowledge in this study are consistent with the reports of other researchers (Dwyer & Dwyer, 1990; Elliott, 1993) who maintain that prior knowledge plays a significant part in how learners interact with the learning material and perform on various learning tasks measured by different criterion tests. Driscoll (2000) emphasized the same point, stating that the prior knowledge that learners bring to the learning environment dictates to a large extent what they will take away from it in terms of new knowledge, concepts added to their cognitive structure, or details elaborating schemata.

However, by examining the significant differences among subjects identified as possessing high prior knowledge, it can be said that concept mapping strategies were not as effective as expected by the researcher. Out of the three concept mapping strategies, only concept matching mapping was uniformly more effective than the control and can significantly facilitate learning achievement at the conceptual, rules and principles levels and aid subjects in general academic performance. The other two concept mapping strategies could not make significant differences in facilitating achievement as measured by the criterion tests.
This finding agrees with reports from other researchers (Davey & Kapinus, 1985; Elliott, 1993; Pintrich et al., 1986), who found in their studies that learners with high prior knowledge of the subject matter performed well following instruction that was incomplete and less structured, allowing the individual to use self-selected or metacognitive learning strategies. Students with limited prior knowledge benefited most from more detailed and structured learning material. In this study, subjects were not given the freedom of choosing their own learning strategies but were required to use different concept mapping strategies. For those high prior knowledge subjects, forcing them to use unfamiliar learning strategies impedes their learning.

For those subjects identified as possessing low prior knowledge, concept mapping strategies were generally effective in facilitating learning. Concept matching made significant differences at all levels of learning when compared with the control. Also, all three concept mapping strategies made significant differences on learning at conceptual level as measured by the criterion test of terminology when compared with the control. These results showed that for subjects identified as possessing low prior knowledge, concept matching may have provided them with added cueing or have aided them in processing information from the learning material, which resulted in better achievement as measured by the criterion tests when compared to the control group.

However, it also should be mentioned that the student-generated concept mapping was least effective for the subjects with low prior knowledge. Subjects with low prior knowledge had double barriers in using this mapping strategy: comprehending their learning material without much prior knowledge and generating with frustration concept maps to represent their limited understanding of the learning material. When using the
student-generated concept mapping strategy with low prior knowledge students, these
double barriers must be carefully considered. The significant and insignificant differences
found in this study with subjects identified as possessing low and high prior knowledge
shed light on which type of concept mapping strategies is the most effective in facilitating
achievement of specific educational objectives.

**Null Hypothesis Three**

Ho 3: *There is no significant interaction between levels of prior knowledge and
instructional treatment type on the criterion tests measuring different educational
objectives.*

Study results showed no significant interactions in four levels of criterion testing
between student prior knowledge and concept mapping treatments. Therefore, null
hypothesis 3 was retained. The relationship between prior knowledge and the three
concept mapping treatments used in this study operated independently of each other. As a
result, findings about prior knowledge and three concept mapping strategies in facilitating
achievement of different educational objectives discussed above were due to the
experimental effects rather than the interactions of the two independent variables in this
study.
Summary of the Findings

The following conclusions may be drawn about prior knowledge and the three concept mapping strategies in facilitating achievement of different educational objectives from its findings.

- The three concept mapping strategies (concept matching mapping, proposition identifying mapping, and student-generated mapping) were not equally effective in facilitating achievement of different educational objectives as measured by the criterion tests when compared with the control.

- Concept matching mapping strategy (Treatment 2), the simplest and most straightforward mapping strategy, was the most effective among the three mapping strategies not only in facilitating learning at factual level but also at the higher levels of CONCEPT, and rules and principles. The significant differences in achievement were found between the concept matching and the control on all criterion tests.

- Proposition identifying mapping strategy (Treatment 3) was not significantly different in facilitating achievement of different educational objectives as measured by the criterion tests when compared with the other three treatments (Treatment 1, Treatment 2, and Treatment 4).

- The student-generated concept mapping strategy (Treatment 4) was the most demanding both in terms of the cognitive load and the time needed to complete the treatment. Significant differences were found in achievement at the CONCEPT level and in the general academic performance between the student-
generated concept mapping and the control (Treatment 1) as measured by the criterion test of terminology and the total test.

• In spite of all the significant differences found, the achievement scores in all concept mapping treatments were not as satisfactory as expected. This indicated that concept mapping strategies alone in learning might not be effective enough to bring about the expected learning outcomes.

• Subjects identified as possessing high prior knowledge significantly outperformed subjects identified as possessing low prior knowledge in all concept mapping treatments on all the criterion tests.

• Among the subjects identified as possessing low prior knowledge, concept matching mapping (Treatment 2) achieved significantly higher scores than the control (Treatment 1) on all criterion tests. Proposition identifying mapping (Treatment 3) achieved significantly higher scores than the control (Treatment 1) on the criterion test of terminology and on the total test. Student-generated concept mapping (Treatment 4) achieved significantly higher score than the control (Treatment 1) on the criterion test of terminology. Regarding the significant differences found on the criterion test of terminology, concept matching mapping was the most effective and student-generated concept mapping was the least effective.

• Among the subjects identified as possessing high prior knowledge, the significant differences were only found in achievement as measured by the criterion tests of terminology, comprehension and the total test between the concept matching (Treatment 2) and the control (Treatment 1).
• There are no significant interactions between prior knowledge and concept mapping treatments in this study.

**Instructional Implications**

From instructional perspective, the above findings reveal that concept mapping strategies are not equally effective in facilitating learning at different levels. The effective use of concept mapping strategies should be the one that would facilitate learning at the desired level of learning hierarchy and help learners achieve the intended educational objectives. In selecting or devising concept mapping strategies for instructional purposes, the learning objectives and intended learning outcomes should be considered prior to the types of concept mapping strategies to be used to achieve them.

Concept mapping can take various forms. Some simple and straightforward concept mapping activities like concept matching could be as effective as those complicated ones like the student-generated concept mapping. However, the time spent in completing the different concept mapping activities is very different. By appropriately applying different concept mapping strategies in instructions according to particular educational objectives, not only effectiveness but also efficiency of learning can be greatly enhanced.

Concept mapping can be very demanding depending on what type of concept mapping strategies is being used and who are using it. Complicated concept mapping strategy like the student-generated one can be very difficult for the students with low prior knowledge. Those students with low prior knowledge usually have double barriers in using the student-generated concept mapping strategy: low prior knowledge in
comprehending the learning material and difficulties in mapping out their understanding of the learning material. It is advisable to use additional learning strategies like rehearsal, elaborative, and organizing strategies and to provide more cueing in processing the learning material while the students with low prior knowledge of a learning domain are engaged in generating their own concept maps. Alternatively, instructors can provide more training on concept mapping prior to the use of the student-generated concept mapping to make sure that those students with low prior knowledge would not be frustrated with the learning strategy itself or provide more detailed guidance when the students with low prior knowledge are generating their own concept maps.

**Limitations**

Some of important limitations identified in this study include the following. Limited time on training and practicing concept mapping might have reduced the effectiveness of experimental treatment in the study. Concept mapping is a very demanding learning strategy that requires sustained efforts and good mapping skill in order to use it effectively. Subjects in this study were not well prepared in using concept mapping strategies. A 50-minutes training workshop on concept mapping was not enough to turn a naïve concept mapper into a skillful user of concept mapping strategies.

Novak (1995) pointed out that successful use of concept mapping requires practice and a great deal of trial and error. Concept mapping is most effective when accompanied by comprehensive training, instructor guidance, and long-term practice (Roop, 2002). Smith and Dwyer (1995) also discussed the fact that their subjects might not have enough time to master the concept mapping strategies. Spaulding (1989) and
Roshan (1997) suggested providing more practice time on concept mapping strategies prior to the study and claimed that the sufficient practice could increase the students’ performance. This study might have produced different results if more time were spent on preparing the subjects for concept mapping.

The study was quantitative in nature. This depicts only one side of the coin through quantitative analysis of the data collected. How these data were produced remained untouched. For instance, why proposition identifying mapping was confusing and misleading to some of the subjects remains unanswered.

The workload for subjects in the student-generated concept mapping was too much for most of the subjects. Obvious impatience, which led to many poor quality concept maps, was observed during the treatment.

**Recommendations for Future Research**

According to the limitations identified in this study, the following recommendations are made for future research on concept mapping strategies.

- Future research should focus on exploring the types of concept mapping strategies that would facilitate learning at higher levels of the learning hierarchy. Specifically, the types of concept mapping strategies that facilitate achievement at CONCEPT, rules and principles, problem solving levels by analyzing and synthesizing the problem situations, and evaluating alternative problem solutions should be explored.

- Future studies about concept mapping strategies could include the evaluation of the concept maps, and conducting a post-study survey and interviews to produce a
fuller, better and more accurate picture of different concept mapping strategies in facilitating learning achievement. It is believed that the information on the mapping activities would shed light on the real causes of learning outcomes affected by mapping strategies, which would be very valuable for the actual application of concept mapping.

- Future exploration of the concept mapping strategies should be done in combination with other learning strategies to produce a realistic picture of concept mapping strategies in facilitating learning. In many situations, learners use more than one learning strategy to address their learning needs or learning problems. Conducting concept mapping strategy studies together with other learning strategies like note-taking, summarizing, and questioning would produce more practical information on concept mapping.

- The achievement tests in this study immediately followed the instruction. It would be more useful to see the delayed instructional effects of different concept mapping strategies. This would provide a new dimension of information on concept mapping in facilitating achievement of different educational objectives.

- Concept mapping is a very demanding learning strategy that requires sustained efforts and good mapping skills in order to use it effectively. Providing more training time and more practice opportunities to the subjects before conducting the study is crucial.

- Course-related content should be used to improve student motivation in concept mapping and reveal the actual instructional effects of concept mapping in facilitating different course-related learning objectives.
References


Appendices

Appendix A: Informed Consent Form, Learning Material and the Criterion Tests
Appendix A.1: Informed Consent Form
Informed Consent Form
(IRB# 01B1105)
The Penn State University, University Park

Title of study
The Instructional Effects of Varied Concept Mapping Strategies in Facilitating Achievement of Different Educational Objectives.

Description
1. This study examines the effects of three concept mapping strategies in the web-based course and their relationship with prior knowledge levels. Concept mapping is a very useful learning strategy. It helps people clarify the concepts and their relationships by using graphics like lines and boxes. By conducting this research, the researcher hopes to find evidence of effective uses of concept mapping strategies in facilitating learning and their relationship with prior knowledge.

2. The study consists of two parts. In Part 1, you will be asked to take a prior knowledge test of physiology. The test contains 36 multiple choice questions and will probably take 10 ~ 15 minutes to finish it. Then, you are asked to participate in a concept map training workshop to learn concept mapping. This will take about 30 ~ 45 minutes. In Part 2, you will be convened in a University Park campus computer lab. You will be required to login online and browse a given website. This website contains an instructional material about human heart. Then you may be asked to do some concept mapping activities depending on which study group you are in. After you finish concept mapping activities, you will take three sets of tests. Each test has 20 multiple-choice questions relating to the instructional materials. Your participation in this research will take about approximately 2 hours (1 hour for each part).

3. There is no risks known of participating the study. Participating in this study, you will learn how to use concept mapping strategy. This is beneficial to your study in university.

4. You must be at least 18 years of age or older to participate in this study. You will receive extra credit for your course study by participating in this study. However, you can also earn this extra credit by doing alternative course assignment given by the instructor, which will take about the same amount of time and effort to complete.

Consent form
I have read this consent form and understand its content. I understand my participation is voluntary that I can stop participating in this study at any time or decline to answer any given questions at my own will. I also understand that my participation in this research is confidential to the degree permitted by the technology used. Specifically, no guarantees can be made regarding the interception of data sent via the Internet by any third parties. Only the person in charge will have access to my identity, and to the information that can be associated with my identity.

I hereby agree to participate in this study. Participant Name (in PRINT) ______________________

Participant’s Signature: ___________________________ Date October ______ , 2002

Researcher’s name: ___________________________ Date October 20, 2002

If you have any questions or concerns, please contact the researcher and his advisor at
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Appendix A.2: Instructional Material
The Heart and Its Functions

The human heart is a hollow, bluntly conical, muscular organ. Its pumping action provides the force that circulates the blood through the body. In the average adult, the heart is about five inches long and about two and one half inches thick. A man’s heart weighs about eleven ounces and a woman’s heart weighs about nine ounces. The heart lies toward the front of the body and is in a slanting position between the lungs, immediately below the breastbone. The wide end points toward the right shoulder. The small end of the heart points downward to the front of the chest and toward the left. The lower portion of the heart is called the apex and is the part that you feel beating.

In order to better comprehend the following instruction, it will be helpful to visualize a cross-section view of a human heart in a position such that you are facing the person. As you visualizing it, the right side of the heart will be on the left side.

To understand the functioning of the heart you will need to be able to identify the parts of the heart. The heart is enclosed in a thin double-walled sac. The layer which forms the outer wall of the sac is called the pericardium. It is composed of a tough, transparent elastic tissue. It protects the heart from rubbing against the lungs and the walls of the chest. The inner portion of the double walled sac is called the epicardium. It is attached to the heart muscle.

The heart muscle is called the myocardium. It controls the contraction and relaxation of the heart. The myocardium constitutes by far the greatest volume of the heart and its contraction is responsible for the propulsion of the blood throughout the body. The myocardium varies in thickness. For example, the myocardium forming the auricle walls is thin when compared to the thickness of the myocardium forming the ventricle walls.

The endocardium is the name given to the inside lining of the heart wall.

The human heart is really two pumps combined into a single organ which circulates blood to all parts of the body. The heart is divided longitudinally into two halves by septum. The two halves may be compared to a block of two houses, which are independent of each other but have a common wall, the septum, between them.

Each half of the heart is divided into an upper chamber and a lower chamber; the upper chamber are called auricles and the lower chamber are called ventricles. Although there is no direct communication between the right and left sides of the heart, both sides function simultaneously. As we stated previously, the upper chambers on each sides of the septum are auricles, the lower chambers are called ventricles. Auricles have thin walls and act as receiving rooms for the blood while the ventricles below act as pumps, moving the blood away from the heart.
As you would view a cross-sectional diagram of the heart, blood enters the right auricle through veins. Only veins carry blood to the heart. The superior and inferior vena cavae are the two veins which deposit blood in the right auricle. The superior vena cava deposits blood into the right auricle from all body parts above the heart level, for example, the head and the arms.

The other vein, the inferior vena cava, deposits blood into the right auricle from the trunk and legs --- that is from regions below the heart level. As blood from the body fills the right auricle, some of it begins to drip into the right ventricles immediately.

The auricles and ventricles on each side of the heart communicate with each other through openings. The opening between the right auricle and right ventricle is called the tricuspid valve. This valve consists of three triangular flaps of thin, strong, fibrous tissue. These flaps permit the flow of blood into right ventricles, but prevent it from flowing backward into the right auricle because the ends of the flaps are anchored to the floor of the right ventricle by slender tendons.

The three flaps act like swinging doors which open only in one direction. Thus, blood passes from the right auricle through the tricuspid valve into the right ventricle. As soon as the right ventricle is filled with blood, both ventricles begin to contract.

The first effect of the pressure produced in the right ventricle is to force blood behind the flaps of the tricuspid valve.

While the blood pressure behind the flaps brings the flaps together and prevents the flow of the blood, the contraction of the right ventricle continues until the blood presses hard enough to open the pulmonary valve and to force the blood into the pulmonary artery. The pulmonary valve is located between the right ventricle and the pulmonary artery.

The pulmonary valve, like the tricuspid valve, consists of three flaps which fill with blood backing up in the pulmonary artery. As soon as the right ventricle begins to relax from its contraction, the pulmonary valve prevents blood from flowing back into the right ventricle from the pulmonary artery. The pulmonary valve opens only when the pressure in the right ventricle is greater than the pressure in the pulmonary artery, forcing the blood into the pulmonary artery.

The pulmonary valve is composed of flaps or pockets, which the swollen pulmonary artery quickly fill with blood as soon as the right ventricle begins to relax from its contraction. The flaps or pockets of the valve are thus pressed together, and no blood flows back into the right ventricle.

After the blood passes through the pulmonary valve it enters the pulmonary artery, from which it is carried up through the heart to both the left and right lungs where it is cleaned and oxygenated.
Returning from the lungs, the blood enters the heart through four pulmonary veins and collects in the left auricle.

Like the right auricle, the left auricle also contracts when it is full, squeezing blood through the mitral valve into the left ventricle. The mitral valve is located between the left auricle and left ventricle.

The mitral valve is similar in contraction to the tricuspid valve. As the left ventricle contracts simultaneously with its mate, the right ventricle, it forces blood behind the flaps of the mitral valve, thereby closing the path back to the left auricle.

The contraction of the left ventricle pumps the blood through the entire body. For this reason it is the largest, strongest, and most muscular section of the heart. When the left ventricle which is filled with blood contracts, the resulting pressure in the ventricle opens the aortic valve located in the mouth of the aorta.

The aorta is the largest artery which carries the blood from the left ventricle.

The Circulation of the Blood

The directional flow of blood in the heart is determined by valves which allow the blood to flow in only one direction.

Both auricles receive blood simultaneously through unguarded opening in the veins. The right auricle receives its blood through the superior and interior vena cavas while the left auricle receives its blood through the pulmonary veins.

A wave of muscular contraction starts at the top of the heart and passes downward, simultaneously, over both sides of the heart; that is, both auricles contract at the same time and then relax as the contraction passes down to the ventricles. When the auricles are caused to contract they become small and pale, and in doing so the blood in their chambers is subjected to increased pressure which forces blood through both the tricuspid and mitral valves.

As the ventricles fill, eddies of the blood float the flaps on both the tricuspid and mitral valves out to a partially closed position. As the ventricle pressure becomes greater than that in the auricles, the valves are tightly closed and so prevent blood from being forced backward into the auricles.

While the auricles are relaxing from the contraction, blood flows into them from the veins as the contraction of the ventricle is initiated.

The instant that the contraction of the auricles has been completed, the ventricles are stimulated to contract; this contraction increases the pressure in the chambers forcing the valves, both the tricuspid and mitral, completely shut.
The pulmonary valve and aortic valve, also called the semi-lunar-valves, that guard the entrances to the pulmonary artery on the right and aortic artery on the left are closed by the back pressure provided by blood already in these vessels. When the ventricle pressure becomes greater than in the exit vessels, the pulmonary and aortic valves open.

Blood flows from the right ventricles into pulmonary artery then route to the lungs and from the left ventricle into the aorta for distribution through the entire body.

Immediately following ejection of blood into the arteries, the ventricles begin to relax; this lowers the pressure within their chambers, and the greater pressure in the arteries closed the semi-lunar valves. Pressure within the ventricle is sufficient, however, to maintain closure of the tricuspid and mitral valves against the already increasing auricle pressure.

As the ventricles relax further, pressure within them decreases correspondingly, and the tricuspid ad mitral valves are forced open by increased auricle pressure caused by blood flowing into them from veins. Therefore, before the next auricle contraction, blood is already flowing from the auricles into the ventricles because a greater blood pressure exits in the auricles than in ventricles.

The Cycle of the Heartbeat Consists of Two Parts

The relaxation of the ventricles, during which they are filled with blood is called the diastolic phase.

The heart relaxes between beats in the diastolic phase. Blood flows into the heart filling both auricles. While blood is flowing into the auricles, the recoil of the artery wall still maintains part of the pressure developed by the contraction of the ventricles. This is the time of lowest pressure in the arteries or what is called the diastolic pressure.

The contraction phase or systolic phase begins when the auricles contract. The blood forces sits way through the mitral and tricuspid valves into ventricles.

The ventricles contract and force the blood through the semi-lunar valves, that is, the pulmonary and aortic valves.

After passing through the pulmonary and aortic valves the blood enters the pulmonary and aortic arteries. The blood leaves the ventricles under terrific pressure and surges through the arteries with a force so great that it bulges their elastic walls. At this point, arterial blood pressure is greatest; this pressure is called the systolic pressure. The heart relaxes again and the tricuspid and mitral valves close. Blood flows into the auricles; the mitral and tricuspid valves are forced to open, and the cycle begins again.
Appendix A.3: Prior Knowledge Test of Physiology
Prior Knowledge Test of Human Physiology

First Name (in PRINT)____________________
Last Name (in PRINT) ____________________
Your Class Section Number ________________

Directions: Please select ONE answer which you feel best completes the sentence by circling the letter of the given choices.

1. The part of the tooth which contains the hardest substance in the body is the:
   A root  B Dentine  C cement  D Enamel

2. The digestion of food occurs principally in the:
   A stomach  B small intestine  C mouth  D large intestine

3. Contraction of the smooth muscle of the alimentary canal is called:
   A peristalsis  B digestion  C absorption  D assimilation

4. Worn-out red blood cells are decomposed in the:
   A heart  B lungs  C kidneys  D liver

5. "Swollen glands" means an enlargement of the:
   A lymph nodes  B heart valves  C vena cava  D protal vein

6. The chief value of perspiration is that it
   A eliminates body odors  B opens the pores  C reduces weight  D regulates body temperature
7. Endocrine glands produce:
   A enzyme  B endoplasm
   C hormones  D serums

8. The body is stimulated to unusual activity by increased secretion from the:
   A pancreas  B adrenal glands
   C thyroid gland  D thymus gland

9. The spinal cord is made up of:
   A bone tissue  B cartilage tissue
   C connective tissue  D nerve tissue

10. Nerves from the eyes and ears are connected to the:
    A cerebellum  B cerebrum
    C medulla  D spinal cord

11. The chromosome number of the body cells of identical human twins is:
    A 12  B 24
    C 46  D 92

12. The person who can give blood to any other person but can receive only his own type blood has blood type:
    A A  B O
    C AB  D B

13. The ribs are attached to the spine and meet in front of the body at the:
    A skull  B limbs
    C joints  D breastbone

14. The ribs protect the:
    A stomach  B breastbone
    C spinal cord  D lungs
15. The hollow interior of the long bones is filled with:
   A  marrow  B  minerals
   C  red and white corpuscles  D  Haversian canals

16. The windpipe is located ______ the esophagus:
   A  in front of  B  behind
   C  to the left of  D  to the right of

17. The carbon dioxide-oxygen exchange with the atmosphere occurs in the:
   A  nose  B  trachea
   C  lungs  D  bronchi

18. Blood is oxygenated in the capillaries of:
   A  air sacs  B  heart
   C  muscle  D  liver

19. During inspiration, the ribs:
   A  do not move  B  move downward
   C  move inward  D  move upward

20. The part of the brain that controls respiration is the:
   A  medulla  B  cerebellum
   C  cerebrum  D  spinal cord

21. A defense of the body against bacteria is:
   A  hemoglobin  B  phagocytes
   C  red blood cells  D  blood platelets
22. The disease hemophilia is associated with
   A the bone structure   B blood clotting
   C the structure of nervous tissue   D the formation of red corpuscles

23. The liquid that bathes every cell and acts as a medium of exchange is:
   A cell sap   B fibrinogen
   C lymph   D fibrin

24. Urine is stored in an organ called the:
   A diaphragm   B kidney
   C bladder   D lungs

25. Secretions of the ductless glands pass:
   A into tubes or ducts   B directly into the blood
   C directly into the organs where they are used   D out of the body

26. Inactivity of the thyroid gland from infancy may produce a condition known as:
   A diabetes   B beriberi
   C cretinism   D Addison's disease

27. The concentration of sodium and potassium in the blood is controlled by:
   A adrenin   B cortin
   C insulin   D secretin

28. Diabetes is caused by the improper functioning of the:
   A parathyroids   B thyroids
   C pancreas   D adrenals

29. The adult human heart is said to beat approximately ________ times per minute.
   A 85   B 72
   C 60   D 58
30. Growth and repair of body tissue involves:
   - A protein
   - B fats
   - C starch
   - D sugar

31. Blood enters the heart through:
   - A arteries
   - B vena cavas
   - C the aortic arch
   - D pulmonary veins

32. Blood leaves the heart through the:
   - A tricuspid valve
   - B aorta
   - C superior vena cava
   - D mitral valve

33. The portion of the heart which divides longitudinally into 2 halves is called the:
   - A myocardium
   - B tendons
   - C pericardium
   - D septum

34. A blood vessel which carries deoxygenated blood is the:
   - A aorta
   - B pulmonary artery
   - C hepatic artery
   - D pulmonary vein

35. The backward flow of blood in the veins is prevented by:
   - A muscles
   - B valves
   - C the heart beat
   - D lymphatics

36. The chamber of the heart which pumps oxygenated blood to all the parts of the body is the:
   - A left auricle
   - B right ventricle
   - C right auricle
   - D left ventricle

THANK YOU VERY MUCH!
Appendix A.4: Criterion Tests
Criterion Tests

This is the last part of the study. Please type your full name. Your name is used for reporting your participation to the course professor for extra course credit. Please remember to fill in your time at the beginning and at the end of each test. Thank you very much and good luck!

Your Full Name:______________________

What time is it now? __________________ (according to the time on your computer)

Identification Test

Directions: Select ONE best answer that identifies the part of the heart indicated by the numbered arrow by clicking on the radio button. (All the heart images are the same.)

1. Arrow number one (1) points to the ________.
   A. Septum   B. Aorta
   C. Pulmonary Artery   D. Pulmonary Vein
   E. None of These above

2. Arrow number two (2) points to the ________.
   A. Superior Vena Cava   B. Inferior Vena Cava
   C. Pulmonary Artery   D. Tricuspid Valve
   E. Aorta

3. Arrow number three (3) points to the ________.
   A. Right Ventricle   B. Right Auricle
   C. Left Auricle   D. Left Ventricle
   E. Heart Muscle

4. Arrow number four (4) points to the ________.
   A. Pulmonary Valve   B. Pulmonary Vein
   C. Aortic Valve   D. Tricuspid Valve
   E. Mitral Valve

5. Arrow number five (5) points to the ________.
   A. Aorta   B. Pulmonary Artery
   C. Superior Vena Cava   D. Inferior Vena Cava
   E. Pulmonary Vein

6. Arrow number six (6) points to the ________.
   A. Aortic Valve   B. Pulmonary Valve
   C. Mitral Valve   D. Tricuspid Valve
   E. Semi-lunar Valve

7. Arrow number seven (7) points to the ________.
   A. Left Ventricle   B. Right Ventricle
   C. Right Auricle   D. Left Auricle
   E. Vascular Space
8. Arrow number eight (8) points to the _________.
   A. Myocardium  B. Ectoderm
   C. Pericardium  D. Endocardium
   E. Epicardium

9. Arrow number nine (9) points to the _________.
   A. Endocardium  B. Myocardium
   C. Pericardium  D. Ectoderm
   E. Septum

10. Arrow number ten (10) points to the _________.
    A. Endocardium  B. Pericardium
    C. Septum  D. Myocardium
    E. Aortic Valve

11. Arrow number eleven (11) points to the _________.
    A. Epicardium  B. Pericardium
    C. Endocardium  D. Myocardium
    E. None of These

12. Arrow number twelve (12) points to the _________.
    A. Pericardium  B. Myocardium
    C. Endocardium  D. Endoderm
    E. Apex

13. Arrow number three (13) points to the _________.
    A. Pericardium  B. Endocardium
    C. Ectocardium  D. Endoderm
    E. Myocardium

14. Arrow number four (14) points to the _________.
    A. Right Ventricle  B. Left Ventricle
    C. Left Auricle  D. Right Auricle
    E. Apex

15. Arrow number five (15) points to the _________.
    A. Pulmonary Veins  B. Tendons
    C. Aortas  D. Pericardium
    E. None of These

16. Arrow number six (16) points to the _________.
    A. Venic Valve  B. Pulmonary Valve
    C. Tricuspid Valve  D. Mitral Valve
    E. Aortic Valve

17. Arrow number seven (17) points to the _________.
    A. Superior Vena Cava  B. Tricuspid Valve
    C. Aortic Valve  D. Pulmonary Valve
    E. Mitral Valve

18. Arrow number eight (18) points to the _________.
    A. Right Auricle  B. Right Ventricle
    C. Left Auricle  D. Left Ventricle
    E. Semi-Lunar Chamber
19. **Arrow number nine (19) points to the _______.**
   A. Inferior Vena Cava  
   B. Superior Vena Cava  
   C. Aortas  
   D. Pulmonary Veins  
   E. Pulmonary Arteries

20. **Arrow number ten (20) points to the _______.**
   A. Inferior Vena Cava  
   B. Aorta  
   C. Pulmonary Artery  
   D. Septum  
   E. Superior Vena Cava

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**Terminology Test**

Directions: Select ONE answer you feel best completes the sentence by clicking the given radio button.

21. **_________ is (are) the thickest walled chamber(s) of the heart.**
   A. Auricles  
   B. Myocardium  
   C. Ventricles  
   D. Pericardium  
   E. Endocardium

22. **The contraction of the heart occurs during the _______ phase.**
   A. Systolic  
   B. Sympathetic  
   C. Diastolic  
   D. Parasympathetic  
   E. Sympatric

23. **Lowest blood pressure in the arteries occurs during the _______ phase.**
   A. Sympatic  
   B. Sympathetic  
   C. Diastolic  
   D. Systolic  
   E. Parasympathetic

24. **Blood from the right ventricle goes to the lungs through the _______.**
   A. Tricuspid Valve  
   B. Aortic Artery  
   C. Pulmonary Artery  
   D. Pulmonary Veins  
   E. Superior Vena Cava

25. **The _______ is (are) the strongest section(s) of the heart.**
   A. Left Ventricle  
   B. Aorta  
   C. Septum  
   D. Right Ventricle  
   E. Tendons

26. **When blood runs through the heart from the lungs, it enters the _______.**
   A. Left Auricle  
   B. Pulmonary Valve  
   C. Left Ventricle  
   D. Right Ventricle  
   E. Pulmonary Artery

27. **Vessels that allow the blood to flow from the heart are called the _______.**
   A. Veins  
   B. Arteries  
   C. Apex  
   D. Tendons  
   E. Valves

28. **Blood passes from the left ventricle out the aortic valve to the _______.**
   A. Lungs  
   B. Body  
   C. Aorta  
   D. Pulmonary Artery  
   E. Left Auricle
29. The chamber of the heart which pumps oxygenated blood to all parts of the body is the _________.
   A. Right Auricle
   B. Left Auricle
   C. Aorta
   D. Left Ventricle
   E. Right Ventricle

30. The ________ is another name for the part of the heart called the heart muscle.
   A. Apex
   B. Epicardium
   C. Endocardium
   D. Myocardium
   E. Septum

31. ____________ is (are) the part(s) of the heart which controls its contraction and relaxation.
   A. Myocardium
   B. Endocardium
   C. Ventricles
   D. Auricles
   E. Septum

32. The ________ is the name given to the inside lining of the heart wall.
   A. Epicardium
   B. Endocardium
   C. Pericardium
   D. Myocardium
   E. Septum

33. Blood from the body enters the heart through the _________.
   A. Aortic Artery
   B. Pulmonary Veins
   C. Pulmonary Artery
   D. Superior and Inferior Vena Cavas
   E. Superior Vena Cava Only

34. The membrane which borders on the inside lining of the pericardium and is connected to the heart muscle is called _________.
   A. Extoxim
   B. Epicardium
   C. Endocardium
   D. Myocardium
   E. Septum

35. The __________ allow(s) blood travel in one direction only.
   A. Septum
   B. Valves
   C. Arteries
   D. Veins
   E. Tendons

36. The __________ is the common opening between the right auricle and the right ventricle.
   A. Mitral Valve
   B. Tricuspid Valve
   C. Septic Valve
   D. Pulmonary Valve
   E. Aortic Valve

37. The ________ is a triangular flapped valve between the left auricle and the left ventricle.
   A. Aortic Valve
   B. Pulmonary Valve
   C. Septic Valve
   D. Tricuspid Valve
   E. Mitral Valve

38. The semi-lunar valves are located at the entrance to the __________.
   A. Pulmonary Veins
   B. Superior and Inferior Vena Cavas
   C. Pulmonary and Aortic Arteries
   D. Mitral and Tricuspid Valves
   E. Ventricles

39. The outside covering of the heart is called the ___________.
   A. Endocardium
   B. Epicardium
   C. Pericardium
   D. Myocardium
   E. None of These

40. Immediately before entering the aorta, blood must pass through the ___________.
   A. Left Ventricle
   B. Mitral Valve
   C. Lungs
   D. Superior Vena Cava
   E. Aortic Valve

What time is it now? __________________
(Please continue to the Test of Comprehension)
Comprehension Test

Directions: Select ONE answer that you feel best completes the sentence by clicking the given radio button.

41. Which valve is most like the tricuspid in function?
   A. Pulmonary  
   B. Aortic  
   C. Mitral  
   D. Superior Vena Cava

42. When the blood is being forced out the right ventricle, in which position is the tricuspid valve?
   A. Beginning to Open  
   B. Beginning to Close  
   C. Open  
   D. Closed

43. When the blood is being forced out the aorta, it is also being forced out of the ________.
   A. Pulmonary Veins  
   B. Pulmonary Arteries  
   C. Superior Vena Cava  
   D. Cardiac Artery

44. The contraction impulse in the heart starts in ________.
   A. The Right Auricle  
   B. Both Ventrices Simultaneously  
   C. Both Auricles Simultaneously  
   D. The Arteries

45. In the diastolic phase the ventricles are __________.
   A. Contracting, Full of Blood  
   B. Contracting, Partially Full of Blood  
   C. Relaxing, Full of Blood  
   D. Relaxing, Partially Full of Blood

46. During the first contraction of the systolic phase, in what position will the mitral valve be?
   A. Beginning to Open  
   B. Open  
   C. Beginning to Close  
   D. Close

47. During the second contraction of the systolic phase, blood is being forced from the heart through the ________.
   A. Pulmonary and Aortic Arteries  
   B. Superior and Inferior Vena Cavas  
   C. Tricuspid and Mitral Valves  
   D. Pulmonary Veins

48. When the blood is entering through the vena cava, it is also entering through the ________.
   A. Mitral Valves  
   B. Pulmonary Veins  
   C. Pulmonary Artery  
   D. Aorta

49. When the heart contracts the ________.
   A. Auricles and Ventricles Contract Simultaneously  
   B. Ventricles Contract First, Then the Auricles  
   C. Right Side Contract First, Then the Left Side  
   D. Auricles Contract First, Then the Ventricles

50. While the blood from the body is entering the superior vena cava, blood from the body is also entering through the ________.
   A. Pulmonary Veins  
   B. Aorta  
   C. Inferior Vena Cava  
   D. Pulmonary Artery

51. When the blood leave the heart through the pulmonary artery, it is also simultaneously leaving the heart through the ________.
   A. Tricuspid Valve  
   B. Pulmonary Veins  
   C. Aorta  
   D. Pulmonary Valve

52. When the pressure in the right ventricle is superior to that in the pulmonary artery, in what position is the tricuspid valve?
   A. Closed  
   B. Open  
   C. Beginning to Close  
   D. Confined by Pressure from the Right Auricle
53. When the ventricles contract, blood is forced out the ____________.
   A. Superior and Inferior Vena Cavas
   B. Pulmonary Veins
   C. Tricuspid and Mitral Valves
   D. Pulmonary and Aortic Valves

54. Blood leaving the heart through the aorta had left the heart previously through the ____________.
   A. Vena Cavas
   B. Pulmonary Veins
   C. Pulmonary Artery
   D. Tricuspid and Mitral Valves

55. When the blood in the aorta is exerting a superior pressure on the aortic valve, what is the position of the mitral valve?
   A. Closed
   B. Open
   C. Beginning to Open
   D. Confined by Pressure from the Right Ventricle

56. When the tricuspid and mitral valves are forced shut, in what position is the pulmonary valve?
   A. Closed
   B. Beginning to Open
   C. Open
   D. Beginning to Close

57. During the second contraction of the systolic phase, in what position is the aortic valve?
   A. Fully Open
   B. Partially Open
   C. Partially Closed
   D. Fully Closed

58. Blood is being forced out the auricles simultaneously as blood is ____________.
   A. Entering Only the Vena Cavas
   B. Being Forced Out the Pulmonary and Aortic Valves
   C. Passing through the Tricuspid & Mitral Valves
   D. Being Forced Out through the Pulmonary Artery

59. If the aortic valve is completely open, the ____________.
   A. Second Contraction of the Systolic Phase Is Occurring
   B. Diastolic Phase Is Occurring
   C. Tricuspid & Mitral Valves Are Completely Open
   D. Blood Is Rushing into the Right & Left Ventricles

60. When the heart relaxes, the ____________.
   A. Auricles Relax First, Then the Ventricles
   B. Right Side Relaxes First, Then the Left Side
   C. Left Side Relaxes First, Then the Right Side
   D. Ventricles Relax First, Then the Auricles

This is the end of the study. Please notice that once you click the "submit" button, you will not be able to do the test again. You should see a "Thank you" note page after successful submission. If not, please let our assistant know about it. Thank you!

Click the button to Submit.

Please leave the lab quietly and thank you for your participation!
Appendix B: Concept map workshop materials
Appendix B.1: Concept Map Workshop Material for the First Pilot Study
Concept Mapping
(Workshop Handout)

Charles Xiaoxue Wang

The College of Education
Pennsylvania State University

Fall 2001
Use Concept Map to Summarize Your Reading

Look at the cartoon picture on the cover of this handout. Do you feel that it reveals some truth there? In most cases, you are appreciated by what you have done rather than how hard you get it done. This is specially true in academia.

We read a lot as university students but what are about the results of your reading? Do you remember the last time when you were desperately searching in your memory for the information you needed? You knew it was there but you just could not dig it out! This workshop will introduce you how to use concept mapping to avoid this embarrassing situation.

1. What is a concept map?

Concept map is a graphic representation of ideas and concepts. It consists of concepts or nodes linked by labeled lines to show relationships and inter-relationships between terms. Concepts are arranged hierarchically so that the most inclusive, subsumptive concepts appear at the top of the map, with less inclusive, subordinate concepts below (Jonassen & Grabowski, 1993, p.439). Look at following example of concept map.
2. Concept mapping as a learning tool
   • To summarize reading materials
   • To organize knowledge domains
   • To organize ideas for writing and research
   • To plan your research project and identify the variables in it.
   • to fix learned materials in long-term memory
   • to revise effectively for examination.

3. How to summarize reading materials through concept mapping
   To summarize your reading materials through concept mapping, you need to be able to do the following:
   • Identify the topic, main concepts and sub-concepts in your reading for concept mapping.
   • Clarify the four main types of inter-relationships among the topic, main concepts, and sub-concepts.
   • Select appropriate graphic symbols for concept mapping.
   • Apply some basic strategies in concept mapping.
   • Follow certain procedure of concept mapping.
   • Actual mapping and editing the concept map.
4. **Exercise:** Please map out the following passage and compare yours with others’.

**Changing Engine Oil**

From “Nissan Sentra Owner’s Manual” (1993)

To change engine oil is not difficult. As a matter of fact, it’s one of the simplest (and most valuable) operations you can perform on your car. All you’ll need is the oil, an oil filter, a drain pan of some type, an oil spout, an adjustable wrench, and a filter wrench.

In preparing for the oil change, besides getting tools listed above ready, you need to warm the car up and then raise the front end of the car by supporting it on drive-on ramps or jackstands.

In draining the oil, first you need to locate the drain plug on the bottom of the oil pan and slide a low flat pan of sufficient capacity under the engine to catch the oil. Then, loosen the plug with a wrench and turn it out to drain the oil. After the oil is drained out, use a rag clean the drain plug and the area around the drain hole in the oil pan. Finally, install the drain plug and tighten it finger-tight. If you feel resistance, stop and be sure you are not cross-threading the plug.

In changing the filter, you first remove the oil filter with a filter wrench. The filter can hold more than a quart of oil, which will be hot. Then, make sure to clean the mounting
base on the engine. Now, position a new filter on the mounting base and spin it on by hand. Do not use a wrench. When the gasket contacts the engine, tighten it another ½ - 1 turn by hand.

In refilling the engine oil, locate the oil cap on the valve cover. Then, remove the cap and add oil to the engine. An oil spout is the easiest way to do it, but a funnel will do just as well.

Finally, in checking for leaks, start the engine and see if the oil pressure warning light will remain on for a few seconds; when it goes out, stop the engine and check the level on the dipstick.

5. Final Words
Different people may have different ways to represent what they read. Your concept map should reflect your understanding of the content. It is always advisable to write a follow-up note describing what you have mapped. If you want to know more about concept mapping, please go to the following sites. Thanks for your participating in this workshop!

**Discovery of Concept Map:**
http://www.personal.psu.edu/users/x/q/xqw1/insys441b/index.htm

**Build a Concept Map:**
http://www.personal.psu.edu/users/x/q/xqw1/insys441d/index.htm.

**Answer for reference**
Changing Engine Oil

1. Preparing for the oil change
   1.1 Get tools ready & warm up the car
   1.2 Raise the front end of the car

2. Draining the oil
   2.1 Locate the drain plug
   2.2 Loosen the plug
   2.3 Drain the oil
   2.4 Clean the drain plug
   2.5 Install the drain plug

3. Changing the filter
   3.1 Remove the oil filter
   3.2 Cleaning the mounting base
   3.3 Position a new filter

4. Refilling
   4.1 Locate the oil cap
   4.2 Remove the cap
   4.3 Add the oil

5. Checking for leaks
   5.1 Start the engine & check the oil pressure warning light
   5.2 Stop the engine & check the level on the dipstick

Creating Your Procedural Concept Map (Wang, 2000)
Appendix B.2: Concept Map Workshop Material for the Second Pilot Study
1. **What are concept maps?**

   Concept maps are most commonly defined as two-dimensional diagrams that consist of concepts or nodes linked by labeled lines to show relationships between and among those concepts. The concepts are usually arranged hierarchically with the most inclusive, general concepts appear at the top of the map and the less inclusive, subordinate concepts below.
2. Why concept maps work?
   a. Linking new concept with what we knew:
      • “Big, shining, noisy bird” = “Airplane”.
   b. Expanding the capacity of our short term memory
      • Make abstract ideas and concepts in tangible form.
   c. Meaningful learning experience
      • Discovering the new relationship among concepts
      • Make the implicit explicit
      • Increase the irretrievability

3. How could concept maps help me with my study?
   d. Using concept maps to summarize your study
      • Preparing for the test – big and holistic picture your study
      • Identify your weak points
   e. Using concept maps to organize your study
      • Prioritize your study effort
      • Zooming in and zooming out
   f. Using concept maps to enhance your communication
      • Presentation --- project overview
4. How to create a concept map

**Three components:** Concepts, propositions, and structure of concept map
5. Procedure of creating concept maps:

- **Identify the concepts to map**
  - Topics, main concepts, and sub-concepts

- **Identify the relationships**
  - Topics & main concepts and main concepts & sub-concepts
Frequently used categories of relations

- set/sub-set
- whole/part
- characteristics
- causal
- spatial/temporal
- doer/action

- has example/is an example of
- has part/is a part of/includes/covers
- has characteristics/is a characteristic of
- causes/is caused by
- occurred at/location or time of
- Acts as, function, control, etc.

(Adapted from Lapp, Flood, & Hoffman (1998) Using concept mapping as an effective strategy in content area instruction. In *Content Area Reading and Learning.*)

- **Select graphics and decide the structure**
  - Be simple and consistent

- **Let’s practice**
  - T-Tests
  - What is psychology?
  - The Aim, Research Methods, and Goals of psychology
• Check list for concept mapping
  (1) Are topics, main concepts and sub-concepts clear and correctly expressed.
  (2) Do link words/phrases correctly and clearly express the relations between the topics, main concepts and sub-concepts?
  (3) Are the graphics used for mapping simple and consistent?
  (4) Is the concept map an effective presentation of the topic?
  (5) Can you tell what the main concepts are in your map without looking at it? (A good concept map should help you remember them.)
T-Tests

The t-test assesses whether the means of two groups are statistically different from each other. The purpose of the t-test is to determine whether the difference in two means is likely to be due to chance or to some other cause, such as, a treatment. So it is widely used to test the hypothesis especially in randomized experimental design.

There are two kinds of t-test: independent t-test and dependent t-test. Independent t-test is sometimes called two-sample t-test or student’s t-test. Dependent t-test is sometimes called paired-samples t-test or correlated t-test.

Independent t-test (two-sample t-test, student’s t-test): This is used to compare the means of one independent variable for two groups of cases. As an example, in social study, people may want to compare mean difference of income between male faculty and female faculty in a university. In this case, the independent variable identified is income while the two groups are male faculty and female faculty of a particular university. In short, independent t-test to compare the same independent variable of two different groups.

Dependent t-test (paired-samples t-test, correlated t-test): This is used to compare the means of two dependent variables for a single group. The procedure computes the differences between values of the two dependent variables for each case and tests whether the average differs from zero. For example, you may be interested to evaluate the effectiveness of a reading program. Before the program starts, you give trainees a pretest to measure their reading ability. At the end of the program, you give them a post-test to measure their reading ability again. Thus each subject has two measures, sometimes called, before and after measures. By comparing the results of the two tests, you could find out the effectiveness of the reading program. In this case, the two dependent variables are the results of pretest and post-test. The results are of the same group --- people participate in the reading program.

--- Adapted from Yoder, E. (2001). AEE 521 Course Handout. The College of Agricultural Sciences, Pennsylvania State University

What is psychology?

Psychology is defined as the science of behavior and cognition. Behavior is generally defined as anything you do, especially if it is observable to others. Psychologists emphasize the study of behavior because it can be observed and recorded. Many behaviors,
such as eating, talking, writing, running, or fighting, are easily observable.

Cognition includes mental processes like dreaming, thinking, remembering, or solving problems. These cognitive activities are usually not observable, and often studied through self-reports provided by research subjects. Cognitive behavior is now usually included in the general concept of behavior.

Another area of scientific study of psychology is the biological, or physiological processes that often accompany both behavior and cognition. Brain wave activity during dreaming or thinking, heart rate during strong emotion or fighting, or blood chemistry changes during eating are examples of physiological processes.

While some psychologist may focus on one area, many study psychology from all the three perspectives. Since the behavioral, cognitive, and physiological processes are usually interconnected, many psychologists include all three when they discuss the concept of behavior. Here behavior includes observable actions, cognitive activities, and their physiological processes.

Adopted from Pettijohn (1989) Psychology: A Concise Introduction
Psychology seeks to understand behavior through meeting four basic goals: *description, prediction, control, and explanation.*

*Description* is important in any science. It helps psychologists understand basic patterns of behavior. Description of behavior allows them to develop theories, or assumptions, about the behavior. It also helps to fill in gaps of what we know about behavior. For example, child development is an area of psychology that describes the stages of motor development in babies and has enabled psychologists to formulate a theory of normal motor development. This helps people identify possible problems in babies who do not develop in the normal sequence.

Psychologists often make *predictions* about behavior: these are based on the descriptions they have obtained. For example, psychologists have described many situations where people exhibit certain behavior in order to have something pleasant occur. These pleasant occurrences can be called rewards or reinforcements. After observing that reinforcements encourage people to modify their behavior, you might develop a theory predicting that people will increase a particular behavior if rewarded. As an example, you might find that when you smile, people are nice to you. You could predict that if you smiled more, more people would be nicer. Once you concluded that the frequency of a given behavior increases after a reward, you are in a position to control (modify) behavior by giving or withholding rewards. For example, you could control the frequency with which you dog sits up and begs by offering dog biscuits as a reward. When you stop giving biscuits, the dog will probably decrease begging behavior.

The fourth goal of psychology is *explanation.* By describing, predicting, and controlling behavior, we gain insight into the forces that motivate people. Then we can begin to explain why people engage in various behaviors. For example, hunger has been explained as motivate behavior in many studies. The conditions that cause and alleviate hunger are described as well as the behaviors that control it. You feel hungry both because your body needs food for energy and because you have learned to eat at certain times of the day.

Adopted from Pettijohn (1989) *Psychology: A Concise Introduction*
Concept Mapping Activities for the Second Pilot Study

Please read the passage “T-Tests” and fill in the concepts accordingly.
Concept Mapping Activities for the Second Pilot Study

Please read the passage “What is psychology?” and fill in both the concepts and link words according to it.

Psychology

is defined as

The Science of Behavior and Cognition

studies

1

2

3

4

5

6

7
Concept Mapping Activities for the Second Pilot Study

Please read “The Aim, Research Methods and Goals of Psychology” and complete the following concept map according to the passage.

Check list for concept mapping.
(1) Are topics, main concepts and sub-concepts clear and correctly expressed?
(2) Do link words/phrases correctly and clearly express the relations between the topics, main concepts and sub-concepts?
(3) Are the graphics used for mapping simple and consistent?
(4) Is the concept map an effective presentation of the topic?
(5) Can you tell what the main concepts are in your map without looking at it? (A good concept map should help you remember them.)
Appendix B.3: Concept Map Workshop Material for the Major Study
1. **What are concept maps?**

Concept maps are most commonly defined as two-dimensional diagrams that consist of concepts or nodes linked by labeled lines to show relationships between and among those concepts. The concepts are usually arranged hierarchically with the most inclusive, general concepts appear at the top of the map and the less inclusive, subordinate concepts below.
Concept Map Workshop Outline for the Major Study

2. Why concept maps work?
   g. Linking new concept with what we knew:
      • “Big, shining, noisy bird” = “Airplane”.
   h. Expanding the capacity of our short term memory
      • Make abstract ideas and concepts in tangible form.
   i. Meaningful learning experience
      • Discovering the new relationship among concepts
      • Make the implicit explicit
      • Increase the irretrievability

3. How could concept maps help me with my study?
   a. Using concept maps to summarize your study
      • Preparing for the test – big and holistic picture your study
      • Identify your weak points
   b. Using concept maps to organize your study
      • Prioritize your study effort
      • Zooming in and zooming out
Concept Map Workshop Outline for the Major Study

b. Using concept maps to enhance your communication
   • Presentation — project overview

4. How to create a concept map

c. Procedure of creating concept maps:
Concept Map Workshop Outline for the Major Study

(1) **Identify the concepts to map**
- Topics, main concepts, and sub-concepts

(2) **Identify the relationships**
- Topics & main concepts and main concepts & sub-concepts
- Frequently used categories of relations
  - set/sub-set        has example/ is an example of
  - whole/part        has part/ is a part of.includes/covers
  - characteristics   has characteristics/is a characteristic of
  - causal            causes/is caused by
  - spatial/temporal  occurred at /location or time of
  - doer/action       Acts as, function, control, etc….

(Adapted from Lapp, Flood, & Hoffman (1998) Using concept mapping as an effective strategy in content area instruction. In *Content Area Reading and Learning.*)

(3) **Select graphics and decide the structure**
*Be simple and consistent*
Editing your concept maps

- Are topics, main concepts and sub-concepts clear and correctly expressed?
- Do link words/phrases correctly and clearly express the relations between the topics, main concepts and sub-concepts?
- Are the graphics used for mapping simple and consistent?
- Is the concept map an effective presentation of the topic?
- Can you tell what the main concepts are in your map without looking at it? (A good concept map should help you remember them.)

Let's practice

- T-Tests
- What is psychology?
- The Aim, Research Methods, and Goals of psychology
Reading for Concept Mapping Workshop Activities

T-Tests

The t-test assesses whether the means of two groups are statistically different from each other. The purpose of the t-test is to determine whether the difference in two means is likely to be due to chance or to some other cause, such as, a treatment. So it is widely used to test the hypothesis especially in randomized experimental design.

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While some psychologist may focus on one area, many study psychology from all the three perspectives. Since the behavioral, cognitive, and physiological processes are usually interconnected, many psychologists include all three when they discuss the concept of behavior. Here behavior includes observable actions, cognitive activities, and their physiological processes.

Adopted from Pettijohn (1989) Psychology: A Concise Introduction

The aim, research methods, and goals of psychology

Psychology is defined as the science of behavior and cognition. As a science, psychology shares goals and scientific methods with other sciences, such as biology, chemistry, sociology, and anthropology. Scientists begin with a body of knowledge and then, proceed systematically to investigate a topic to add to that body of knowledge. Scientists use a variety of research methods, including observation, survey, test and experiment. These research methods allow scientists to reach the goals of description, prediction, control and explanation. The ultimate aim for psychologists is to understand behavior and help people.

As an example of this aim, many clinical and counseling psychologists are involved in helping people with personal and emotional problems. Others, called experimental psychologists, are engaged in research to discover the basic principles of behavior, using a wide variety of subjects: monkeys, rats, and people. Still other psychologists are busy applying research findings to people’s everyday problems. Consumer psychologists, study purchasing behavior, including what type of advertisements influence people most. Educational psychologists make teaching and learning more effective. And social psychologists are involved in reducing prejudice and aggression.
Psychology seeks to understand behavior through meeting four basic goals: description, prediction, control, and explanation.

Description is important in any science. It helps psychologists understand basic patterns of behavior. Description of behavior allows them to develop theories, or assumptions, about the behavior. It also helps to fill in gaps of what we know about behavior. For example, child development is an area of psychology that describes the stages of motor development in babies and has enabled psychologists to formulate a theory of normal motor development. This helps people identify possible problems in babies who do not develop in the normal sequence.

Psychologists often make predictions about behavior: these are based on the descriptions they have obtained. For example, psychologists have described many situations where people exhibit certain behavior in order to have something pleasant occur. These pleasant occurrences can be called rewards or reinforcements. After observing that reinforcements encourage people to modify their behavior, you might develop a theory predicting that people will increase a particular behavior if rewarded. As an example, you might find that when you smile, people are nice to you. You could predict that if you smiled more, more people would be nicer. Once you concluded that the frequency of a given behavior increases after a reward, you are in a position to control (modify) behavior by giving or withholding rewards. For example, you could control the frequency with which you dog sits up and begs by offering dog biscuits as a reward. When you stop giving biscuits, the dog will probably decrease begging behavior.

The fourth goal of psychology is explanation. By describing, predicting, and controlling behavior, we gain insight into the forces that motivate people. Then we can begin to explain why people engage in various behaviors. For example, hunger has been explained as motivate behavior in many studies. The conditions that cause and alleviate hunger are described as well as the behaviors that control it. You feel hungry both because your body needs food for energy and because you have learned to eat at certain times of the day.

Adopted from Pettijohn (1989) *Psychology: A Concise Introduction*
Concept Mapping Activities for the Second Pilot Study

Please read the passage "T-Tests" and fill in the concepts accordingly.
Concept Mapping Activities for the Second Pilot Study

Please read the passage “What is psychology?” and fill in both the concepts and link words according to it.

Psychology

is defined as

The Science of Behavior and Cognition

studies

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7
Concept Mapping Activities for the Second Pilot Study

Please read “The Aim, Research Methods and Goals of Psychology” and complete the following concept map according to the passage.

Check list for concept mapping.

1. Are topics, main concepts and sub-concepts clear and correctly expressed?
2. Do link words/phrases correctly and clearly express the relations between the topics, main concepts and sub-concepts?
3. Are the graphics used for mapping simple and consistent?
4. Is the concept map an effective presentation of the topic?
5. Can you tell what the main concepts are in your map without looking at it? (A good concept map should help you remember them.)
Appendix C: Directions and Treatments
Appendix C.1: Directions and Treatment for the First Pilot Study
Dear Participants,
Thank you very much for participating in my study. Here are the procedures you need to follow in this study.

1) Login the Blackboard.com (http://www.blackboard.com), and click “My Blackboard” on the top right corner. Your user ID is your Penn State User ID (e.g. “jwh163”) Your pass word is “map”.

2) Click “Study of Concept Mapping Strategies” to get into the course site.

3) Go to “Course Information” to read instructional materials at your own pace.

4) When you feel you understand the materials well and ready for the tests, Go to the “Assignment” to take the tests. PLEASE do not refer to the instructional materials when you are taking the tests. You have only one chance to do the test. Once you submit the test, the test will not be available for you any more.

Again, thank you very much for your participating in my study!

Regards

Charles Xiaoxue Wang
CONCEPT MAPPING TASK

Thank you!

INSTRUCTTIONAL MATERIALS

PLEASE DO NOT READ IT UNTIL YOU FINISH YOUR

2

(Treatment Two, The First Pilot Study)

CONCEPT MAPPING TASK
Please identify the concepts and fill in the concept map boxes according to the reading materials. Now look at your watch. You start the concept mapping at ______ . Please remember to record the time when you finish concept mapping. Thank you.
The Circulation of the Blood

1. Path of the Blood
   - Starts when the blood from head and arms goes through
   - Starts when the blood from trunk and legs goes through
   - Enter into
   - Through
   - Through
   - To
   - To

2. Direction of the Blood Flow
   - Determined by four
   - Includes

3. Contraction and Relaxation of Heart
   - Which starts simultaneously at
   - Which includes
   - When they contract
   - Passes contraction down to

4. Forces the blood through
   - Passes contraction down to
Please look at your watch. You finished this concept map at ____________. Thank you very much!
CONCEPT MAPPING TASK

(Treatment Three, The First Pilot Study)

3

PLEASE DO NOT READ IT UNTIL YOU FINISH YOUR INSTRUCTIONAL MATERIALS

Thank you!

Concept Mapping task
Please creating concept maps according to the reading materials by using the concept map boxes given. Now look at your watch. You start the concept mapping at ______. Please remember to record the time when you finish concept mapping. Thank you.

**Concept map 1**

Please map out the relationship of the parts of heart according to the reading.

- Double Walled Sac
- Pericardium
- Epicardium
- Myocardium
- Endocardium
- Septum
- Two Halves of the Heart
Concept map 2
Please map out the functions of 4 chambers and 4 valves of heart.
Concept map 3
Please map out the path of the blood according to the reading.
Concept map 4
Please map out the circulation of heartbeat.

Heartbeat  Diastolic phase  Systolic Phase  Contraction  Right Auricle  Right Ventricle  Left Auricle  Left Ventricle

Please look at your watch. You finished this concept map at __________. Thank you very much!
CONCEPT MAPPING TASK

(Treatment Four, The First Pilot Study)

4

PLEASE DO NOT READ IT UNTIL YOU FINISH YOUR INSTRUCTIONAL MATERIALS

Thank you!

Concept Mapping task
Please create concept maps according to the reading materials. Now look at your watch. You start the concept mapping at ______. Please remember to record the time when you finish concept mapping. Thank you.

Concept map 1
Please map out the relationship of the parts of heart according to the reading.
Concept map 2
Please map out the functions of 4 chambers and 4 valves of heart.
Concept map 3
Please map out the path of the blood according to the reading.
Concept map 4
Please map out the circulation of heartbeat.

Please look at your watch. You finished this concept map at ____________. Thank you very much!
Appendix C.2: Directions and Treatment for the Second Pilot Study
CONCEPT MAPPING STRATEGIES STUDY

(Course Project of INSYS 596, Spring 2002)

**Instructors:** Dr. Dwyer

**Student:** Charles Xiaoxue Wang

Control Group (Treatment 1)
Direction and Treatment One for Concept Map Learning Strategies
(The Second Pilot Study)

Dear Participant of **Group One**:

Welcome to my study and thank you very much for your participation! Here is what you need to do in this study.

1. Remember that you are in **Group ONE**!
2. Login online and please use **Internet Explorer** to go to the website [http://www.personal.psu.edu/users/x/q/xqw1/cm](http://www.personal.psu.edu/users/x/q/xqw1/cm) (Netscape does not work properly).
3. You have to do the following by all yourself.
4. Read the instructional text.
5. Take the online multiple choice question tests and submit them online.
6. Leave the lab quietly.

If you have any questions, please raise up your hand and our research assistant will come to you. Thank you very much.

Sincerely Yours

Charles Xiaoxue Wang
CONCEPT MAPPING STRATEGIES STUDY

(Course Project of INSYS 596, Spring 2002)

Instructors: Dr. Dwyer

Student: Charles Xiaoxue Wang
Direction and Treatment Two for Concept Map Learning Strategies  
(The Second Pilot Study)

Dear Participant of **Group Two**:

Welcome to my study and thank you very much for your participation! Here is what you need to do in this study.

1. Remember that you are in **Group Two**!
2. Login online and please use **Internet Explore** to go to the website [http://www.personal.psu.edu/users/x/q/xqw1/cm](http://www.personal.psu.edu/users/x/q/xqw1/cm) (Netscape does not work properly).
3. You have to do the following by all yourself.
4. Read the instructional text.
5. Complete concept mapping activities according to the text.
6. Take the online multiple choice question tests and submit them online.
7. Leave the lab quietly.

If you have any questions, please raise up your hand and our research assistant will come to you. Thank you very much.

Sincerely Yours

Charles Xiaoxue Wang
Participant’ Name (in Print):___________________________

Direction: Please complete the concept map by filling in the concepts according to reading Part 1.

Concept Map of Parts of Heart from Outside to Inside

Symbols Used

- Concept
- Link Words
**Direction:** Please complete the concept map by filling in the concepts according to reading **Part 2 & 3.**

**Concept Map of Heart Structure**

- **Left is the right half of the heart:** Right is the left half of the heart.
- **Human Heart** is divided by **Septum**
- **Right Half** is divided into**
  - is divided into
  - is divided into

- **Left Half** is divided into**
  - is divided into
  - is divided into

**Symbols Used**
- Concepts
- Heart Chambers
- Valves
Direction: Please complete the concept map by filling in the concepts according to reading Part 2, 3 & 4.

Concept Map of Heart Valves and Their Location
Direction: Please complete the concept map by filling in the concepts according to reading Part 2, 3 & 4.

Concept Map of Blood Path in the Heart
**Direction:** Please complete the concept map by filling in the concepts according to reading Part 5.

**Concept Map of Two Phases of the Heart Beats**
CONCEPT MAPPING STRATEGIES STUDY

(Course Project of INSYS 596, Spring 2002)

Instructors: Dr. Dwyer

Student: Charles Xiaoxue Wang
Dear Participant of **Group Three**:

Welcome to my study and thank you very much for your participation! Here is what you need to do in this study.

1. Remember that you are in **Group Three**!
2. Login online and please use **Internet Explore** to go to the website [http://www.personal.psu.edu/users/x/q/xqw1/cm](http://www.personal.psu.edu/users/x/q/xqw1/cm) (Netscape does not work properly).
3. You have to do the following by all yourself.
4. Read the instructional text.
5. Complete concept mapping activities according to the text.
6. Take the online multiple choice question tests and submit them online.
7. Leave the lab quietly.

If you have any questions, please raise up your hand and our research assistant will come to you. Thank you very much.

Sincerely Yours

Charles Xiaoxue Wang
Participant’ Name (in Print): ______________________________

Direction: Please complete the concept map by filling in both the concepts and the link words according to reading Part 1.

**Concept Map of Parts of Heart from Outside to Inside**

- Human Heart
  - is enclosed in
    - A thin, double-walled Sac
  - has
    - Heart Muscle
    - the inside lining of heart wall
  - has
    - [Blank]
    - [Blank]
    - [Blank]
    - [Blank]

**Symbols Used**
- Concept
- Link Words
Direction: Please complete the concept map by filling in concepts and link words according to reading Part 2 & 3.

Concept Map of Heart Structure

Left is the right half of the heart:
Right is the left half of the heart.

Human Heart is divided by

Septum

Right Half

Left Half

No direct communication & function simultaneously

Symbols Used

- Concepts
- Heart Chambers
- Valves
**Direction:** Please complete the concept map by filling in concepts and link words according to reading Part 2, 3 & 4.

**Concept Map of Heart Valves and Their Location**

[Diagram of a concept map with nodes and arrows]
Direction: Please complete the concept map by filling in concepts and link words according to reading Part 2, 3, & 4.
Direction: Please complete the concept map by filling in the concepts according to reading Part 5.

Concept Map of Two Phases of the Heart Beats
CONCEPT MAPPING STRATEGIES STUDY

(Course Project of INSYS 596, Spring 2002)

Instructors: Dr. Dwyer

Student: Charles Xiaoxue Wang

Student-generated Mapping (Treatment 4)
Direction and Treatment One for Concept Map Learning Strategies
(The Second Pilot Study)

Dear Participant of **Group Four**:

Welcome to my study and thank you very much for your participation! Here is what you need to do in this study.

1. Remember that you are in **Group Four**!
2. Login online and please use Internet Explorer to go to the website [http://www.personal.psu.edu/users/x/q/xqw1/cm](http://www.personal.psu.edu/users/x/q/xqw1/cm) (Netscape does not work properly).
3. You have to do the following by all yourself.
4. Read the instructional text.
5. Complete concept mapping activities according to the text.
6. Take the online multiple choice question tests and submit them online.
7. Leave the lab quietly.

If you have any questions, please raise up your hand and our research assistant will come to you. Thank you very much.

Sincerely Yours
Charles Xiaoxue Wang
Participant’s Name (in Print): ____________________________

**Direction:** Please create a concept map about parts of heart from outside to inside according to reading **Part 1.**

**Concept Map of Parts of Heart from Outside to Inside**

- **Symbols Used**
  - Concept
  - Link Words

- **Human Heart**
  - is enclosed in
  - has
  - has
  - the inside lining of heart wall

- **A thin, double-walled Sac**
- **Heart Muscle**
**Direction:** Please create a concept map about heart structure according to reading **Part 2 & 3.**

**Concept Map of Heart Structure**

- **Left is the right half of the heart:** Right is the left half of the heart.
- **Human Heart** is divided by **Septum** into **Right Half** and **Left Half**.
- **No direct communication & function simultaneously**

**Symbols Used**
- Concepts
- Heart Chambers
- Valves
**Direction:** Please create a concept map of heart valves and their locations according to reading **Part 2, 3, & 4.**

**Concept Map of Heart Valves and Their Location**
Direction: Please create a concept map of blood path in the heart according to reading Part 2, 3 & 4.
**Direction:** Please create a concept map of two phases of heart beats according to reading **Part 5.**

**Concept Map of Two Phases of the Heart Beats**
Appendix C.3: Directions and Treatments for the Major Study
Concept Mapping Study for Group One

First Name (in PRINT) __________________

Last Name (in PRINT) __________________

Your Starting Time ____________________
Dear Participant of Group One:

Welcome to my study and thank you very much for your participation! Here is what you need to do by yourself in this study.

1. Login online and please use Internet Explore to go to the website http://www.personal.psu.edu/users/x/q/xqw1/cm (Netscape does not work properly).
2. Write your name in PRINT and your starting time according to the time on your computer on this cover page.
3. Read instructions and begin your study. Remember that you are in Group ONE! There is no concept mapping activities for you. If you are interested in what others are doing, I can send it to you after this study. For the purpose of this study, please follow the instruction exactly.
4. Read the text and take the multiple choice question tests and submit them online.
5. Hand in this instructional sheet to our research assistant and get a copy of the informed consent form for this study at exit while leaving the lab quietly.

If you have any questions, please raise up your hand and our research assistant will come to you. Thank you very much.

Sincerely Yours
Charles Xiaoxue Wang
Concept Mapping Study for Group Two

First Name (in PRINT) ___________________

Last Name (in PRINT) ___________________

Your Starting Time  ___________________
Dear Participant of Group Two:

Welcome to my study and thank you very much for your participation! Here is what you need to do by yourself in this study.

1. Login online and please use **Internet Explore** to go to the website [http://www.personal.psu.edu/users/x/q/xqw1/cm](http://www.personal.psu.edu/users/x/q/xqw1/cm) (Netscape does not work properly).

2. Write your name in **PRINT** and your starting time according to the time **on your computer** on this cover page.

3. Read instructions and begin your study. Remember that you are in **Group TWO**!

4. Read the text and do concept mapping activities according to the instructions.

5. Hand in this activity sheets to our research assistant when you complete mapping activities and are ready to take the tests.

6. Take the multiple choice question tests and submit them online.

7. Leave the lab **quietly** and get a copy of the **informed consent form** for this study from research assistants at exit.

8. If you have any questions, please raise up your hand and our research assistant will come to you. Thank you very much.

Sincerely Yours

Charles Xiaoxue Wang
1. Please fill in the boxes in the concept map according to the reading of Part 1 focusing on parts of the heart.
2. Please fill in the boxes in the concept map according to the reading of Part 2 focusing on chambers of the heart.
3. Please fill in the boxes in the concept map according to the reading of Part 2, 3, & 4 focusing on valves, their locations relationship between them.

Left is the right half of the heart.
Right is the left half of the heart.

The Direction of the Blood is determined by:

Four Valves

Symbols Used:
- Valve
- Heart Chambers
- Arteries

One closed while the other is open:
- is anchored to the floor of
- is located between
- Right Atricle

One closed while the other is open:
- is also called
- is located between
- Right Ventricle

One closed while the other is open:
- is located between
- Pulmonary Artery

One closed while the other is open:
- is also called
- is located between
- Semi-Lunar Valve

One closed while the other is open:
- is also called
- is located between
- Semi-Lunar Valve
4. Please fill in the boxes in the concept map according to the reading Part 2, 3, & 4 focusing on blood veins and arteries when blood goes through twice in the human heart.
5. Please fill in the boxes in the concept map according to the reading of Part 5 focusing on the relationship between the chambers and valves in the two phases of the heartbeat.
Concept Mapping Study for Group Three

First Name (in PRINT) __________________

Last Name (in PRINT) __________________

Your Starting Time ____________________
Dear Participant of Group Three:

Welcome to my study and thank you very much for your participation! Here is what you need to do by yourself in this study.

1. Login online and please use Internet Explore to go to the website http://www.personal.psu.edu/users/x/q/xqw1/cm (Netscape does not work properly).
2. Write your name in PRINT and your starting time according to the time on your computer on this cover page.
3. Read instructions and begin your study. Remember that you are in Group Three!
4. Read the text and do concept mapping activities according to the instructions.
5. Hand in this activity sheets to our research assistant when you complete mapping activities and are ready to take the tests.
6. Take the multiple choice question tests and submit them online.
7. Leave the lab quietly and get a copy of the informed consent form for this study from research assistants at exit.

If you have any questions, please raise up your hand and our research assistant will come to you. Thank you very much.

Sincerely Yours
Charles Xiaoxue Wang
1. Please fill in link words or phrases for propositions between concepts according to the reading of Part 1 focusing on parts of the heart. There are four of them in this concept map.
2. Please fill in link words or phrases for propositions between concepts according to the reading of Part 2 focusing on chambers of the heart. There are eight of them in this concept map.

**Left is the right half of the heart.**

**Right is the left half of the heart.**

Symbols Used

- Heart Chambers
- Valves
3. Please fill in link words or phrases for propositions between concepts according to the reading of Part 2, 3, & 4 focusing on valves, their locations and relationships between them. There are eight of them in this concept map.

- Left is the right half of the heart.
- Right is the left half of the heart.

Symbols Used:
- Valve
- Heart Chambers
- Arteries

Diagram:
- Four Valves
- Tricuspid Valve
- Pulmonary Valve
- Mitral Valve
- Aortic Valve
- Tendons
- Semi-Lunar Valve
- Right Auricle
- Right Ventricle
- Pulmonary Artery
- Left Auricle
- Left Ventricle
- Aorta
4. Please fill in link words or phrases for propositions between concepts according to the reading Part 2, 3, & 4 focusing on blood veins and arteries when blood goes through twice in the human heart. There are five of them in this concept map.
5. Please fill in link words or phrases for propositions between concepts according the reading of Part 5 focusing on the relationship between the chambers and valves in the two phases of the heart beat. There are eight of them in this concept map.

Please check to see if all the concept maps correctly reflect your understanding of the texts.
Concept Mapping Study for Group Four

First Name (in PRINT) ______________

Last Name (in PRINT) ______________

Your Starting Time ______________

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Dear Participant of Group Four:

Welcome to my study and thank you very much for your participation! Here is what you need to do by yourself in this study.

7. Login online and please use Internet Explore to go to the website http://www.personal.psu.edu/users/x/q/xqw1/cm (Netscape does not work properly).

8. Write your name in PRINT and your starting time according to the time on your computer on this cover page.

9. Read instructions and begin your study. Remember that you are in Group Four!

10. Read the online text and do concept mapping activities according to the instructions.

11. Hand in this activity sheets to our research assistant when you complete mapping activities and are ready to take the tests.

12. Take the multiple choice question tests and submit them online.

13. Leave the lab quietly and get a copy of the informed consent form for this study from research assistants at exit.

If you have any questions, please raise up your hand and our research assistant will come to you. Thank you very much.

Sincerely Yours

Charles Xiaoxue Wang
Create a concept map according to the reading of Part 1 focusing ONLY on the important parts of the human heart.
Create a concept map about the chambers of the heart according to the reading of Part 2 & 3.
3. Create a concept map about valves of the human heart according to the reading of Part 2, 3, and 4 focusing only on their locations and relationship between them.
4. Create a concept map about **blood path** according to the reading of Part 2, 3, & 4 focusing on **blood veins** and **arteries** when blood goes through twice in the human heart.
5. Create a concept map about **two phases of the heart beat** according the reading Part 5 focusing on the relationship between **the chambers** and **valves**.
VITA
Xiaoxue Wang

EDUCATION

Doctor of Philosophy in Instructional Systems
The Pennsylvania State University, U.S.A. 8/2003

Master of Education in Teaching English to the Speakers of Other Languages
University of Manchester, Manchester, U.K. 5/1992

Bachelor of Arts, Teaching of English Language and Literature
Southwestern China Normal University, Chongqing, P. R. China. 7/1982

PROFESSIONAL EXPERIENCE

Associate Professor and Professor in Charge
Intensive Language Training Center (ILTC)
Sichuan University, Chengdu, Sichuan, P. R. China. 12/1994 – 12/1998

Lecturer & Program Coordinator
ILTC, Sichuan University, Chengdu, Sichuan, P. R. China. 8/1988 – 11/1994

Assistant Professor
ILTC, Sichuan University, Chengdu, Sichuan, P. R. China. 6/1988 – 8/1988

Middle & High School English Teacher
Ba Yi Middle and High School,
Anxian County, Sichuan, P. R. China. 8/1982 – 6/1987

HONORS AND AWARDS

Alumni Society Graduate Student Research Initiation Grant

Teacher of the Year
Sichuan University, Chengdu, Sichuan, P. R. China 1995

Teacher of the Year
ILTC, Sichuan University, Chengdu, Sichuan, P. R. China 1997 – 1998
1995 – 1996

Research Funds for Excellent Returned Scholars
Ministry of Education, Beijing, P. R. China 1993