

MIND MAPPING AND OUTLINING: COMPARING TWO
TYPES OF GRAPHIC ORGANIZERS FOR LEARNING
SEVENTH-GRADE LIFE SCIENCE

by

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ABSTRACT

Graphic organizers are frequently utilized by teachers to assist learning. Characteristics of graphic organizers include an organizational process, opportunities for brainstorming, planning, assessment, illustrations, visual stimuli, note taking, checking understanding, and allowing an instructor to effectively deliver instruction (Ausubel, 1969; Bromley, Irwin-DeVitis, & Modlo, 1995; Gregory & Chapman, 2002; Marzano, R.J., Pickering, D.J., & Pollock, J.E., 2001; Stronge, 2002). Mind mapping and outlining are specific instructional tools teachers utilize to improve learning. These instructional tools have the characteristics of graphic organizers and allow individuals to process information. Mind mapping and outlining allow individuals to foster and create meaningful learning, which is critical to the learning process (Ausubel, 1969; Novak, 1981).

The purpose of this study was to determine effects of mind mapping and outlining on learning Life Science in the seventh grade. This study evaluated unit test scores, one-week delayed comprehensive posttest scores, and attitudes of students toward the strategy implemented on a Life Science Unit on cellular biology. Permission was obtained from the Texas Tech Institutional Review Board and Hobbs (NM) Municipal Schools to conduct this study. Consent was received and each participant was randomly assigned to one of three groups (control, outlining, and mind mapping) to assure equal distribution of difference between these groups (Gall, Borg, & Gall, 1996). A one-way ANOVA was conducted to determine effects of groups in unit test scores and one-week delayed

comprehensive posttest scores. A MANOVA was utilized to evaluate effects of groups' attitude survey scores.

Results of the study demonstrated a significant difference in means of unit test scores. A post-hoc test was conducted to evaluate which groups were different. A significant difference existed for students who used the outlining strategy to answer unit test questions on cellular biology when compared to the control and mind-mapping groups. In evaluation of one-week delayed comprehensive posttest results on cellular biology, a significant difference did not exist between groups. Attitudes toward the strategy being implemented differed between means of groups for survey questions two and seven. The mind-mapping group indicated significant agreement regarding the statement "I enjoyed creating an (outline, mind map, writing information) for the cell block." Ancillary data was compiled of basic and application questions of unit test and one-week delayed comprehensive posttest. In unit test basic questions, the outlining group performed significantly better than the mind-mapping group. In the one-week delayed comprehensive posttest, the outlining group performed significantly better than the control group.

Limitations in this study involved students' lack of engagement of the learning process, student diversity, classroom disruptions, student interactions, student resistance, and immediacy of feedback. Recommendations for further study include grouping students according to their developmental level using Piaget's theory, modeling of note taking strategies by teachers, increasing the length of training sessions on graphic organizers, and selecting other areas of science content.

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CHAPTER I

GENERAL NATURE AND PURPOSE OF THE STUDY

Introduction

Teachers continually develop and refine their instructional skills. For many years, they have tried to improve methods to effectively deliver instruction. Scientific researchers have identified various areas of the brain and extensively explored this three-pound mass. Through their explorations, teachers have utilized information gained to help students' learning in the classroom. Furthermore, prominent researchers (Ausubel, 1969; Brooks & Dansereau, 1987; Diamond & Hopson, 1998, Gagné & Dick, 1983; Gardner, 1983) have established various theories to influence teachers' understanding of instruction and effective delivery of information (Marzano, Norford, Paynter, Pickering, & Gaddy, 2001; Sousa, 1995; Stronge, 2001; Sylwester, 1995).

Student diversity has forced teachers to explore various strategies to meet individual needs. Currently, with the enforcement of the "No Child Left Behind" Act, teachers are expected to meet every child's needs, regardless of their diverse needs (Sousa, 2003). Additionally, teachers are expected to deliver and exhibit quality teaching. With all of these tools and demands, how are teachers to deliver effective instruction?

A teacher considers several components of instruction, which are integral to learning. When considering adolescent development, teachers have carefully planned the lesson to guide the learning process (Stronge, 2002). Within careful planning, an instructor must be mindful of theories, which have been established to facilitate instruction and cognitive learning. Gagné and Dick (1998) stated that the instructional

process involves planning with learning outcomes in mind. Ausubel (1969) reported that an individual must be cognitively ready in order to learn new material. Without this readiness, the individual will have difficulty in learning new concepts and creating meaningfulness for the information. When considering the cognitive maturity and developmental level of students, the teacher must utilize this information to manipulate meaningful learning (Ausubel, 1969). Additionally, an adolescent's brain is rapidly undergoing a surge of hormones and pruning neurons (Feinstein, 2004). Pruning is a process in which the brain keeps neurons and synapses being used and eliminates neurons and synapses not being used. Thus, pruning allows for thinking processes to be refined (Feinstein, 2004). Due to this refining process, the refined pathways can be enhanced with memory. Memory is a key component to how an individual can retrieve information for learning (Brooks & Dansereau, 1987). To be effective, an instructor must be cognizant of the ever-changing adolescent brain.

Teachers utilize various instructional strategies to be effective in assisting students' learning. Cooperative learning, note-taking assistance, memory devices, graphic organizers, and other methodological reinforcements are instrumental to supplement instruction. Graphic organizers are beneficial tools and facilitate learning in an organized manner (Ausubel, 1969) and teachers use these in various content areas. Graphic organizers assist learning by providing an opportunity for visual stimuli, planning, brainstorming, recording information in a nonlinear fashion, assessment, checking understanding, problem solving, elaboration, creating analogies, note taking, summarizing, illustrating sequence of events, and other creative ways of instruction (Bromley, Irwin-DeVitis, & Modlo, 1995; Gregory & Chapman, 2002). By presenting

information in a pictorial form, teachers and students can focus on key ideas, access information, and stimulate learning. Mind mapping nurtures learning by exhibiting characteristics of graphic organizers and helps the learner perform “whole-brain processing” (Margulies, 1991, p.12). “Whole-brain processing” means the individual is utilizing both sides of the brain (Margulies, 1991). Outlining is an organizer, which allows the individual to take information given in a class lecture and present it in a linear, logical, and sequential manner.

In 1970, a young man was having difficulty and was unsuccessful in the world of education. It was not long before he explored his strengths and devised a method to help his learning, which he termed mind mapping. Mind mapping is a note-taking, organizational technique, which allows individuals to “organize facts and thoughts” (Buzan, 2002, p.10) in a map format containing a “central image, main themes radiating from the central image, branches with key images and key words, plus branches forming a connected nodal structure” (Buzan, 1993, p.59). Buzan (2002) created this method for utilization of both sides of the brain. In using the method, Buzan realized that it aided his memory, allowed him to recall information better, and enhanced his learning. As a result, he began to experience success. Unfortunately, this method did not become popular until thirty years later. Since 1970, the effects of mind mapping have been tested.

In using mind mapping, visual representations abet memory by allowing the brain to encode information. Outlining allows an individual to reflect on material learned which assists memory. In doing this task, the individual is able to process information and extrapolate important meaning based on prior knowledge acquired from experience

(Brooks & Dansereau, 1987). Thus, outlining allows information to be readily available for learning.

Statement of the Problem

Effective teachers use diverse methods and strategies for delivery of instruction. In day-to-day activity, teachers continuously modify their instruction to meet the needs of a diverse student body. However, how useful are these modifications? Which strategies assist in the learning process? How does the teacher know it was the impact of the strategy and not the impact of other teaching materials? Furthermore, teachers are practical individuals and search for methods to nurture effective student learning. For this reason, the researcher was curious whether mind mapping and outlining would aid the learning process.

The purpose of this study was to determine the effects of mind mapping and outlining on learning seventh-grade Life Science. To answer questions related to the problem, the researcher obtained knowledge of mind mapping, outlining, and how to deliver effective instruction to assist students in effective learning. This information was pertinent to determine if mind mapping and outlining were instructional strategies that promote students' learning.

Rationale for the Study

This study was to examine the effects of mind mapping and outlining for learning Life Science in seventh grade. Studies have been conducted to test the effective use of mind mapping with adults, medical students, fifth- and sixth-grade students (Farrand,

Hussian, & Hennessy, 2002; Goodnough & Woods, 2002; Peterson & Snyder, 1998; Taliaferro, 1998; Williams, 1999). Studies have been conducted on the use of outlining as a graphic organizer to aid reading comprehension (Katayama & Robinson, 2000; Kim, Vaugh, Wanzek, & Wei, 2004; Robinson & Katayama, 1998). Cognitive theories, instructional theories, and adolescent development were analyzed to formulate and design instruction toward the developmental level of early adolescence. Effective teachers utilize various strategies to assist students' learning (Marzano, Pickering, and Pollock, 2001; Stronge, 2002). Seventh graders are a year older than sixth graders and, possibly, have transitioned into Piaget's formal operations stage of development, which allows students to use abstract thinking in creating mind-mapping notes. Seventh graders, who are many years younger than adults and college-aged individuals, may have different results with these graphic organizers than previously completed studies report.

Questions and Hypotheses

The purpose of this study was to examine mind mapping and outlining as tools for learning seventh-grade Life Science. As a way of comparing instructional strategies, three groups were formed: a control group, an outlining group, and a mind-mapping group. The researcher formulated questions and hypotheses for each group.

Question 1:

What are the relative effects of mind mapping, outlining, and a control condition on the unit test scores of seventh-grade students studying cellular biology?

Hypothesis 1: Students in the mind-mapping group will perform significantly higher on the unit test than those in the

outlining group, and students in the outlining group will perform significantly higher than those in the control group.

Question 2:

What are the relative effects of mind mapping, outlining, and a control condition on the one-week delayed comprehensive posttest scores of seventh-grade students studying cellular biology?

Hypothesis 2: Students in the mind-mapping group will perform significantly higher on the one-week delayed comprehensive posttest than those in the outlining group, and students in the outlining group will perform significantly higher than those in the control group.

Question 3:

What are the relative effects of mind mapping, outlining, and a control condition regarding student attitudes toward the corresponding instructional strategy of seventh-grade students studying cellular biology?

Hypothesis 3: Students in the mind-mapping group will have significantly higher attitude scores than those in the outlining group, and students in the outlining group will have significantly higher scores than those in the control group.

Definition of Terms

Bilingual. These students were monolingual or bilingual Spanish/English speaking individuals, who were classified by tests given by certified members in the school district.

Full Inclusion. The state of New Mexico requires special education students to attend “regular classrooms.” Usually, a special education teacher accompanies students to assist with instruction. Special education students who participated in this study were identified by tests given by certified members in the school district and classified as special education students.

Life Science. A commercially available science curriculum used in the Hobbs Municipal School District for students in seventh grade.

Mind Mapping. An organizer that is a visual representation with a central theme surrounded by branches, themes, images, pictures, thoughts, patterns, and ideas taken from information given during a class lecture.

Outlining. An organizer, which allows the individual to take information given in a class lecture and present it in a linear, logical, and sequential manner.

Pre-Advanced Placement. Pre-Advanced Placement is a program designed by The College Board to offer students an opportunity to earn college credit while in high school. The prefix, *pre*, indicates before students reach high school, and offers, in this case, junior high students an opportunity to prepare for Advanced Placement courses in high school. Considering the developmental level of early adolescent students, this researcher labels this Life Science course as “preemie Pre-AP” because it is a junior high school

level course. Additionally, these students are developing skills to be successful in an Advanced Placement Course, which begins in seventh grade.

Assumptions

This researcher made several assumptions regarding the study. Mind mapping and outlining were utilized to assist the individual with recall and comprehension of content. One reason mind mapping was helpful with recall was the utilization of both sides of the brain. If this was true, participants in the mind-mapping group will have significantly higher test scores when compared to the control group and the outlining group. Outlining is beneficial with recall because students are continually reviewing material as they are writing in outline form.

A second assumption was the developmental level of participants. According to Piaget's theory, individuals in seventh grade are developmentally in the formal operations stage. Applying Piaget's theory, these individuals have the capacity to think abstractly and formulate a picture to coincide with the written information in the mind map, which served as a process for creative note taking and constructed mind-mapping notes. As a result, creating mind-mapping notes had more meaning to the individual; thus, the individual had better recall for learning. However, if an individual cannot think abstractly, mind mapping may be meaningless.

Limitations of the Study

This research was designed to examine the effects of learning for seventh-grade Life Science by using mind mapping and outlining. Because this study occurred in a

school setting in a small New Mexico community, results of this study may not be generalizable to other populations.

Another limitation of the study was that the test utilized was not a standardized test. Rather, it was a test formulated by *McGraw-Hill Life Science Computer Test Manual Bank*. As a result, the test was selected because it is practical for the cell unit taught for this study and because validated instruments assessing this content knowledge for seventh-grade students were not available.

Teacher bias could influence results in the study. Teachers may unknowingly make statements to students in their normal daily instructions. However, by allowing teachers to alternate classes every other day, teacher bias would be less likely to occur.

Classroom instruction had numerous interruptions. Many students participated in various school-sponsored activities. Consequently, these students may have received less instruction.

Group dynamics can be a limiting factor. When students shuffled from one teacher to another, students resisted change and group dynamics were altered (i.e., schedule changes, new students, group assignments, etc.). Thus, instruction and participation were reduced.

Student diversity contributed to unmanageable conditions. Due to adolescent hormonal development, students were more active during the mid-morning to late morning hours rather than the early morning hours. Students' maturation process was varied. Some students between ages 11 and 14 were developmentally and mentally more mature than others.

Student confidence was lacking in performance of the strategy. Students continuously asked the teacher to model what to write for the strategy. This may be a reason for nonperformance in taking notes and engagement in the strategy process.

Student interaction and conversations influenced results. Although students were randomly assigned to groups, students sharing information about science content with each other was apparent. Students were curious and were social individuals.

Immediate feedback on test performance was necessary. Due to raters taking time in marking tests, it was difficult for students to receive immediate feedback on their performance. As a result, students perceived the study to be insignificant and this situation may have influenced their performance.

Significance of Study

Considering Piaget's formal operations stage of cognitive development, seventh-grade students are able to formulate abstract thought. Because students abstractly create pictures to support thoughts and ideas, mind mapping and outlining were utilized in this study. While studies have been conducted to test the effective use of mind mapping with adults, medical students, college-aged students, fifth and sixth graders (Farrand, Hussain, & Hennessy, 2002; Goodnough & Woods, 2002; Peterson & Snyder, 1998; Taliaferro, 1998; Williams, 1999) and the effective use of outlining (Hamilton, Seibert, Gardner, & Talbert-Johnson, 2000; Katayama & Robinson, 2000; Kim, Vaughn, Wanzek, & Wei, 2004; Lazarus, 1996), this was the first experimental study conducted with seventh-grade students using mind mapping and outlining.

Summary

Teachers continually search for methods to improve student learning. In searching, teachers consider the developmental level of students and design instruction. A successful teacher is cognizant of pedagogical and content strategies to assist students' learning. This study focused on the effectiveness of mind mapping and outlining in nurturing the learning process in seventh-grade students.

CHAPTER II

REVIEW OF LITERATURE

Introduction

This chapter contains a review of the literature pertinent to the study. There are five main sections. These are adolescent development, memory, instruction, instructional methodologies, and teacher collaboration. In adolescent development, three categories are discussed. These categories are physical development, cognitive development, and social development. Memory is discussed and broken into sections based on memory storage and types of memory. Furthermore, memory is expanded into how an individual can utilize memory for recall, which is necessary for the creation of graphic organizers. Instruction is presented with theories, which assist teachers in setting guidelines for acquiring knowledge or skill through effective instruction. Instructional methodologies include graphic organizers and various instructional formats. For this study, information on graphic organizers will be limited to mind mapping and outlining. Finally, teacher collaboration and benefits from collaborating with other teachers are presented.

Adolescent Development

Adolescent development is a broad category and can be divided into three sub-categories – early adolescence, middle adolescence, and late adolescence. For this study, the concern lies with early adolescent development. This particular age group was of interest because seventh-grade students are early adolescent individuals and range in age from 11-14. Physical, cognitive, and social development must be considered when

teaching adolescents. In physical development, adolescents exhibit diverse physical characteristics. Adolescents' cognitive development is expressed through the physical changes of the brain and a majority of adolescents exhibit Piaget's formal operations stage of cognitive development. Social development of adolescence has challenged teachers to comprehend adolescents' behavior. Knowledge of adolescent development is important to teachers for understanding. In knowing how early adolescents develop, the teacher can structure lessons and activities for their learning. It was important in this study because the researcher was working with students in early adolescence.

Physical Development

Adolescents exhibit diverse physical development. Outwardly, students portray a mosaic of heights, shapes, sizes, and appearance. Inwardly, hormones burst and flourish during the genesis of adolescence. Females begin maturity around the age of ten or eleven years old. Upon completion of their growth spurt, around the age of sixteen, females will have gained an "average height of seven inches" (Knowles & Brown, 2000, p.12). Primary characteristics of females are the hormone secretion of estrogen to the reproductive organs for ovulation and menstruation. Females' secondary characteristics are "increased proportion of fat to muscle, broader hips, and developed breasts" (Feinstein, 2004, p.100). Males enter adolescence approximately at the age of twelve or thirteen. The growth spurt for males is complete at approximately the age of sixteen (Feinstein, 2004) with a total height gain "of nine to ten inches" (Knowles & Brown, 2000, p.12). The primary sex characteristic of males is the hormone secretion of testosterone, which allows the reproductive organs to begin production of sperm.

Secondary characteristics of males involve “facial, chest, pubic and underarm hair growth, rougher skin, more oily and sweat glands, deeper voice, denser bones, wider shoulders, and an increase proportion of muscle to fat” (Feinstein, 2004, p.100). To meet demands of adolescent growth, appetite increases. As a result, adolescents may gain “eight to ten pounds a year” (Knowles & Brown, 2000, p.12). With all demands placed on the body, sleep becomes a necessity to accommodate physiogenesis for both sexes. Although numerous hormones are involved in the physical development of both sexes, the cognitive development of the brain also undergoes rapid changes and these changes influence behavior.

Cognitive Development

Teachers must be cognizant of cognitive development in early adolescence. The physical changes experienced in the brain give rise to the cognitive development described by Piaget. Piaget stated that adolescents at the age of 11 or 12, and maybe even later, should be in the “formal operations stage.” Individuals in this stage should be able to “mentally juggle and think logically about ideas, which cannot be seen, heard, tasted, smelled, or touched” (Sigelman, 1999, p.179). Additionally, cognitive development includes the ability to think abstractly, formulate hypothetical concepts, and process consequences of actions (Beamon, 1997; Eccles & Wigfield, 1997; Knowles & Brown, 2000; Sigelman, 1999), and “propositional thinking, interpretation of symbols, concepts, themes, sayings, and generalizations . . .” (Beamon, 1997, p.42). This development is important to the study because a student must be able to abstractly create a symbol or image to utilize in the mind map he/she has created. Egocentrism is evident in the formal

operations stage of cognitive development because the individual cannot isolate his/her adolescent thought from that of an adult (Sigelman, 1999). This is a process of development for early adolescents. In order for a teacher to give effective instruction, cognitive development must be considered. Furthermore, physical changes occur in the brain, which influences adolescents' cognitive development and behavior.

Brain development within this age group can vary between three to five years. Rapid neural firing and pruning mold the brain. Pruning is the process the brain undergoes to eliminate neurons not being used; the neurons, which stay behind, are strengthened to prepare the brain for its specific development later in life (Feinstein, 2004). For example, if an adolescent is not practicing skills needed to solve problems, perform tasks such as experiments, or enhance reading skills, the individual will lose the neurons needed to perform certain tasks (Feinstein, 2004). It is during this stage of development that adolescents develop the neuronal connections needed to assist in specific tasks, which may be of interest later in life in choosing a vocation or career.

The hypothalamus monitors various activities within the human body. The hypothalamus regulates hormones, food intake, thirst, biological rhythms (Tortora, 1989) “regulate the sleep patterns, blood pressure, body temperature, digestion, and pain” (Feinstein, 2004, p.108). The hypothalamus tells the pituitary gland, via chemical messages, that the body is ready to endure hormonal changes. Once the pituitary gland receives the chemical message, hormones start changes. A neurotransmitter, serotonin, regulates the body as best it can with the rapid changes. This neurotransmitter allows individuals to feel calm and peaceful. If this balance is disrupted, certain unacceptable behaviors might be demonstrated.

In teenagers, the frontal lobes are underdeveloped. This area is responsible for judgment, prediction, decision-making, “personality, verbal communication, planning, and concentration” (Feinstein, 2004; Fox, 1990, p.186). As a result, teenagers exhibit behaviors demonstrating actions lacking judgment such as choosing to visit with friends rather than completing homework (Feinstein, 2004). However, teenagers can rely on one part of the brain, the amygdala, which is fully developed at birth to assist in reasoning.

The amygdala is the emotion regulator. Teenagers depend on the amygdala to assist in judgment. For example, consider an individual in early adolescence. This individual, A, views a second individual, B, from across the room. Individual B gives a non-expressive look. However, individual A sees the same look and makes an interpretation as the look being one of “individual B dogged me.” Students interpret dogging to mean giving a dirty look or staring at the person. Now, as an adult, we rely on our frontal lobes for reasoning, consciously and logically analyzing the situation. However, adolescent individual A is relying on the amygdala to make the interpretation for her. Therefore, she reacts on the emotional amygdala and, consequently, may fight individual B. (Feinstein, 2004)

The hippocampus is actively weeding unused dendrites or pruning dendrites. The hippocampus is responsible for formulating new memories. During the process of adolescence, the hippocampus prunes information, which is not relevant to the individual. This allows the brain to fine tune the neurons to strengthen its processes. This is why the learning process is important for teachers to understand. These structures have a profound effect on the learning of individuals in the classroom. If teachers know the brain development of students, instructors can cultivate an enriched learning environment.

Enriched environments contribute to adolescent development. Diamond (1998)

defined an enriched environment as an environment that

“provides a nutritious diet, stimulates all senses, atmosphere free of undue pressure or stress, presents novel challenges, promotes development of a broad range of skills, an atmosphere that promotes exploration and fun of learning, gives opportunity to choose own activities, gives a chance to assess the results of efforts and to modify them.” (p. 107-108)

Diamond (1998) performed extensive research on enriched environments. She and her team at Berkeley have conducted laboratory experiments on rats. Rats were subjects in an enriched environment, an impoverished environment, and a controlled environment.

Diamond’s team discovered rats in an enriched environment had more cortical growth than rats in impoverished environments, which had no cortical growth. In fact, for some rats, brain growth was inhibited or decreased in size. This research can be used to assist teachers’ comprehension of enriched environments’ influence on brain development.

Being cognizant of how enrichment can assist brain development, a teacher can offer an enriched environment for students’ growth.

With knowledge of factors involved with cognitive development, teachers can comprehend adolescent thinking. Certain structures of the brain have a profound influence on behaviors and actions of teenagers. Furthermore, understanding these structures in physical brain development will lead to the social development of adolescents. Along with brain development, social development is important to understanding adolescence.

Social Development

Social development in adolescence is very challenging. The adolescent's body undergoes rapid change and maturation and "eleven to fourteen year olds feel painfully self-conscious and shift to their self-image repeatedly" (Diamond, 1998, p.237). This period involves adolescents being more aware of how they look or want to look in front of their peers. They are very self-conscious. As a result, adolescent individuals are egocentric. Peer influence becomes a factor in some of their behaviors. Some behaviors seen in the group are supporting peers, parents are no longer the primary influence; social interaction with their friends is a priority, wanting to establish independence, being egocentric and repeated forgetfulness. A teacher needs to understand these social behaviors of adolescent development.

Adolescent development is a broad category and divided into subcategories – early adolescence, middle adolescence, and late adolescence. For this study, the concern lies with early adolescent development. This particular age group was of interest because seventh-grade students are early adolescent individuals and range in age from 11-14. This age group is experiencing the genesis of adolescence through the bursting hormones, brain growth, and awkwardness. To some, it may be termed: "the best of times; the worst of times."

Memory

This section involves information pertaining to memory. Memory storage is a complex process and divided into two sub-categories – duration (how long) and formation (how made) (Markowitz & Jensen, 1999). Memory duration involves the

length of time it takes to remember a task in order to follow through with the action and can be categorized into “immediate perceptual memory, working memory, short-term memory, and long-term memory” (Markowitz & Jensen, 1999, p.2). Memory formation is the process in how memories are formed and can be reclaimed through pathways. Many types of memory can be formulated into two major categories, which are explicit and implicit memory (Jensen, 1998). Furthermore, recalling information is an intricate process and can involve rehearsal, coding, chunking and rote memorization, which is necessary for creation of graphic organizers, especially mind mapping and outlining.

Markowitz and Jensen (1999) define memory as “the biological process whereby information is coded and retrieved” (p.1). On a neuronal and chemical level, the brain undergoes an intrinsic process in which memory becomes “a collection of complex electrochemical responses activated through multiple sensory channels and stored in unique and elaborate neuronal networks throughout the brain” (Markowitz & Jensen, 1999, p.1). Memory is a dynamic and fluid process (Jensen, 1998). Every new encounter with novel information an individual experiences allows the brain to alter neuronal and chemical structures (Markowitz & Jensen, 1999). When information is introduced to an individual and processed through memory pathways, the new information is stored in certain areas of the brain (Markowitz & Jensen, 1999; Sousa, 1995).

Memory storage is a complex process and can also be divided into two categories – duration (how long) and formation (how made) (Markowitz & Jensen, 1999; Sousa, 1995). Memory duration involves the length of time it takes to remember a task in order to follow through with the action. Memory duration can be categorized into immediate perceptual memory, working memory, short-term memory, and long-term memory.

Immediate perceptual memory, which allows an individual to remember items “long enough to write or type”, exists (Markowitz & Jensen, 1999, p.2). The duration of immediate perceptual memory is one second. Usually, if an individual is interrupted in thought during this process, he/she will forget the information.

Working memory is the second category. This allows individuals to remember items long enough to continue with a certain action. For example, when a person searches for a phone number, he/she remembers the number long enough to dial.

A third category is short-term memory, which assists an individual remember information for approximately twenty seconds or longer. This process is dependent upon numerous utilized cues or practiced intentional exercises. For example, when an individual exits a store, he/she may recall the location of the car based on remembering landmarks surrounding the vehicle. (Markowitz & Jensen, 1999)

Long-term memory encodes information, which can last a lifetime, and is the fourth category. With long-term memory, a person may recall how he met his spouse. In recalling, the person tells every detail and description, which reinforces the memory. Memory storage is a complex process and memory formation is important.

Memory formation is the process in how memories are formed and can be reclaimed through pathways. In order for memories to be created, several processes have to occur. Markowitz and Jensen (1999) have identified six characteristics of memory formation.

1. We think, feel, move and experience life (sensory stimulation);
2. All experiences are registered in the brain;
3. They are prioritized by value, meaning, and usefulness, by brain structures and processes;
4. Many individual neurons are activated;

5. Neurons transmit information to other neurons via electrical and chemical reactions;
6. Repetition, rest, and emotions strengthen these connections. Lasting memories are formed. (p.6)

However, certain factors, such as the “importance of information, time, purpose of learning, content being introduced, strength of memory pathways, and stimuli such as scent, sound, or emotions have an impact on memory formation” (Markowitz & Jensen, 1999, p.2; Sylwester, 1995).

Two major categories of memory exist: explicit and implicit memory (Jensen, 1998; Sousa, 1995). These categories are different from the first presentation of memory duration and memory formation in that they are describing in detail what these memories are and how a person may experience the process. The first category is explicit memory, which includes semantic and episodic memory. The second category is implicit memory, which includes procedural, reflexive, conditioned response and emotional memory.

Explicit memory is also named declarative memory. An individual forms memory pathways through focus, attention, and making conscious effort to remember events. Learning how to spell and reciting multiplication tables are examples. Two subcategories of explicit memory are semantic and episodic memory (Jensen, 1998; Sousa, 1995). In semantic memory, individuals pay attention to “words, symbols, abstractions, video, textbooks, computers, and written stories” (Jensen, 1998, p.103). In episodic memory, persons focus on “locations, events, and circumstances” (Jensen, 1998, p.103).

Implicit memory is also referred to as non-declarative memory. Implicit memory has four subcategories. These are “procedural, reflexive, sensory conditioning, and emotional” (Markowitz & Jensen, 1999, p.2). The first category is procedural memory or

motor memory. This involves physical skills such as “bicycle-riding, body-learning, working with manipulatives, and hands-on learning” (Jensen, 1998, p.103) and other activities such as “fishing, tying shoe laces, and driving a car” (Markowitz & Jensen, 1999, p.3). A second category is reflexive memory or stimulus-response. This memory includes “automatic and non-conscious learning” (Jensen, 1998, p.103) and the brain “codes, stores, and retrieves information instantly and instinctually” (Markowitz & Jensen, 1999, p.3). Reflexive memory is further divided into conditioned responses and emotional memory (Jensen, 1998). The third category, sensory conditioning or conditioned responses, involves events such as knowing a stove is hot and any activity which requires repetition. Emotional memory, the fourth category, is a memory with intense emotions ranging from trauma to pleasure. Being cognizant of these types of memory can assist in recalling information retrieved from storage sites in the brain.

Pieces of information are retrieved from storage sites in the brain that were established by the use of the memory pathways traveled when the information was learned. As a result, aids are necessary to assist in recall of the information learned. Recalling information is an intricate process and can involve processes such as rehearsal, coding, chunking, and rote memorization. These are necessary for creating graphic organizers, especially mind mapping and outlining. Students must consciously attend to the process of learning and formation of their memories of the content. Learning is “the transfer of information from short-term to long-term storage” (Seamon, 1980, p.110).

Two other processes must be considered. The first process is called rehearsal, “which is a form of stimulus repetition” (Seamon, 1980, p.110). When this happens, a second process “coding” must occur. Coding is “an alteration or addition to the

information in the short-term store which restricts the amount of information, but enhances the strength of the traces produced in the long-term store” (Seamon, 1980, p.111). Coding is good for memory pathways because it allows pathways to become stronger and able to retrieve memories. Once this process begins, the learner begins to reshape and refine his knowledge. If this process is not considered, motivation may be lacking in accomplishing completion of the conceptual organizer (Novak, 1981). Memory has a role in utilizing this organizer (Novak, 1980). An instructor must be aware of the role memory plays within constructing a conceptual map. Short-term memory requires an individual to make a concerted, conscious effort in analyzing the information to see if it is valuable information to place within the concept map (Novak, 1980). If meaningful learning does not occur between the student, teacher, and diagram, this organizer will be meaningless (Novak, 1981). Once information is determined as being valuable, the brain can “chunk” it for coding to long-term memory, which makes the information meaningful to the learner due to accessing and linking their prior knowledge to the concept (Novak, 1980).

“Chunking” is the process that allows an individual to group in fragments information from a large source of information by categorizing or creating a pattern (Sousa, 2003). Persons are gathering groups of information, categorizing, and processing the learned information through use of the working memory. A pre-adolescent individual is able to chunk “three to seven items, with an average of five” (Sousa, 2003, p.74). As a person develops through adolescence, a “chunking” range of five to nine exists. Thus, the adolescent is able to “chunk” an average of seven large blocks of information (Sousa, 2003). For example, some students may have learned the alphabet by chunking –

“abcdefghijklmnop, qrs, tuv, wxyz” (Sousa, 2003, p.74). This twenty-six letter alphabet was broken into smaller blocks of information by grouping letters from a large source of information, twenty-six letters, so an individual can remember the information. Students may learn how to chunk information; however, many students rely on rote memorization in learning.

Rote memorization is difficult to maintain because the individual has to relate the information learned to previous knowledge. Ausubel (1969) provided insight as to why students would learn by rote memorization. Students learn from experience that correct answers are sought in some subject areas. Additionally, some students may have high anxiety levels or have experienced repeated failure in a particular subject and rely on rote memorization to survive. In addition, students may lack confidence and may be under excessive pressure to comprehend information presented in class; therefore, students rely on memorizing key terms.

Types of memory, memory storage and memory formation are intricate processes and need to be understood for this study. An individual relies on memory for creating a graphic organizer. How the information is stored is critical to the processes involved in retrieval of the information. Chunking is a strategy adolescents can use to remember information. If a teacher presents more information than an adolescent is able to chunk, then the remembering information becomes harder to learn. If an adolescent is relying on rote memorization, learning becomes difficult and it is harder to create a graphic organizer. However, if the adolescent is using rehearsal, chunking, and coding, creating a graphic organizer becomes easier and will aid the recall process.

Instruction

Teachers are unconsciously aware of influences of components of instructional theory on instructional design. Hosford (1975) lists three functions of the theory of instruction. As one begins a lesson, processes are formulated and reflected on the lesson given to students; thus, teachers are planning and conducting the lesson. Once the lesson begins, the individual starts to modify, test, or reject the strategy used to teach the lesson. If the content of the lesson does not fit into the curriculum well, the teacher may voice a concern about it being removed or reevaluated. In order for this dynamic process to occur, hidden preparation happens. This preparation includes verbal presentation and delivery, sequence of instruction, and objectives of instruction.

This section discusses instruction as it pertains to instructional theories and cognitive theories. Bruner (1966) and Gagné and Dick (1983) have defined and presented guidelines of instructional theories. These theories can be broken into sections, which are integral to the instructional process. They include the verbal presentation of instruction and delivery of instruction, sequence of instruction, and objectives of instruction. Cognitive theory involves the process of how individuals' process information received during instruction. In order for an individual to process information given in note form, the individual must be "cognitively ready" and able to cognitively arrange information for meaningful learning to occur

Instructional Theory

Bruner (1966) and Gagné and Dick (1983) have presented a framework and definition of an instructional theory. Bruner (1966) reported that the purpose of an

instructional theory is to set forth guidelines for acquiring knowledge or skill through effective instruction. According to Bruner (1966), four major features of an instructional theory exist.

1. A theory of instruction should specify the experiences, which most effectively implant in the individual a predisposition toward learning – learning in general or a particular type of learning.
2. A theory of instruction must specify the ways in which a body of knowledge should be structured so that the learner can most readily grasp it.
3. A theory of instruction should specify the most effective sequences in which to present the materials to be learned.
4. A theory of instruction should specify the nature and pacing of rewards and punishments in the process of learning and teaching. (pp. 10-11)

These guidelines provide a framework toward becoming a more effective teacher.

Additionally, Gagné and Dick (1983) defined theories of instruction as an “attempt to relate specified events comprising instruction to learning processes and learning outcomes, drawing upon knowledge generated by learning research and theory” (p.264). By teachers using instructional theories, some outcomes of instruction will have optimal “learning, retention, and learning transfer” (p.264). Gagné defined instruction “as a set of events external to the learner which are designed to support the internal processes of learning” (as cited in Gagné and Dick, 1983, p.266). Being cognizant of guidelines and the definition of instruction, a teacher can compose instruction and facilitate effective learning.

An instructional theory can be broken into sections that are integral to the instructional process. They include the verbal presentation and delivery of instruction, sequence of instruction, and objectives of instruction for the lesson. All parts are necessary for effective instruction to occur.

Verbal presentation and delivery of instruction are important and occur simultaneously. Gagné and Briggs (as cited in Gagné & Dick, 1983) termed this process as the “internal process of learning”, also known as “events of instruction” (Petry, Mouton, & Reigeluth, 1987, p.17). The instructor verbally presents information for “gaining attention, informing learner of the objective, stimulating recall of prerequisites, presenting the stimulus material, providing ‘learning guidance’, eliciting the performance, providing feedback, assessing the performance, and enhancing the retention and transfer” (Gagné & Dick, 1983, p.266). An instructor must verbally deliver instruction in a meaningful, guided, and stimulating way.

The sequencing of instruction is important to the instructional process. Once the instructor has identified the verbal information, he/she analyzes and manipulates the sequence of instruction to meet objectives and goals of the lesson. The educator is formulating and sequencing the instructional process while hierarchically organizing the information (Petry, Mouton, & Reigeluth, 1987). Thus, this process allows for effective instruction. However, objectives are essential to the instructional process.

Merrill (as cited in Gagné & Dick, 1998), who participated in the development of a theory of instruction, states objectives are imperative to the quality of instruction. Along with objectives, “consistency and adequacy” must be present in the preparation and delivery of instruction. An instructor utilizes objectives to evaluate the instructional process. Objectives create a framework for instruction, which includes “learned capabilities . . .” (Petry, Mouton, & Reigeluth, 1987, p.13). Specific learning outcomes (“learned capabilities”) are evaluated by “verbal information, intellectual skills, cognitive strategies, motor skills, and attitudes” (Gagné & Dick, 1983, p.265; Petry, Mouton, &

Reigeluth, 1987, p.13) that students can perform. Students can verbally present information based on what was learned. Students' intellectual skills can be evaluated by how well they perform an intellectual task based on what was learned. For example, cognitive strategies include how an individual can make the process of learning more efficient and effective, i.e. – mind mapping and outlining. Motor skills are processes of how well an individual can perform a task such as driving, skiing, pitching a baseball, or performing an experiment. Attitudes are “complex mental states of human beings that affect their choice of personal action towards people, things, and events” (Petry, Mouton, & Reigeluth, 1987, p.15). These are examples of how an instructor may assess specific outcomes or learned capabilities for effective instruction.

Cognitive Theory

Cognitive theory is closely related to instructional theories. Cognitive theory involves a process in how individuals' process information received from instruction. The methods utilized in this process assist with recall.

In order for an individual to process information given in note form, the individual must be “cognitively ready” and able to cognitively arrange information for meaningful learning. “Cognitive readiness” is “the adequacy of the student's existing cognitive equipment for coping with the demands of a specified new learning task” (Ausubel, 1969, p.175). Readiness is influenced by two factors, which include prior knowledge and cognitive maturity. Cognitive readiness is necessary for individuals to create meaning based on his/her prior knowledge. As a result, Ausubel (1969) states “meaning elicited by any particular symbol or group of symbols will depend upon the

ideas that exist in the learner's mind" (p.54). Thus, if an individual is not cognitively ready, he/she may have some difficulty in creating meaning, which requires maturity and knowledge as well as time to reflect, think, and create.

Ausubel (1969) created relationships between meaningful learning to psychological meaning. In order for "meaningful learning" to occur, Ausubel (1969) asserts that the individual must have established learning by determining if the information received is meaningful. If this information is meaningful, then the individual will process the information and this will strengthen his/her knowledge. It is the teacher's responsibility to be cognizant of the student's cognitive maturity and present material in a manner, which will facilitate and nurture growth. Along with Ausubel's "cognitive readiness" and "meaningful learning", Piaget's theory of cognitive development is considered.

Piaget defined four stages of cognitive development. They are sensorimotor, preoperational, concrete operations, and formal operations. Piaget believed individuals transitioned through these stages of cognitive development (Woolfolk, 2001) and exhibited certain characteristics. For this study, the researcher was interested in the formal operations stage of cognitive development.

The formal operations stage of cognitive development involves most individuals who are eleven years of age or older (Sigelman, 1999; Woolfolk, 2001). Persons who are in the formal operations stage of cognitive development are able to create and test hypotheses, make predictions, perform deductive and inductive reasoning, think abstractly, and systematically and logically problem solve (Sigelman, 1999; Woolfolk, 2001). However, Piaget acknowledged that individuals transition through these stages of

development at different rates and individuals “may show characteristics of one stage in one situation, but characteristics of a higher or lower stage in other situations” (Woolfolk, 2001, p.30). Therefore, knowing a person’s age is not a true indication of his/her cognitive stage of development.

By being educated in some components of instructional theory, teachers can speculate on ways to consciously and effectively instruct students on the process of graphic organizers. Teacher should be cognizant of the students’ cognitive maturity and present material in a manner that will facilitate and nurture the growth. However, knowledge of a person’s age is not a true indicator of his/her cognitive stage of development. Behaviors of adolescents need to be observed and utilized with knowledge of instructional and cognitive theories. Additionally, instructional methodologies can be utilized to assist the learning process and cognitive development of adolescents.

Instructional Methodologies

Instructional methodologies are methods used during instruction to aid the process of student learning. Various methodologies exist such as collaborative learning, graphic organizers, the Socratic method, questioning strategies, inquiry methods, role playing, memory techniques, concept attainment models, peer teaching/peer coaching, advance organizers, note taking strategies, direct instruction models, brain compatible strategies and other techniques (Fogarty, 1997; Joyce, Weil, and Calhoun, 2000; Marzano, Pickering, and Pollock, 2001). While the researcher has acknowledged various strategies, she is interested in two particular types of graphic organizers – mind mapping and outlining – and their effect on learning cellular biology in seventh-grade Life Science.

For this reason, these graphic organizers are discussed and presented in the following sections.

Graphic Organizers

Graphic organizers (GOs) have been defined as a “visual format used to organize ideas, concepts, and information . . .” (Fogarty, 1999, p.236) and have various common names. Common names are “tree diagrams, thematic illustrations, structured overviews, semantic networks, semantic maps, episodic maps, concept maps, and flow charts” (Horton, Lovitt, & Bergerud, 1990, p.12). Additionally, GOs have been called “a semantic feature analysis, cognitive maps, story maps, framed outlines, and Venn diagrams” (Kim, Vaughn, Wanzek, & Wei, 2004, p.105).

Graphic organizers stem from Ausubel’s creation of advanced organizers (Moore & Readence, 1984). Advanced organizers are hierarchal in nature and “relationships between concepts are not explicitly labeled” (Moore & Readence, 1984, p.11) and may contain “many subordinate ideas that can be linked to particular characteristics . . .” (Joyce, Weil, & Calhoun, 2000, p.248). GOs differ from advanced organizers in that “graphic organizers use lines, arrows, and spatial arrangement to depict text structure and relationships among key vocabulary terms” (Alvermann, 1981, p.44) and are the “visuospatial arrangement of information containing words or statements that are connected graphically to form a meaningful diagram” (Horton, Lovitt, & Bergerud, 1990, p.12). Furthermore, GOs allow information to be manipulated in vertical, horizontal, or hierarchical arrangements to display various relationships (Robinson & Katayama, 1998). As a result, graphic organizers allow . . . “students to organize information and allow

students see their thinking” (Gregory & Chapman, 2002, p.87). However, both advanced organizers and graphic organizers allow the user to formulate and associate ideas to prior knowledge so the learner can encode information for better recall and greater comprehension (Alvermann, 1981; Ausubel, 1969; Horton, Lovitt, & Bergerud, 1990; Katayama & Crooks, 2003; Kim, Vaughn, Wanzek, & Wei, 2004; Moore & Readence, 1984, Ritchie, & Gimenez, 1995/1996).

Graphic organizers were originally designed to assist teachers in preparing students for reading, preparatory activities, and accessing students’ prior knowledge (Horton, Lovitt, & Bergerud, 1990; Moore & Readence, 1984) by providing a systematic, clear organizer for synthesis. Once teachers established students’ knowledge, instructors began to facilitate, assemble and clarify any misunderstandings for assimilation of the information (Moore & Readence, 1984). By creating this environment for learning, the teacher is allowing the brain to prepare for deeper and whole-brain processing (Alvermann, 1981; Margulies, 1991) of information.

The benefits of GOs are many. Studies have confirmed graphic organizers assist individuals in reading text and assist with reading comprehension (Alvermann, 1981; Kim, et.al, 2004; Chang, Sung, & Chen, 2002). In using graphic organizers, students visualize information by “displaying facts or ideas in stable patterns” (Clarke & Martell, 1994, p.71). Ritchie and Gimenez (1995/1996) reported that GOs direct students’ attention to primary concepts to be learned and allow for organization of relationships in picture format. Using graphic organizers, teachers can facilitate students’ manipulation of meaningful learning (Ausubel, 1969) so information can be retrieved through memory pathways (Sirias, 2002). Hence, Jonassen, Beisser, and Yacci (as cited in Ritchie and

Gimenez, 1995/1996) reported that students are able to apply, synthesize and transfer knowledge to various situations.

Teachers benefit from using graphic organizers by presenting information in an organized manner (Ausubel, 1969). Thus, graphic organizers allow students to view a pictorial representation and visual presentation of information (Clarke & Martell, 1994). Teachers can assess students' extraction and manipulation of information by evaluating their composition of the graphic organizer during the process of instructional delivery. Graphic organizers are beneficial for visual stimuli, planning and brainstorming, recording information in a nonlinear fashion, assessment, checking understanding, problem solving, elaboration, creating analogies, note taking, summarizing, illustrating sequence of events and other creative ways of instruction (Bromley, Irwin-DeVitis, & Modlo, 1995; Gregory & Chapman, 2002). By presenting information in a pictorial form, teachers and students can focus on key ideas as well as access and stimulate knowledge.

Graphic organizers allow students and teachers to manipulate information in a visual format. Additionally, GOs provide a flexible format for individuals to insert pictures, text, and ideas.

Mind Mapping. Buzan (2002) invented mind maps in the early 1970s. He realized that the education system primarily focused on left-brain strengths, which include the use of "language, logic, numbers, sequence, looks at detail, linear, symbolic representation, and judgmental characteristics" (Wycoff, 1991, p.12). As a result, he was unsuccessful in school. Hence, Buzan cultivated a method to exercise the right side of the brain, which is characterized by "images, rhythm, music, imagination, color, looks at the whole, patterns, and emotions" (p.12). As a result, Buzan integrated a strategy for

utilization of both sides of the brain for “whole brain processing” (Margulies, 1991), better recall, and enhanced memory (Buzan, 2002).

Mind mapping has been defined as “the ultimate organizational tool with each of the branches emanating from the central image . . .” (Buzan, 2002, p.4). Jensen (1998) defines mind mapping as “a creative pattern with connected ideas.” It has characteristics of visual representations with a central theme surrounded by images, pictures, thoughts, patterns, words, and ideas. Thus, mind mapping is a demonstration of both left and right brain utilization.

Features of mind mapping include a blank sheet of paper. The theme is isolated on the center of the blank paper. Around the theme, a shape can be designed to encompass the topic. Branches are distinctively added with color and extend in various directions from the central theme displaying key words or details. The creator of a mind map can personalize his/her creation by manipulating colors, symbols, patterns, pictures, print sizes; illustrating relationships by using arrows or directionality; and using different numbers of words. In addition, the individual is required to use his/her imagination (Buzan, 2002; Buzan, 1993; Jensen, 1992; Learning Forum Success Products, 1988; Margulies, 1991; Wycoff, 1991). Mind mapping has characteristics of graphic organizers because it allows an individual to manipulate pictures, create relationships, and arrange information in various hierarchical, vertical, and horizontal positions. In addition, it allows the creator to depict his/her meaningful learning as visual representations (Ausubel, 1969).

Studies of mind mapping have been conducted with various age groups. Positive and negative effects have resulted and each study has contributed to the enhancement of

teaching. Through the various uses of mind mapping, the instructor can evaluate students' learning.

Farrand, Hussain, and Hennessy (2002) studied second- and third-year medical students. Two groups were composed, a self-selected study group and mind mapping group. Each group read an article from *Scientific American* and answered questions. The self-selected study group could utilize any study technique of their choice. The mind-mapping group was trained in the mind-mapping technique and was required to use that strategy. Farrand, Hussain, and Hennessy found that "mind maps provide an effective study technique when applied to written material" (p.426).

Positive effects from the study were given. Mind mapping was likely to "encourage a deeper level of processing" (p.430) and improve cognitive processing for better memory formation when compared to the self-selecting group. As a result, this process allowed for improvements.

In addition, negative effects of mind mapping were found. Students' were disgruntled and resistant to the deep-level processing and did "not spontaneously adopt strategies that foster such learning" (p.430). Additionally, students in the mind-mapping group were unwilling to accept use of memory aids. In this study, males were more resistant than females and adhered to traditional techniques such as elaboration, repetitions, and rehearsal. Motivation was higher in the self-selecting group than the mind-mapping group. In order to remedy lack of motivation, the researchers speculated about presenting a possible beneficial, explanation of mind mapping to students; thus, this may assist in raising scores. Another possible way to eliminate lack of motivation was to assist students in utilization of memory strategies. Based on Farrand, Hussain, and

Hennessey (2002) study, motivation was a limitation to the study; however, mind mapping was beneficial when applied to written material and allowed for deeper processing.

Taliaferro (1998) conducted a study with sixth graders in Language Arts. She established two groups: an outlining group and a mind-mapping group. This was a quasi-experimental design. Each group was given a teacher-designed Initial Recall Test (IRT) and a teacher-designed posttest ten days after the completion of the treatment. Students in Taliaferro's sixth-grade class were performing at Piaget's concrete operations stage of development. Her results indicated that the outlining group performed better than the mind-mapping group on the posttest.

Positive results from Taliaferro's study involved peer-assisted review, note-taking skills, and improvement of students' ability levels. Peer review was beneficial to students because if they were misunderstanding information, they could confirm or gather suggestions from their peers. Note-taking skills were enriched in Taliaferro's study. Students were able to use their left-brain skills and organize information in a linear format. Students enjoyed the mind-mapping exercise.

Negative results of the study were students' level of cognitive development. Students were not able to "think abstractly" (Taliaferro, 1998, p.32). As a result, students were unable to "take written information and represent it with pictures that would help them recall that information. The ability to select proper illustrations and represent large pieces of text in short phrases, pictures, and symbols would have required abstract thought" (p.33). Students needed more exposure to develop their "right brain skills" (p.32).

Goodnough and Woods (2002) performed a qualitative, interpretive case study on two fifth-grade classes and two sixth-grade classes. The researchers conducted “semi-structured interviews, gathered field notes, used an open-ended questionnaire, and reviewed documents” (p.7). In this study, the researchers explained and discussed the content and justified utilization of the mind-mapping technique with students. They introduced the use of symbols and assisted students in brainstorming other uses of symbols. Goodnough and Woods (2002) permitted students to explore and become accustomed to the mind-mapping strategy by providing time and support. The researchers frequently offered students a teacher-generated mind map to complete, provided a rubric, and used the mind-mapping strategy to assess students’ understanding of content.

Positive effects of this study were many. Students’ perceptions of mind mapping were “fun, interesting, and a motivating approach to learning” (Goodnough & Woods, 2002, p.8). In addition, students preferred to use mind mapping in an individual situation rather than a group situation because they could express their own ideas for their own meaning. Mind mapping provided students with an opportunity to improve their learning. Teacher perceptions were discussed. One of the researchers involved was a teacher who gave her perceptions of mind mapping. Upon the use of graphics and text, she discovered that teaching mind mapping was cognitively demanding. Consequently, she became a reflective practitioner on teaching content and understanding students’ confusion. Furthermore, she predicted students’ mistakes in note taking, which allowed corrections for students’ misunderstandings. Students who had troubles in written expression became successful, were more self-confident, and explained and understood concepts. Mind

mapping allowed them to expand on ideas and sculpt information in a flexible, organized format.

Negative results were evident. The authors were not able to present information to other staff members because the information on mind mapping was lacking. Goodnough and Woods (2002) speculated teachers would resent hearing about the use of mind mapping because teachers are apprehensive to change. A follow-up questionnaire, which asked about frequent manipulation of mind mapping, was given to students a year later. Students' responses gave insight for teachers' lack of opportunity or knowledge of mind mapping strategy.

Peterson and Snyder (1998) presented a paper about the use of mind mapping to teach social problems analysis to students in a community college. While it was not an empirical study, they presented student responses on the utilization of mind mapping in the college course. Positive and negative outcomes were found.

Positive effects were that students who embraced mind mapping were comfortable and allowed their creative expression to flow. It permitted organization, problem solving, and brainstorming. Using mind mapping, students expanded their visual representation of theoretical constructs, which in turned allowed for "analysis and description of social problems" (Peterson & Snyder, 1998, p.21).

Negative effects were many. Some students were resistant to the assignment because mind mapping was unfamiliar to them. Thus, it required practice and frequent utilization in order for students to become familiar with the strategy. As a result, poor mind mapping assignments were constructed and "low-level involvement" was seen (Peterson & Snyder, 1999, p.23). Students were apprehensive about their ability to draw

and some were lacking sufficient thinking skills. Peterson and Snyder (1999) presented mind mapping to faculty and offered implications for usage in college courses. However, some faculty members were resistant to exploiting mind mapping.

Williams (1999) conducted a study on adults in a corporation who volunteered. In this study, she considered brain hemisphericity and learning styles influence on mind mapping. Brain hemisphericity is the use of the brain hemispheres, right hemisphere or left hemisphere. Learning style refers to how an individual learns. Her conclusion was that adults in the mind-mapping group did not score higher than the other group on an achievement test. However, positive and negative outcomes surfaced in the study.

According to this study, the mind-mapping technique, as confirmed by other studies, “is helpful as a study aid and helps learners understand and recall information better” (Williams, 1999, p.96). Furthermore, knowledge acquisition was increased. This technique allowed adults to discover mind mapping as being a useful tool.

Negative outcomes of the study involved adults who found this strategy to be “uncomfortable to use” (Williams, 1999, p.99). Their reasoning was because it lacked structure and required spontaneity. Time and practice were required for adults to feel comfortable with the strategy.

Many authors have conducted studies with various developmental levels of participants ranging from fifth graders to adults. Common themes that emerged from the studies related to time, preparation, motivation, thinking abilities, practice, developmental level and other skills. Students who adapted to the mind-mapping strategy had great success and enjoyed the process. In contrast, students who were not receptive to the mind-mapping strategy, displayed behaviors counter to their classmates. The behaviors

these individuals exhibited included low motivation, lack of participation, and possibly lack of developmental maturity.

Outlining. According to Weiler, an “outline is used to organize ideas or facts in a logical order. It is a plan for writing, telling, or doing something. An outline includes only main ideas and important details” (Weiler, 2002, p.2). An outline has many names such as guided notes, skeleton outline, and framed outlines (Hamilton, Seibert, Gardner, & Talbert-Johnson, 2000; Katayama & Robinson, 2000; Kim, Vaugh, Wanzek, & Wei, 2004; Lazarus, 1996).

Teachers use outlines for various reasons. They can use them to organize instructional information, save time, and design organized projects. It allows individuals to group ideas and facts together. By classifying items, the writer can “organize the information by topic, include all important information, leave out any information that does not fit, and plan the project in a logical way” (Weiler, 2002, p.2). However, outlining can be one of the most difficult processes an individual may encounter.

To compose an outline, students must have well developed process skills. In developing an outline, a student must be able to formulate “logical relationships in the text” (Irvin, 1990, p.147), analyze and synthesize content, and create an outline displaying only the main parts (Irvin, 1990). This intricate process may be difficult for an individual.

While it is beneficial for students to know how to outline, the teacher can give guidelines. To instruct students, it is best to facilitate learning how to outline. Irvin (1990) suggested these guidelines:

1. Discuss the plan of a formal outline.

2. Give the students an already completed outline in which the details are printed but the major headings are omitted. Students then fill in these major headings as they read.
3. Give the students an outline in which more slots are to be filled.
4. Give the students the outline skeleton and tell them to fill in the information.
5. Tell the students the number of main headings in the chapter.
6. Finally, have students produce a complete outline without assistance. (p.149)

Lazarus (1996) used skeleton outlines as guided notes with her adolescent students with mild disabilities. She defines guided notes as “skeleton outlines that contain the main ideas and related concepts of a lecture and designated spaces for students to complete as the lecture occurs” (p.37). Lazarus suggested for a teacher to compose skeleton outlines the teacher should use information from “existing lecture notes, use a consistent format, and provide maximum student responding” (p. 37) by using visual cues, demonstrating visual overviews during the lecture, providing advanced copies, and reviewing constructive feedback on recorded information. Furthermore, she reinforced students’ practice of using skeleton outlines by “modeling, providing guided practice, and allowing independent practice” (p. 38-39).

While guidelines have been presented on outlining, research has been conducted on graphic organizers and outlining. Robinson and Katayama (1998) conducted an experiment on the effects of graphic organizers and outlining with individuals. According to their research, outlining “may be instructionally inferior to spatial displays of information” (Robinson & Katayama, 1998, p.18).

Katayama and Robinson (2000) conducted another study on college students on the “encoding benefits” (p.119) of use of skeletal, complete, or partial graphic organizers or outlining. Students were to either complete notes on a skeletal note structure, partial

note structure, or complete note structure. A skeletal note structure creates notes from a note structure not containing any notes and students fill in the information. A partial note structure means students have half of the notes and they fill in the rest of the information. A complete note structure means students do not fill in any notes and review the information. Katayama and Robinson (2000) found that students completing partial notes performed better than those using skeletal notes or complete notes. Completing partial notes by these individuals was beneficial because they were not overwhelmed with the many tasks it takes to complete skeletal notes or viewing complete notes. Thus, partial notes were more effective in allowing for encoding to occur than completing skeletal notes or viewing complete notes.

Kim, Vaugh, Wanzek, and Wei (2004) completed a synthesis of research on graphic organizers, which included information pertaining to “framed outlines” (p.111), and how these outlines affected the reading comprehension of students with a learning disability. Kim, Vaugh, Wanzek, and Wei (2004) stated that reading from text is difficult for students because it requires the student to read information containing “unfamiliar, technical vocabulary” and “perform cognitive tasks” necessary to aid comprehension (p.105) due to poor organization of text. Kim, Vaugh, Wanzek, and Wei (2004) found that “framed outlines” assisted students’ reading comprehension because they allowed the reader to identify main ideas and important facts from text.

Slater, Graves, and Piché (1984) conducted a study on ninth-grade students. In this study, the researchers tested the effects of structural organizers. The researchers randomly assigned students to one of four groups: “structural organizer with outline grid, structural organizer without outline grid, control condition with notetaking, or control

condition without notetaking” (p. 3). A structural organizer with outline grid was composed of “information on the organization of the passage and a skeleton outline depicting the passage organization” (p.3). Slater, Graves, and Piché (1984) concluded, “structural organizers can facilitate students’ comprehension and recall of expository text” (p.27). Furthermore, the researchers found that note taking benefits students when they are actively involved in the process of “discovering, naming, and applying various organizational patterns” (p. 27). Time was needed to construct notes and was beneficial when completing notes. For an educator, providing a structural organizer would benefit students and increase their reading and comprehension.

Danielson (1985) conducted a two-part study about using webbing to assist twenty-one sixth-grade students with outlining. She stated “outlining is often a difficult skill for students to comprehend and use successfully” (p. 3). In order to alleviate this problem, Danielson thought that webbing, a visual representation, would assist students. Webbing is the graphic organizer that provides a “diagram of the main ideas and supporting details” (p. 4). In the first part of the study, three groups were formed – one group to finish a “partially completed outline,” one group to answer oral questions, and one group to complete an outline web. The time to complete the outline web was lower than the other two groups, indicating a faster completion time. In the second part of her study, the same three groups were formed except their task was to listen to a story and complete the task assigned. The oral questions group and the outline web group performed well in the “accuracy” of information and “average completion time” (p. 9). Danielson concluded that having a supplemental web assisted students in visualizing the

main ideas and supporting details used in outlining and allowed students to “improve their outlining skills and make outlining a more meaningful and attainable skill” (p.10).

Tuckman (1993) conducted a study using coded elaborative outlines with college students. Coded elaborative outlines (COE) are “outlines of main points that include the coding of information read and elaborate on the information to enhance meaning” (p.5). He composed five groups. The groups were “required CEOs, voluntary CEOs, CEO instruction only, required standard outlines, and no outlines” (p.6-8). Tuckman found that if creating the CEO assignment was required for students they had higher exam scores and higher grades. On the other hand, if the assignment was not required the students were not likely to use the outlining strategy. As a result, Tuckman concluded that coding and elaboration in the outlines aided students in studying and comprehension of material.

Hamilton, Seibert, Gardner, and Talbert-Johnson (2000) conducted a study on seven incarcerated students with learning and behavior problems using guided notes. The guided notes were constructed based on the teacher's lecture notes. Accuracy of notes and daily quiz scores were evaluated to determine if the use of guided notes assisted students in better grade performance. The researchers concluded that the use of guided notes “increased the likelihood of participants having complete and accurate notes” and “can aid the classroom teacher in developing structured lectures” (p.138).

Outlining has benefits if it is used appropriately. An outline assists students in organizing text from an unorganized presentation of material. Students must have well developed process skills in order to synthesize and establish logical relationships between information given. Katayama and Robinson (2000), Kim, Vaugh, Wanzek, and Wei

(2004), and Slater, Graves, and Piché (1984) found that outlining does aid in encoding and reading comprehension.

Teacher Collaboration

In this section, teacher collaboration is defined. Benefits are discussed based on the research of Blase and Blase (2004). Adult learning is an important component in considering collaboration.

Collaboration is defined as “to work together, especially in a joint intellectual effort” (Soukhanov, 1984, p.280). Teacher collaboration is important in the process of instruction. With demands placed on teachers, it is imperative they work together.

Blase and Blase (2004) conducted a study on teacher collaboration. In their study, they concluded that peer collaboration is beneficial to teaching if the following behaviors are followed.

1. Teachers should learn from each other.
2. Teachers should be models for each other.
3. Teachers should share their motivation and inspiration with each other.
4. Teachers should help each other learn how to deal with students.
5. Teachers should consider reflections, discussion, debate with other teachers, and support from them invaluable.
6. Teachers should learn about cognition and learning from each other. (p.186)

With these behaviors in place, teachers can become reflective practitioners. This process enhances collaboration; however, one must consider teachers as adults.

Staff development is important when considering teachers as adult learners.

According to Brookfield (1988), six principles exist for applying adult learning. The first principle is adults choosing to learn and wanting to gain knowledge. The second is

maintaining respect for individuals. Adults have their own uniqueness and individual characteristics. Once this is recognized, individuals will offer collaborative efforts. As the learning process continues, adults will have to become their own reflective practitioner and individually analyze their efforts. When confidence is gained, teachers can autonomously pursue other avenues.

Adult learning is a valuable component in considering collaboration. Knowles, Holton, and Swanson (1998) established six key principles of adult learning. These are:

1. The learner's need to know – the why, what, how;
2. Self-concept of the learner – autonomous, self-directing;
3. Prior experience of the learner – resource, mental models;
4. Readiness to learn – life related, developmental task;
5. Orientation to learning – problem centered, contextual; and
6. Motivation to learn – intrinsic value, personal payoff (p.4)

A leader must have knowledge of these key aspects of adult learning and the dynamics, which can have an influence on collaboration. The benefits of student learning increase when the previous information is known. Senge, Cambron-McCabe, Lucas, Smith, Dutton, and Kleiner (2000) and Fullan (2001) state collaboration promotes teachers to encourage each other, identify problems, unify, problem solve, support each other, and foster a collaborative community.

Teacher collaboration is important to this study. In order to have the number of participants in this study, two teachers were involved in the process of presenting cellular biology information. Presentation of information to a fellow teacher was enhanced by knowing benefits of teacher collaboration and how adults learn. This assisted the process of the study.

Summary

This chapter contained information pertinent to the study. There were five main sections. These were adolescent development, memory, instruction, instructional methodologies, and teacher collaboration. Physical development, cognitive development, and social development were important in understanding early adolescent development because this was the age group involved in this study. Memory was discussed and was broken into sections based on memory storage and types of memory. Furthermore, memory was expanded into how an individual can utilize memory for recall, which is necessary for creation of graphic organizers. Instruction was presented with theories, which assisted teachers in setting guidelines for acquiring knowledge or skill through effective instruction. Instructional methodologies were presented in various forms; however, for this study, graphic organizers was discussed, particularly mind mapping and outlining. Finally, teacher collaboration was presented with definition and benefits from collaborating with other teachers.

Understanding adolescent behavior is pertinent to this study because it is the age group being studied with mind mapping and outlining. Memory played a part in composing mind mapping or outlining because these adolescents use different types of memory and ways of storing information. The process early adolescent individuals stored memories is dependent on how they recall information to compose their mind mapping exercise, outlining exercise, or creating notes on cellular biology. Furthermore, teachers' organization of instruction, which involved verbal presentation, sequential preparation, and creation of objectives, pertaining to cellular biology had to be composed in alignment with Piaget's stage of cognitive development for early adolescent students. Additionally,

teacher collaboration was necessary because two teachers were involved in the study.

This provides a framework for two teachers, with each working together and understanding how an adult learns, to collaborate and become reflective practitioners in delivery of cellular biology. Each component was important to this study.

CHAPTER III

METHODOLOGY

Introduction

An effective teacher can deliver instruction with assistance from various instructional tools. Graphic organizers exist for teacher utilization. However, some teachers never dissect their techniques to learn which are more effective.

The researcher was interested in testing the effects of mind mapping and outlining for learning seventh-grade Life Science. In this quantitative study, the researcher relied on a posttest control experimental design to assist in answering questions concerning significant results between the three groups. Data was gathered from early adolescent individuals. The data was analyzed for statistical significance. Thus, results have allowed the researcher to make appropriate conclusions and implications.

Population and Samples

Participants were 271 seventh-grade students between ages 11 and 14 who were enrolled in a Life Science course. Due to attrition, the sample size decreased to 183 individuals. All students attended a junior high school in a New Mexico school district. These individuals arrived at junior high from six different elementary schools. The ethnic population of the 183 participants was 54.6% Hispanic, 42.1% Caucasian, 2.2% African American, and 1.1% Asian. The sample included 94 females and 89 males.

Research Design

For this study, a posttest-only control-group experimental design was used. Students in classes were randomly assigned to one of three groups – mind mapping, outlining, and control. Random assignment was utilized for “assuring initial equivalence between different treatment groups” (Gall, Borg, & Gall, 1996, p.487).

All groups received the same instruction on cell structures and their functions. Each group obtained a picture of diagrams of three different types of cells: animal, plant, and bacteria. The main difference between groups was the instructional strategy implemented for each group.

Due to early adolescent development, participants were tested twice during the cell unit. After six days of instruction, the first cellular biology test for lesson one occurred. Then, instruction continued for the next seven days. After the seventh day of instruction, a second cellular biology test for lesson two was given. Following the second test, students received an attitude survey for the instructional strategy they participated. A third test, a one-week delayed comprehensive posttest, was given to students to examine retention and application of cellular biology information.

Procedures for Treatment Groups

All Participants

Permission was received from the Texas Tech University Institutional Review Board to conduct this study. (Refer to Appendix J.) All participants received a letter requesting parent permission and student assent for participation in this study. (Refer to Appendix H.) Permission was obtained and participants in each class were randomly

assigned to one of three groups – mind mapping, outlining, and control. If permission was not granted, a student was still randomly assigned to one of three groups, but data for the participant was eliminated.

Common Procedures

Every participant received training on the outlining and mind-mapping strategies. Each group had the same design of the cell block for labeling and recording each structure and function of each type of cell. A cell block was a card stock sheet of paper, which consisted of two 8.5 inches by 14 inches, and had pictures of an animal cell, plant cell, bacterial cell, and a microscope. Two pictures were on each card stock sheet. Students folded the card stock in half with pictures facing outside. Each open corner of the two sheets was taped. Once taped, the item was unfolded so it could stand like a cube (Zike, 2001).

Each student had a cell block for recording notes. As the teacher instructed, information was given on a particular cell structure. (Refer to Appendix F.) For example, when the teacher delivered information on the cell membrane, students colored the structure on the animal cell and labeled the structure – cell membrane. As the teacher discussed the function of the cell membrane, students wrote details of the cell membrane on the cell block underneath the labeled cell membrane structure. In order to keep information accurate, students color coded the cell structure and function. For example, if the student colored the cell membrane structure red, the written notes and labeled structure were colored red.

Each group received fifteen days of instruction. The teachers began the day by reviewing previously discussed information with students. After the review, the teachers initiated the lesson. During the last fifteen minutes of the class period, the teachers questioned students about the lesson and allowed them an opportunity to utilize their assigned strategy. At the end of each class period, teachers collected cell blocks to prevent the common excuse: “I forgot it in my locker; may I go get it?” Additionally, each participant had to attend at least 70% (10.5 days) of 15 instructional days. If participation was less than 70%, the individual was eliminated from the study.

Differences among Groups

During the last fifteen minutes of class, the teacher asked questions and allowed students to practice their strategy. (Refer to Appendix F.) In the first three days of the study, teachers modeled the strategy to assist students. Members of the mind-mapping group answered questions and created mind-mapping notes simultaneously. Members of the outlining group answered questions while concurrently outlining. The control group answered questions repeatedly and did not have a strategy. For example, the teacher asked questions prepared for the unit. (Refer to Appendix F.) While the teacher asked questions daily, students were mind mapping the content presented during the last fifteen minutes of the class period. The same process occurred for the outlining group. The control group continually answered questions during the last fifteen minutes without using mind mapping or outlining techniques.

Instrumentation

The *New Mexico Science Content Standards, Benchmarks, and Performance Standards* (New Mexico State Public Department of Education, 2003) were utilized to guide the cell unit. (Refer to Appendix B.) Objectives were formulated based on the cell information included in these content standards. (Refer to Appendix D.) Additionally, the school district had a scope and sequence to be followed when teaching a unit. (Refer to Appendix C.) Once these were examined, a test was sought and the Glencoe McGraw-Hill Company granted permission to use questions from the *Glencoe Life Science Computer Test Bank Manual*. (Refer to Appendix G.)

Two high school biology teachers reviewed each question on the test. They examined the questions for correlation to the objective, scope and sequence, and state's standards and benchmarks. Additionally, reviewers checked the validity of each question.

Considering participants are in the early adolescent developmental stage (ages 11 to 14), the unit test formulated from the *Glencoe Life Science Computer Test Bank Manual* was divided into two sections – lesson one, test one and lesson two, test two. The first part of the test, lesson one test one, consisted of thirty-five questions and was given on the seventh day of instruction. The second part of the test, lesson two test two, consisted of thirty-nine questions and was given on the fourteenth day of instruction. For recording data, the two parts were combined to create the unit test. The unit test reliability calculated using Cronbach's alpha was .91. The researcher took into consideration the attention span of students in this age group and time constraints of class periods. As a result, the researcher decided to administer the unit test in two parts.

On day fifteen, students received a survey to evaluate their attitude toward the instructional strategy utilized. The survey consisted of eight questions and each group received individualized surveys, which were tailored to groups' strategy utilized. The survey reliability calculated using Cronbach's alpha was .75. Surveys for each group are included in Appendix H. One week later, students received a follow-up test (one-week delayed comprehensive posttest), consisting of thirty-four questions composed from *Glencoe Life Science Computer Test Bank Manual* and key concepts learned from the cellular biology unit. The posttest reliability calculated using Cronbach's alpha was .87.

Data Collection Procedures

Standardized test scores were obtained from students' records to assure groups did not have a significant difference prior to experimentation. Once these standardized test scores were gathered, the researcher coded the information to ensure anonymity of participants. Confidentiality was maintained and only the researcher had access to records. Once the Glencoe Life Science Test was administered, scores were gathered and recorded under the same identification.

Procedures were implemented during this study. Due to the teachers' class schedules, each teacher had a specific group during particular class periods. Teacher bias was reduced by random assignment of intact classes and allowed teachers to alternate classrooms. Each teacher rotated to different groups assigned during the designated class period every other day. Class period assignments are included in Appendix A. For example, teacher A instructed in the downstairs classroom while teacher B taught in the upstairs classroom on the first day of experimentation. The next day,

teacher A moved upstairs and teacher B rotated downstairs. Each teacher had six class periods a day lasting 50 minutes, except on Wednesdays. On Wednesdays, the class periods were 40 minutes in length to allow for an in-service hour.

The time of day can be an influential factor on early adolescence and their performance. As a result, specific groups were assigned twice each morning and twice each afternoon to allow for time of day differences. For example, two mind-mapping groups were scheduled in the morning and two mind-mapping groups in the afternoon. Control and outlining groups received identical scheduling.

Tests given to participants contained short answer questions. Upon completion of each test, evaluators scored short answer responses. The evaluators were individuals who taught high school biology. Each evaluator received training in scoring example short answer questions as correct or incorrect for reliability. All training occurred prior to grading.

The teacher participants can influence results of the study. As a result, teachers were trained in methods and implemented the lesson to groups in a consistent manner. To eliminate teacher influence, the researcher designed uniform lessons and statements presented to each group. This information can be viewed in Appendix F.

Analysis of Data

Each individual's data was entered and coded into the SPSS program. The code consisted of numbers assigned to each participant in the study. Once this was formulated, a test of statistical significance was executed.

All statistical tests were conducted with alpha at .05. A test of statistical significance was executed in order to accept or reject the hypothesis (Gall et al., 1996). For this experimental study, a one-way analysis of variance (ANOVA) statistical analysis and multivariate analysis of variance (MANOVA) were utilized to interpret data and evaluate statistical significance between groups.

Summary

During this quantitative study, the researcher was sought to determine the effects of mind mapping and outlining for learning cellular biology in a seventh-grade Life Science course. Three groups of early adolescent individuals were formulated for comparison. A statistical analysis was executed to calculate significant differences among groups regarding unit test scores, one-week delayed unit test scores, and student attitudes.

CHAPTER IV

RESULTS

Research Questions

The purpose of this study was to examine mind mapping and outlining as tools for learning seventh-grade Life Science. As a way of comparing instructional strategies, three groups were formed: a mind-mapping group, an outlining group, and a control group. The researcher formulated questions for each group.

Question 1:

What are the relative effects of mind mapping, outlining, and a control condition on the unit test scores of seventh-grade students studying cellular biology?

Question 2:

What are the relative effects of mind mapping, outlining, and a control condition on one-week delayed comprehensive posttest scores of seventh-grade students studying cellular biology?

Question 3:

What are the relative effects of mind mapping, outlining, and a control condition regarding student attitudes toward the corresponding instructional strategy of seventh-grade students studying cellular biology?

Hypotheses and Results of Data Analysis

Analysis was conducted with SPSS (Version 11.5). All statistical tests were performed with $\alpha = .05$. A Levene's *F* test was executed and displayed support for

the assumption of homogeneity of variance for unit test scores, $F(2,180) = 1.32, p = .27$ and one-week delayed comprehensive posttest scores $F(2, 180) = 1.34, p = .26$. (Refer to Table 4.1.) A one-way analysis of variance (ANOVA) was used to analyze and compare means of each group for significant differences (Hinkle, Wiersma, & Jurs, 2003) for unit test scores and one-week delayed comprehensive posttest scores. A multivariate analysis of variance (MANOVA) was used for attitude scores. Each question and hypotheses were discussed individually.

Table 4.1: Levene's F Test Results for Unit Test Scores and One-Week Delayed Comprehensive Posttest Scores

Source	Levene's Statistic	$df1$	$df2$	p
Unit Test	1.317	2	180	.270
One-Week Delayed Comprehensive Posttest	1.342	2	180	.264

The following hypothesis was formulated along with Question 1: What are the relative effects of mind mapping, outlining, and a control condition on the unit test scores of seventh-grade students studying cellular biology?

Hypothesis 1: Students in the mind-mapping group will perform significantly higher on the unit test than those in the outlining group, and students in the outlining group will

perform significantly higher than those in the control group.

The researcher formulated Hypothesis 1 to state students in the mind-mapping group would perform significantly higher on the unit test than those in the outlining group, and students in the outlining group would perform significantly higher than those in the control group. Means and standard deviations for each group can be viewed in Table 4.2. The number of participants was 59 for the control group, 63 for the outlining group, and 61 for the mind-mapping group. The control group ($M = 25.58$, $SD = 10.32$) and the mind-mapping group ($M = 25.16$, $SD = 12.21$) performed essentially the same on the unit test.

Table 4.2: Means and Standard Deviations for Control, Outlining, and Mind-Mapping Groups for Unit Test

Groups	<i>N</i>	<i>M</i>	<i>SD</i>
Control	59	25.58	10.32
Outlining	63	30.44	11.14
Mind Mapping	61	25.16	12.21
Total	183	27.11	11.46

A one-way analysis of variance (ANOVA) was conducted to evaluate differences between means of groups. The independent variable, instructional strategy, included three groups: control, outlining, and mind mapping. The dependent variable was the unit test. The ANOVA was significant, $F(2, 180) = 4.22$, $p < .05$. (Refer to Table 4.3.) The strength of the relationship, which was assessed by η^2 , between the strategy treatment and

the unit test was .04 (Green & Salkind, 2003). This indicated a small to medium strength of relationship. The strategies accounted for 4% of the variance of the unit test scores. Post-Hoc tests were conducted to evaluate pairwise differences among means. There was a significant difference in means of three groups – control, outlining, and mind mapping. Therefore, the null hypothesis was rejected. The probability that the observed differences in the strategy would have occurred by chance was less than .05. Since the null hypothesis was rejected, it was necessary to conduct a post-hoc multiple comparison analysis in order to determine which pair or combinations of means differed. The 95% confidence intervals for the pairwise differences, as well as means and standard deviations for the three groups are reported in Table 4.4. A significant difference existed between the outlining and control group, and the outlining and mind-mapping group.

Table 4.3: ANOVA of Groups for Unit Test Scores

Source	SS	<i>df</i>	MS	F _(2, 180)	<i>p</i>
Between groups	1070.27	2	535.13	4.22	.02*
Within groups	22818.32	180	126.77		
Total	23888.59	182			

**p* < .05

The researcher formulated the following hypotheses along with Question 2: what are the relative effects of mind mapping, outlining, and a control condition on a one-week delayed comprehensive posttest scores of seventh-grade students studying cellular biology? The Levene’s statistic for this hypothesis was 1.34 and reported in Table 4.1.

Table 4.4: 95% Confidence Intervals of Pairwise Differences in Means of Groups with Unit Test Scores

Groups	<i>M</i>	<i>SD</i>	Control	<i>p</i>	Outline	<i>p</i>
Control	25.58	10.32				
Outlining	30.44	11.14	-9.69 to -.05*	(.05)		
Mind Mapping	25.16	12.21	-5.27 to 4.45	(.98)	-10.06 to -.50*	(.03)

Note: An asterisk indicates the 95% confidence interval does not contain zero; therefore, the difference in means is significant at the .05 level using Tukey HSD.

Hypothesis 2: Students in the mind-mapping group will perform significantly higher on the one-week delayed comprehensive posttest than those in the outlining group, and students in the outlining group will perform significantly higher than those in the control group.

The researcher generated Hypothesis 2 as students in the mind-mapping group would perform significantly higher on the one-week delayed comprehensive posttest than those in the outlining group, and students in the outlining group would perform significantly higher than those in the control group. The number of participants for the one-week delayed comprehensive posttest was 61 for mind mapping, 63 for outlining, and 59 for the control group. The mind-mapping group ($M = 12.08$, $SD = 6.45$) and control group ($M = 11.53$, $SD = 6.22$) performed essentially the same on the one-week delayed comprehensive posttest. Information is reported in Table 4.5.

An ANOVA was conducted to evaluate differences between means of groups in the one-week delayed comprehensive posttest given to the three groups. The independent

Table 4.5: Means and Standard Deviations of Control, Outlining and Mind-Mapping Groups for One-Week Delayed Comprehensive Posttest

Groups	<i>N</i>	<i>M</i>	<i>SD</i>
Control	59	11.53	6.22
Outlining	63	14.32	7.14
Mind Mapping	61	12.08	6.45
Total	183	12.67	6.70

variable was the strategy implemented in the three groups: control, outlining, and mind mapping. The dependent variable was the one-week delayed comprehensive posttest. The ANOVA was not significant, $F(2, 180) = 3.07, p = .05$. (Refer to Table 4.6.) However, the level of significance on the delayed comprehensive posttest was .049 and almost significant at the $p = .05$ level. There was not a significant difference in the one-week delayed comprehensive posttest between means of groups. Therefore, the null hypothesis was retained.

The researcher formulated the following hypothesis along with Question 3: what are the relative effects of mind mapping, outlining, and a control condition regarding student attitudes toward the corresponding instructional strategy of seventh-grade students studying cellular biology?

Hypothesis 3: Students in the mind-mapping group will have significantly higher attitude scores than those in the outlining group, and students in the outlining group will have significantly higher scores than those in the control group.

Table 4.6: ANOVA of One-Week Delayed Comprehensive Posttest

Source	SS	<i>df</i>	MS	$F_{(2, 180)}$	<i>p</i>
Between Groups	269.38	2	134.69	3.07	.05*
Within Groups	7904.95	180	43.92		
Total	8174.33	182			

$p = .05$

A MANOVA was performed on the survey given to evaluate attitude toward the strategy utilized. The Box's Test was executed and was reported $F(72, 89797) = 1.11, p = .250$. Information is reported in Table 4.7.

Table 4.8 displays the eight-item attitude questionnaire administered immediately after participants completed the lesson two test of the study. Each group received individualized surveys, which were tailored to groups' strategy utilized. Each group's tailored questions are indicated within parentheses on Table 4.8. Responses were recorded on a five-point Likert-type scale with scores ranging from 1 (Strongly Agree) to 5 (Strongly Disagree).

Table 4.7: Box's Test for MANOVA of Attitude Survey Questions

Source	Box's Test	<i>df1</i>	<i>df2</i>	<i>p</i>
Survey	1.11	72	89797	.25

Mean responses are reported for each survey question. In general, participants liked the strategy ($M = 2.32$) implemented for their group. Furthermore, participants indicated that using their particular strategy assisted them in organizing information ($M = 1.93$). Also, according to the participants, the use of the strategy aided in understanding the cell structures and functions ($M = 2.01$). Participants were indifferent to finding the particular strategy they used to be difficult ($M = 2.70$). Students were indifferent to using another strategy ($M = 3.32$) and the amount of time spent studying the cell structure and function notes ($M = 2.37$).

The MANOVA included all eight items as dependent variables and groups as independent variable. Using Roy's Largest Root, the test revealed multivariate significance on the strategy utilized by groups, $F(8, 174) = 2.04, p < .05$. The multivariate η^2 was .09, which indicates 9% of the multivariate variance of the survey responses was associated with the group factor. Examination of univariate results displayed a significant difference in two survey questions – two and seven. Participants in the mind-mapping group ($M = 2.02$) indicated significantly more agreement than the outlining group ($M = 2.41$) with the statement “I enjoyed creating an (outline, mind map, writing information) for the cell block,” $F(2, 180) = 3.32, p < .05$. For the statement, “I was given enough time to (create the mind map, study the cell block),” the mind-mapping group ($M = 2.21$) indicated significantly more agreement than the control group ($M = 2.76$), who was indifferent to this statement, $F(2, 180) = 3.51, p < .05$.

Ancillary Data

Basic and Application Test Questions

The researcher was curious if groups differed in response to the basic and application test questions assembled for each test – unit test and one-week delayed comprehensive posttest. The test questions were combined into the appropriate category, basic or application, for evaluation. Basic questions were identified by the *Glencoe Computer Test Bank Manual* as “. . . those on the knowledge and comprehension levels of Bloom’s taxonomy” (p. v). Basic questions were composed to “ask students to define or recognize specific facts relating to whom, what, or when” (p. v). Application questions were formulated on the higher end of Bloom’s taxonomy and composed to evaluate students’ ability to apply, analyze, synthesize, evaluate, predict, solve and decide. Each question was gathered from *Glencoe Computer Test Bank Manual* and grouped into categories as a basic or application question on unit test and one-week delayed comprehensive posttest. The number of basic questions on the unit test was 51 items and the number of application questions on the unit test was 23. The one-week delayed comprehensive posttest consisted of 29 basic questions and five application questions.

An ANOVA was performed for unit test basic questions, unit test application questions, one-week delayed comprehensive posttest basic questions, and one-week delayed comprehensive posttest application questions. Means and standard deviations are reported on Table 4.9. Levene’s *F* test was conducted and displayed support for homogeneity of variance for each group. A one-way ANOVA was executed for the basic and the application questions on the unit test, which can be viewed in Tables 4.9 to 4.15.

Table 4.8: Participants' Attitude Mean Scores in Response to Attitude Survey Items

#	Item	Totals			
		All	Control	Outlining	Mind Mapping
1.	I liked (outlining, mind mapping, taking notes).	2.32	2.44	2.41	2.10
2.*	I enjoyed creating (outlining, mind mapping, writing) for the cell block.	2.27	2.39	2.41	2.02
3.	Using a(n) (outlining, mind mapping, cell block) helped me organize information.	1.93	1.92	1.98	1.90
4.	(Outlining, mind mapping, writing notes) helped me understand the structures and functions of the cell.	2.01	2.00	2.05	1.97
5.	I found (outlining, mind mapping, writing notes on the cell block) to be difficult.	2.70	2.68	2.89	2.52
6.	Another strategy should have been used for me to understand the structures and functions of the cell.	3.32	3.08	3.48	3.38
7.*	I was given enough time to (create outline, create mind map, study the cell block).	2.48	2.76	2.48	2.21
8.	I put a lot of effort into studying my (outline, mind map, cell block) notes for understanding the information on the structures and functions of the cell.	2.37	2.56	2.35	2.20

Note: Items were measured on a five-point scale from 1 to 5 (Strongly Agree to Strongly Disagree).

* $p < .05$

A significant difference existed in unit test basic questions, $F(2, 180) = 4.04, p < .05$.

(Refer to Table 4.10.) The null hypothesis was rejected and group means were different in unit test basic questions. Significant differences did not exist between groups in unit test application questions. (Refer to Table 4.11.)

In addition, a significant difference existed in one-week delayed comprehensive posttest basic questions, $F(2, 180) = 3.15, p = .05$. (Refer to Table 4.12.) Due to the significant results, the null hypothesis was rejected and group means were different on the one-week delayed comprehensive posttest basic questions. However, significant differences did not exist between means of groups on the one-week delayed comprehensive posttest application questions. (Refer to Table 4.13.)

A post-hoc test was analyzed to decipher which groups were different in unit test basic questions and one-week delayed comprehensive posttest basic questions. There was a significant difference between the mean scores of the mind-mapping and the outlining groups in the unit test basic questions. Therefore, the null hypothesis was rejected. The probability that the observed differences would have occurred by chance was less than .05. The outlining group performed significantly better on the unit test basic questions than the mind-mapping group. The strength of the relationship between groups and unit test basic questions, which was assessed by η^2 (.04), was small to medium. The groups accounted for 4% of the variance of responses to unit test basic questions. The 95% confidence intervals for the pairwise differences, as well as the means and standard deviations, are reported in Table 4.14. A significant difference existed between the mean scores of the outlining and control groups in answering the one-week delayed comprehensive posttest basic questions. Therefore, the null hypothesis was rejected. The

Table 4.9: Means and Standard Deviations of Types of Questions for Each Group

Questions	Groups					
	Control (<i>N</i> = 59)		Outlining (<i>N</i> = 63)		Mind Mapping (<i>N</i> = 61)	
	<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>
Unit Test Basic	20.51	8.08	24.21	8.72	20.20	9.35
Unit Test Application	5.00	2.84	6.08	3.02	4.89	3.30
One-Week Delayed Comprehensive Posttest Basic	10.07	5.28	12.57	6.23	10.72	5.64
One-Week Delayed Comprehensive Posttest Application	1.46	1.22	1.75	1.33	1.36	1.17

Table 4.10: ANOVA for Unit Test for Basic Questions

Source	SS	<i>df</i>	MS	$F_{(2,180)}$	<i>p</i>
Between Groups	617.28	2	308.64	4.04	.02*
Within Groups	13740.70	180	76.34		
Total	14357.98	182			

**p* < .05

Table 4.11: ANOVA for Unit Test for Application Questions

Source	SS	<i>df</i>	MS	$F_{(2,180)}$	<i>p</i>
Between Groups	53.87	2	26.93	2.88	.06
Within Groups	1682.80	180	9.35		
Total	1736.67	182			

$p > .05$

Table 4.12: ANOVA for One-Week Delayed Comprehensive Posttest Basic Questions

Source	SS	<i>df</i>	MS	$F_{(2,180)}$	<i>p</i>
Between Groups	207.60	2	103.80	3.15	.05*
Within Groups	5927.42	180	32.93		
Total	6135.02	182			

* $p = .05$

Table 4.13: ANOVA for One-Week Delayed Comprehensive Posttest Application Questions

Source	SS	<i>df</i>	MS	$F_{(2,180)}$	<i>p</i>
Between Groups	4.99	2	2.50	1.61	.20
Within Groups	278.65	180	1.55		
Total	283.64	182			

$p > .05$

Table 4.14: 95% Confidence Intervals of Pairwise Differences in Mean Changes in Groups for Unit Test Basic Questions

Groups	<i>M</i>	<i>SD</i>	Control	<i>p</i>	Outlining	<i>p</i>
Control	20.51	8.08				
Outlining	24.21	8.72	-7.44 to .04	(.05)		
Mind Mapping	20.20	9.35	-3.46 to 4.08	(.98)	-7.72 to -.30*	(.03)

Note: An asterisk indicates that the 95% confidence interval does not contain zero; therefore, the difference in means is significant at the .05 level using Tukey HSD.

probability that the observed differences in the one-week delayed comprehensive posttest basic questions occurred by chance was less than .05. The outlining group performed significantly better than the control group. The strength of the relationship between groups and one-week delayed comprehensive posttest basic questions, which was assessed by η^2 (.03), was small. The groups accounted for 3% of the variance of responses to one-week delayed comprehensive posttest basic questions. The 95% confidence intervals for the pairwise differences, as well as the means and standard deviations, are reported on Table 4.15.

Table 4.15: 95% Confidence Intervals of Pairwise Differences in Mean Changes in Groups for One-Week Delayed Comprehensive Posttest Basic Questions

Groups	<i>M</i>	<i>SD</i>	Control	<i>p</i>	Outlining	<i>p</i>
Control	10.07	5.28				
Outlining	12.57	6.23	.05 to 4.96*	(.05)		
Mind Mapping	10.72	5.64	-.59 to 4.29	(.81)	-1.82 to 3.13	(.17)

Note: An asterisk indicates that the 95% confidence interval does not contain zero; therefore, the difference in means is significant at the .05 level using Tukey HSD.

Summary of Results

Three questions were composed for this study. An ANOVA was performed for the unit test and one-week delayed comprehensive posttest. A significant difference existed in the mean scores of students who used the outlining strategy to answer unit test questions on cellular biology when compared to the control and mind-mapping groups. In evaluating the one-week delayed comprehensive posttest results on cellular biology, a significant difference did not exist between groups. Attitudes toward the strategy being implemented differed between means of the groups for survey questions two and seven. The mind-mapping group indicated significantly more agreement on enjoyment of their strategy when composing notes on the cell block for cellular biology. Ancillary data was compiled for basic and application questions on the unit test and one-week delayed comprehensive posttest. In unit test basic questions, the outlining group performed significantly better than the mind-mapping group. In the one-week delayed comprehensive posttest, the outlining group performed significantly better than the control group.

CHAPTER V

DISCUSSION

Overview of Study

Teachers continually refine and apply their skills to assist students with learning. With the “No Child Left Behind Act”, teaching has become an even more demanding practice. Effective teachers use various strategies to enhance student success. With adolescent development, many techniques should be implemented. Thus, mind mapping and outlining are strategies to use for instruction.

The purpose of this study was to examine mind mapping and outlining as tools for learning seventh-grade Life Science. After receiving permission for student participation, three groups were formed: a mind-mapping group, an outlining group, and a control group. Students were randomly assigned to one of the three groups. The researcher formulated questions and hypotheses for each group.

Question 1:

What are the relative effects of mind mapping, outlining, and a control condition on the unit test scores of seventh-grade students studying cellular biology?

Hypothesis 1: Students in the mind-mapping group will perform significantly higher on the unit test than those in the outlining group, and students in the outlining group will perform significantly higher than those in the control group.

Question 2:

What are the relative effects of mind mapping, outlining, and a control condition on one-week delayed comprehensive posttest scores of seventh-grade students studying cellular biology?

Hypothesis 2: Students in the mind-mapping group will perform significantly higher on the one-week delayed comprehensive posttest than those in the outlining group, and students in the outlining group will perform significantly higher than those in the control group.

Question 3:

What are the relative effects of mind mapping, outlining, and a control condition regarding student attitudes toward the corresponding instructional strategy of seventh-grade students studying cellular biology?

Hypothesis 3: Students in the mind-mapping group will have significantly higher attitude scores than those in the outlining group, and students in the outlining group will have significantly higher scores than those in the control group.

Important differences did result between groups on the unit test scores. The outlining group significantly performed better than the mind-mapping group and control group. However, there was not a difference between the mind-mapping group and the control group. There was no difference in the one-week delayed comprehensive posttest scores between groups.

Attitudes toward the strategy used were significant. Attitudes toward the strategy being implemented differed between means of groups for survey questions two and seven. Participants in the mind-mapping group indicated significantly more agreement than the outlining group with the statement “I enjoyed creating an (outline, mind map, writing information) for the cell block.”

The mind-mapping group also indicated significantly more agreement than the control group, who were indifferent, to the statement “I was given enough time to (create the mind map, study the cell block).” A significant difference existed between the means of the mind-mapping group and the control group on this statement. However, no significant difference existed between the means of the mind-mapping group and the outlining group.

The researcher further analyzed test questions by dividing questions into basic questions and application questions for the unit test and the one-week delayed comprehensive posttest. A significant difference in means resulted between the outlining group and the mind-mapping group in unit test basic questions. Furthermore, a significant difference resulted between the outlining group and the control group in the one-week delayed comprehensive posttest basic questions.

Discussion of Findings

Achievement

Several possible explanations exist for the significant performance of the outlining group when compared with the other groups on the unit test. The outlining strategy was better for this age group than mind mapping or no strategy (control).

One possible reason is the exposure students have to the outlining format in textbooks and other sources while being in school. When students are reading or utilizing textbooks, they are frequently exposed to the outlining format. Thus, students begin to extrapolate information based on this format.

Another possible reason for the significant difference is the students' level of cognitive development. Woolfolk (2001) noted that individuals' cognitive development have differed depending on situational circumstances. Individuals may demonstrate certain characteristics of one stage of cognitive development in solving problems. Participants in this study relied on Piaget's concrete operations stage of cognitive development in learning cell structures and functions. Students in the outlining group were able to extract and logically classify cell structures and functions in an organized manner (Irvin, 1990; Weiler, 2002). However, participants in the mind-mapping group were not able to abstractly create a drawing to coincide with cell structures and functions, which is a characteristic of Piaget's formal operations stage of cognitive development (Sigelman, 1999; Woolfolk, 2001). Furthermore, a lack of cognitive readiness could have resulted in the lower mean test scores for students in the mind-mapping group when compared to students' mean scores in the outlining group.

Cognitive readiness, a third reason, could have influenced results of this study. Ausubel (1969) stated that individuals must be cognitively ready, which is dependent on prior knowledge and cognitive maturity. Based on students' prior knowledge, the outlining group could use previous exposure to outlining and extract information presented. Thus, the information became meaningful (Ausubel, 1969; Novak, 1981) and students were able to learn in the outlining format. In contrast, the mind-mapping group

did not have previous knowledge of mind mapping and had difficulty in creating meaning for learning. The training time may not have been long enough for the mind-mapping group, but may have been adequate training time for the outlining group. Because teachers organized instruction in an outline format, this may have influenced test results.

Finally, instructional delivery could have been an influential factor. Effective teachers plan and sequence their instruction to assist learning. In effective delivery, teachers may organize information in outline form so students can actively extract and synthesize information to organize notes (Gagné & Dick, 1983; Marzano, Pickering, & Pollock, 2001; Petry, Mouton, & Reigeluth, 1987). Having well-designed lessons and supplemental materials assist students with outlining. Thus, significant results occurred.

Various factors may have influenced test scores. Students' prior knowledge of outlining format allowed them to more easily utilize and organize information. Students' level of cognitive development and cognitive readiness may have influenced how well they were able to utilize instructional strategies. Finally, the sequencing and planning of instruction by the researchers in an outline format allowed students to extract and synthesis information in an organized manner. This planning may be partially responsible for the higher unit test scores and one-week delayed comprehensive posttest scores received by students in the outlining group.

Attitudes

Attitudes toward the strategy used were significant and the means differed between groups for survey questions two and seven. Participants in the mind-mapping group indicated significantly more agreement than the outlining group with the statement

“I enjoyed creating an (outline, mind map, writing information) for the cell block.” The mind-mapping group indicated significantly more agreement than the control group, who were indifferent, to the statement “I was given enough time to (create the mind map, study the cell block).”

Two significant differences resulted in the attitude survey. First, the mind-mapping group indicated significantly more agreement in enjoying the creation of mind-mapping notes for the cell block. This finding is consistent with Goodnough and Woods (2002), who found in their study that fifth and sixth graders enjoyed the mind-mapping strategy. This difference may indicate that students prefer to learn various instructional strategies for organizing notes. Second, the mind-mapping group indicated significantly more agreement to having enough time to create the mind-mapping notes. Williams (1999) indicated that time was a factor in individuals becoming comfortable with use of mind mapping. Results indicated that students were comfortable with the mind-mapping strategy.

Basic Questions

The researcher further analyzed test questions by dividing questions into basic questions and application questions for the unit test and the one-week delayed comprehensive posttest. A significant difference in means resulted between the outlining group and the mind-mapping group in unit test basic questions. Furthermore, a significant difference resulted between the outlining group and the control group in the one-week delayed comprehensive posttest basic questions.

Few reasons exist for the outlining group performing significantly better on the basic questions for both the unit test and one-week delayed comprehensive posttest. One reason is that both advanced organizers and graphic organizers allow the user to formulate and associate ideas to prior knowledge so the learner can encode information for better recall and comprehension (Alvermann, 1981; Ausubel, 1969; Horton, Lovitt, & Bergerud, 1990; Katayama & Crooks, 2003; Kim, Vaughn, Wanzek, & Wei, 2004; Moore & Readence, 1984; Ritchie, & Gimenez, 1995/1996). Furthermore, the use of outlining allowed these individuals to hierarchically organize information and allowed students to view information in logical order (Moore & Readence, 1984; Weiler, 2002). By reorganizing information in a linear format, the learner was analyzing the content, which allowed for deeper processing, and enforced memory pathways (Alvermann, 1981).

A second possible reason for the difference in these scores is the repeated daily review of information for rehearsal and coding. In doing this process, members of the outlining group were able to learn the information through the process of rehearsal and coding (Seamon, 1980). Rehearsal came when students were daily reviewing the information, answering questions after the lesson, and constructing the outlining notes. Constant review allowed memory pathways to be reinforced (Alvermann, 1981; Markowitz & Jensen, 1999; Novak, 1980; Sousa, 2003). Once this was reinforced, the outlining group was able to chunk information, which assisted with meaningful learning (Markowitz & Jensen, 1999; Novak, 1980; Sousa, 2003). As a result, they could link their learning to prior knowledge and chunked information, which made learning easier for this group. Thus, significant results occurred.

Another possible reason is that the control and mind-mapping groups were not able to assess prior knowledge. Due to the lack of training in mind-mapping notes, members were unable to create meaningful learning. As a result, this strategy was viewed as insignificant.

Basic questions for the unit test and the one-week delayed comprehensive posttest revealed significant results. Advanced organizers and graphic organizers allowed individuals to formulate and associate ideas to prior knowledge for better recall and comprehension. Daily review of information enhanced rehearsal and coding. Thus, this allowed memory pathways to be reinforced, which allowed for learning.

Summary of Findings

Achievement, attitudes and basic questions were presented in this section. Several possible explanations existed for each category. Achievement was influenced by exposure to outlining format, students' level of cognitive development, students' cognitive readiness, and instructional planning and sequencing. Students' attitude toward mind mapping may indicate that students prefer to learn various instructional strategies for organizing notes. The outlining group performed significantly better on the basic questions due to reviewing daily, assessing prior knowledge, and creating meaningful learning.

Recommendations for Future Research

The researcher has many thoughts and ideas as topics for future research as work was concluded on this study. The following are recommendations for related research on mind mapping and outlining.

Considering Piaget's formal operations stage, some students in the study were functioning at this level. On the contrary, some students were functioning at Piaget's concrete operations stage. An idea for future research would be to determine the level of cognitive development of each student. Using Piaget's classifications, a researcher could divide students into two groups – concrete operations group and formal operations group. Within each group, then the researcher could divide students into three groups – mind mapping, outlining, and control. This would allow the researcher to evaluate any differences between groups and between developmental levels.

Although teachers modeled note taking for each strategy, seventh-grade students were not easily persuaded to manipulate their notes. Student confidence was lacking. As Goodnough and Woods (2002) suggest, an idea for future researchers is to construct partial notes and supplemental illustrations for each group – mind mapping, outlining and control - to encourage student confidence.

A third idea for future research is the length of training time and mastery of one skill before introducing another skill. A researcher needs to have training for students, which lasts longer than three or four days in how to construct mind maps. Students need more time to practice mind mapping and apply abstract drawings to words. Practice may assist in better comprehension of mind maps before learning content. The learning of

mind mapping and content knowledge related to cellular biology simultaneously was overwhelming for some students.

A fourth idea for future research is selection of science content. In studying cellular biology, students were required to abstractly formulate and process cellular functions within the cell structure. Students had to visualize cellular processes occurring and comprehend functions. For students in Piaget's formal operations stage, this process occurred easily. For students in Piaget's concrete operations stage, this process was difficult. Other content areas of the curriculum could be explored using mind mapping. Therefore, other topics need to be examined to determine if better matches between the strategy and content material or content area are possible.

A fifth idea to consider is age groups for future research. While studies have been conducted with fifth and sixth graders, medical students and college-age students, it will benefit research to conduct studies with high-school students. It seemed students in this study were beginning to make the transition into Piaget's formal operations stage of cognitive development. Perhaps, individuals in high school would be functioning at Piaget's formal operations stage of cognitive development and results may show differences in the strategy implemented.

A sixth idea for future research is to consider different types of assessment instruments. The test items used for this study involved more left-brain linear functions. A researcher may construct a test to evaluate content by using rubrics for key ideas and having a variety of types of questions for students to draw on their left-brain and right-brain functions.

A seventh idea for future research is further evaluation of attitude. For this study, attitude was measured immediately after the unit was presented. For future studies, it would be beneficial to measure students' attitude toward science at the end of students' seventh-grade year. This would measure students' attitude toward science with the use of different instructional strategies through the year.

An eighth idea for future research is the evaluation of long-term retention. An idea for future researchers is to allow for passing of a month or more so they can assess students' retention of content knowledge. This would allow the researcher to evaluate how students have used memory to store information by using the mind-mapping and outlining strategies.

A ninth idea for future research is to determine the effects of mind mapping and outlining on male and female students, students from other ethnic populations, and those from a different socio-economic status. An idea for future researchers would be to determine the effects of mind mapping and outlining with these populations. For example, it would be beneficial to design a study to see which gender performs better in the use of the mind-mapping and outlining strategies. Additionally, a study could be created to test the effects of outlining and mind mapping on different ethnic and socioeconomic populations.

Finally, another idea for future research is to study the value of immediate feedback. Immediate feedback was important for these students. An idea for future researchers would be to provide immediate feedback on test scores to students. This may verify to students the reality of the study and reinforce their understanding of it.

Conclusions

This study investigated ways of improving methods of learning using two types of graphic organizers. Mind mapping utilizes both sides of the brain and allows for processing of information. Outlining allows individuals to organize information in a linear, logical, and sequential manner using notes.

The outlining group significantly performed better than the mind-mapping group and control group on the unit test. Attitudes toward graphic organizers used were significant and differed between means of groups for two questions on the survey. Additionally, the outlining group performed significantly better on the basic questions on both the unit test and one-week delayed comprehensive posttest.

Additional research needs to be conducted regarding the effectiveness of mind-mapping and outlining strategies with students who are in high school. The use of mind mapping in different areas of the science curriculum as well as in other content areas also needs to be examined to determine if there are better matches between the strategy and content. Attitudes of students in higher grades regarding mind mapping is another area in which further research is suggested.

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APPENDICES

APPENDIX A

SCHEDULE FOR TEACHERS

Original Schedule

As listed below, each class period is listed by class period for each teacher with the instructional strategy.

	Teacher A:	Teacher B:
Class period	1 – mind map	1 – control
	2 - outline	2 – mind map
	3 – none	3 – none
	4 – control	4 – outline
	5 – mind map	5 – control
	6 – PLC*	6 – PLC*
	7 – outline	7 – outline
	8 – control	8 – mind map

In this chart, the daily lesson plan is listed in the left column. Teacher A will have class periods listed with the instructional strategy to implement. The same is for Teacher B. In day 2, Teacher A will be upstairs giving the instruction to the students upstairs and implementing the appropriate instructional strategy for the class period. The same will occur for Teacher B, only Teacher B will be downstairs during day 2. Each instructor will alternate each day for instruction.

Days and Lesson	Teacher A	Teacher B
1 – Cell parts, Eukaryote, Prokaryote, cell theory, cell membrane - diffusion	1- Mind map (down) 2- outline 3- none 4- control 5- mind map 6- PLC* 7- outline	1- control (up) 2- mind map 3- none 4- outline 5- control 6- PLC* 7- outline

	8- control	8- mind map
2 – Cell membrane – osmosis, examples	1- control (up) 2- mind map 3- none 4- outline 5- control 6- PLC* 7- outline 8- mind map	1- mind map (down) 2- outline 3- none 4- control 5- mind map 6- PLC* 7- outline 8- control
3 – Active transport, endocytosis, phagocytosis, pinocytosis, exocytosis	1- mind map (down) 2- outline 3- none 4- control 5- mind map 6- PLC* 7- outline 8- control	1- control (up) 2- mind map 3- none 4- outline 5- control 6- PLC* 7- outline 8- mind map
4 - nucleus, nuclear membrane, nucleolus	1- control (up) 2- mind map 3- none 4- outline 5- control 6- PLC* 7- outline 8- mind map	1- mind map (down) 2- outline 3- none 4- control 5- mind map 6- PLC* 7- outline 8- control
5 – chromatin, chromosomes	1- mind map (down) 2- outline 3- none 4- control 5- mind map 6- PLC* 7- outline 8- control	1- control (up) 2- mind map 3- none 4- outline 5- control 6- PLC* 7- outline 8- mind map
6 – DNA lab, review information with note taking strategy, review sheet?	1- control (up) 2- mind map 3- none 4- outline 5- control 6- PLC* 7- outline 8- mind map	1- mind map (down) 2- outline 3- none 4- control 5- mind map 6- PLC* 7- outline 8- control
7 – test – UNIT LESSON ONE	1- mind map (down) 2- outline 3- none 4- control	1- control (up) 2- mind map 3- none 4- outline

	5- mind map 6- PLC* 7- outline 8- control	5- control 6- PLC* 7- outline 8- mind map
8 – Cytoplasm, endoplasmic reticulum, ribosomes	1- control (up) 2- mind map 3- none 4- outline 5- control 6- PLC* 7- outline 8- mind map	1- mind map (down) 2- outline 3- none 4- control 5- mind map 6- PLC* 7- outline 8- control
9 – Golgi body, mitochondria – respiration	1- mind map (down) 2- outline 3- none 4- control 5- mind map 6- PLC* 7- outline 8- control	1- control (up) 2- mind map 3- none 4- outline 5- control 6- PLC* 7- outline 8- mind map
10 – Lysosome, cell wall, chloroplasts	1- control (up) 2- mind map 3- none 4- outline 5- control 6- PLC* 7- outline 8- mind map	1- mind map (down) 2- outline 3- none 4- control 5- mind map 6- PLC* 7- outline 8- control
11 – vacuole and bacterial cell	1- mind map (down) 2- outline 3- none 4- control 5- mind map 6- PLC* 7- outline 8- control	1- control (up) 2- mind map 3- none 4- outline 5- control 6- PLC* 7- outline 8- mind map
12 – cell differ and cell organization	1- control (up) 2- mind map 3- none 4- outline 5- control 6- PLC* 7- outline 8- mind map	1- mind map (down) 2- outline 3- none 4- control 5- mind map 6- PLC* 7- outline 8- control
13 – Review information	1- mind map (down)	1- control (up)

with strategy	2- outline 3- none 4- control 5- mind map 6- PLC* 7- outline 8- control	2- mind map 3- none 4- outline 5- control 6- PLC* 7- outline 8- mind map
14 – test – UNIT LESSON TWO	1- control (up) 2- mind map 3- none 4- outline 5- control 6- PLC* 7- outline 8- mind map	1- mind map (down) 2- outline 3- none 4- control 5- mind map 6- PLC* 7- outline 8- control
15 – survey	1- mind map (down) 2- outline 3- none 4- control 5- mind map 6- PLC* 7- outline 8- control	1- control (up) 2- mind map 3- none 4- outline 5- control 6- PLC* 7- outline 8- mind map

* PLC – Professional Learning Communities

APPENDIX B

NEW MEXICO SCIENCE CONTENT STANDARDS, BENCHMARKS, AND PERFORMANCE STANDARDS OF CELL UNIT LESSON PLAN

New Mexico Science Content Standards, Benchmarks, and Performance

Standards listed for seventh grade life science (New Mexico State Department of Education, 2003, p. ii-iv, 13-27):

Strand II: Content of Science

Standard II (Life Science): Understand the properties, structures, and processes of living things and the interdependence of living things and their environment.

Benchmark I (5-8): Explain the diverse structures and functions of living things and the complex relationships between living things and their environments.

Benchmark II (5-8): Understand how traits are passed from one generation to the next and how species evolve.

Benchmark III (5-8): Understand the structure of organisms and the function of cells in living systems.

Performance standards (7th grade):

a. Heredity

Know that hereditary information is contained in genes that are located in chromosomes, including:

1. determination of traits by genes
2. traits determined by one or many genes
3. more than one trait sometimes influenced by a single gene.

b. Structure of organisms

1. Understand that organisms are composed of cells and identify unicellular and multicellular organisms.
2. Explain how organs are composed of tissues of different types of cells (e.g., skin, bone, muscle, heart, intestines).

c. Function of cells

1. Understand that many basic functions of organisms are carried out in cells, including:
 - a. growth and division to produce more cells (mitosis)
 - b. specialized functions of cells (e.g., reproduction, nerve-signal transmission, digestion, excretion, movement, transport of oxygen).
2. Compare the structure and processes of plant cells and animal cells.

3. Describe how some cells respond to stimuli (e.g., light, heat, pressure, gravity).
4. Describe how factors (radiation, UV light, drugs) can damage cellular structure or function.

APPENDIX C

HOBBS MUNICIPAL SCHOOL DISTRICT'S SCOPE AND SEQUENCE OF CELL

UNIT LESSON PLAN

Requirements for school district, scope and sequence, is listed for the cell unit:

7.5 Identify and describe life processes.

A. Characteristics of living organisms

B. Role of the cell

1. parts of cell-structure

2. cell transport

3. cell reproduction

4. models of cells

5. models of DNA

6. cellular energy

a. photosynthesis

b. respiration

APPENDIX D

OBJECTIVES OF CELL UNIT LESSON PLAN

The objectives for the lesson plan were guided by *Glencoe Life Science book* Teacher wraparound edition (Biggs, Daniel, & Ortleb, 1999). Students performed the following:

- Diagram a plant cell and an animal cell with structures,
- Identify parts of the cell and the function of each part,
- Describe the importance of the nucleus in the cell,
- Explain differences among tissues, organs, and organ systems,
- Explain the function of a selectively permeable membrane,
- Describe processes of diffusion and osmosis as related to the cell membrane,
- Compare and contrast passive transport and active transport in relation to function of the cell membrane and nuclear membrane and give examples of each,
- Compare and contrast processes of photosynthesis and respiration in relation to chloroplasts and mitochondria,
- Describe mitosis and explain its importance in relation to the nuclear membrane, chromosomes, and other cell structures,
- Explain differences between mitosis in plant and animal cell structures and functions,
- Give examples of asexual reproduction in relations to chromosomes,
- Describe stages of meiosis and its end products in relation to the nuclear membrane, chromosomes, and other cell structures,
- Name parts of the cell involved in fertilization and explain how fertilization occurs in sexual reproduction,
- Construct and identify parts of a DNA molecule model (chromosomes), and
- Explain how traits are inherited (chromosomes).

List of cell parts given during the lesson were:

- Cell membrane
- Nucleus
- Nuclear membrane
- Nucleolus
- Chromatin
- Cytoplasm

- Endoplasmic reticulum
- Ribosome
- Golgi Body
- Mitochondria
- Lysosome
- Cell wall
- Chloroplasts
- Vacuole

APPENDIX E

RESEARCHERS' TRAINING OF OUTLINING AND MIND-MAPPING STRATEGIES TO STUDENTS

The following instructions constitute the training given to each student. The scientific method will be the example to utilize for both the outline and mind map strategies.

“Outline is used to organize ideas or facts in a logical order. It is a plan for writing, telling, or doing something. An outline includes only main ideas and important details” (Weiler, 2002, p.2). We use an outline for various reasons. We can use it to save us time and design our project to be organized easier and better. It allows us to group ideas and facts together. By classifying things together, we can “organize the information by topic, include all important information, leave out any information that does not fit, and plan the project in a logical way” (Weiler, 2002, p.2).

Title: Characteristics of Living Things

- I. Organization
 - A. Cells – smallest unit
 - B. Has 1 or many cells
- II. Reproduction
 - A. Produce new individuals
 - B. Examples
 - 1. Oak trees – acorns
 - 2. Canada geese – lay eggs
- III. Adjust to surroundings
 - A. Stimulus – organism responds to
 - B. Response – respond to stimuli
 - C. Adaptation – any characteristic that makes an organism better able to survive
 - 1. Inherited traits
 - D. Internal conditions

- 1. Homeostasis – regulation of internal environment
- IV. Growth and Development
 - A. Development
 - 1. Changes organisms undergo as develop
 - 2. Life span – length of time organism is expected to live
- V. Energy
 - A. Main source - Sun
 - B. Oxygen
 - C. Food
 - D. Water
 - E. Minerals

Teacher will give these commands to students for introducing the mind mapping exercise:

1. Close your eyes.
2. Think of your favorite food. Teacher will give about 5-8 seconds for student to process. Teacher will say “Good. Clear.”
3. Think of your favorite car. Teacher will give about 5-8 seconds for student to process. Teacher will say “Good. Clear.”
4. Think of your best friend. Teacher will give about 5-8 seconds for student to process. Teacher will say “Good. Clear.”
5. Teacher will ask these questions: What did you see? Did you see letters or did you see images/pictures? Where did these images appear – upper left of screen, upper right, lower left, lower right, or in center?
6. Teacher will explain that our brain used the right side of the brain to trigger an image to trigger our memory. Various colors, symbols, and pictures may assist an individual in recalling information. Teacher will continue to explain the left side of the brain learns in sequences, works with parts, better with language, acts as interpreter, it is not always logical, and it is concerned with facts. The right side of the brain learns randomly, works with wholes, better with pictures, space and color, it is not always creative, and is concerned with feelings.
(Jensen, 1992)

Features of mind mapping:

1. Blank sheet of paper – preferably 8.5 by 11 inch.
2. Start in center of paper with theme is in the middle of blank paper with some shape around it – square, circle, etc.

3. Add branches. (Each branch is a different color.) For example, you could use an arrow, a squiggly line, a twisted line, a spiral, or any other type of design.
4. Add details. This could be information from your reading, notes, discussion, or topic in class. (An example will be given such as a description/information of the individual.)
5. Personalize your mind map. Personalize by adding key features and tips of mind mapping:
 - Color
 - Symbols (hand-out – Margulies, 1991)
 - Pattern
 - Pictures
 - Different print size
 - Display relationships (i.e. – using arrows)
 - Few words as possible
6. Teacher will assign task to students of designing a mind map of self.
7. Teacher will initiate discussion of how mind maps can be used in every day life. Students will brainstorm various ways.
(Buzan, 2002; Jensen, 1992; Margulies, 1991; Wycoff, 1991)

An example of a mind map was constructed with “Characteristics of Living Things”, which was utilized for the outline strategy.

APPENDIX F

RESEARCHERS' LESSON FOR CELL UNIT

CELL PARTS to be given during the lesson are:

Prior knowledge: **Eukaryote** = cells have a nucleus with a membrane around it.

Example: animal and plant cells.

Prokaryote = cells have no membrane around their nucleus/nuclear material. Example: bacteria cell.

Cell theory -

1. Cells are made up of one or more cells.
2. Cells come from cells that already exist.
3. Cells are the basic unit of structure and function.

I. Cell membrane (structure)

a. Functions

1. forms the outer boundary of cell
2. allows certain materials to move in and out of cell
3. double layer of fats, proteins scattered throughout
4. maintain chemical balance between materials inside and outside the cell
5. food and O₂ move into the cell through the membrane
6. waste products leave the cell
7. selectively permeable

b. Transport

1. **Passive transport** – movement of particles across the cell membrane by diffusion

a. **diffusion** – (book – net movement of molecules from an area of where there are many to an area where there are few). Movement of molecules from an area of many to an area of few – simpler definition

b. **osmosis** – the diffusion of water through the cell membrane

c. Examples of diffusion and osmosis

1. net with holes and sand falling through it
2. solution of colored water
3. Celery stalk with colored water
4. Observing osmosis – p.77

2. **Active transport** – materials require energy to move through the cell membrane

3. **Endocytosis** – when substances are too large to pass through the cell membrane by active or passive transport, the cell membrane encloses the molecule/particle. By doing this, the sphere pinches off forcing the contents to go into the cytoplasm through this process.

- a. **Phagocytosis** – a type of endocytosis in which large particles move into the cell.
 - b. **Pinocytosis** – a type of endocytosis in which fluids move into a cell.
 - 4. **Exocytosis** – wastes moved out of the cell through the cell membrane.
 - a. package fuses with cell membrane and the contents are released from the cell

- II. **Nucleus** (structure)
 - a. **Functions**
 1. directs all activities of the cell
 2. separated by nuclear membrane
 3. contains DNA/genetic blueprints/chromosomes/chromatin
 4. largest organelle in cytoplasm

- III. **Nuclear membrane** (structure)
 - a. **Functions**
 1. a membrane around the nucleus
 2. allows materials to enter and leave through openings in the membrane around the nucleus

- IV. **Nucleolus** (structure)
 - a. **Functions**
 1. makes ribosomes
 2. makes proteins

- V. **Chromatin** (structure)
 - a. **Functions**
 1. a form of hereditary material
 2. made up of proteins, DNA = the chemical that controls the activities of the cell
 3. When cell begins to divide, the strands of chromatin thicken and take on the form of chromosomes, which are easier to see.

- VI. **Chromosomes**
 1. Contain DNA (a.k.a. – “spiral staircase”)
 2. DNA is the master copy of an organism’s information code. (Genetic material/genes/hereditary material/genetic blueprints for cell operation/nucleic acids)
 - a. contains 4 nitrogen bases – adenine, guanine, cytosine, thymine
 - b. initial adenine (A), guanine (G), cytosine (C), thymine (T)
 - c. equal amounts of adenine (A) to thymine(T), equal amounts of guanine (G) to cytosine (C)
 - d. sugar and phosphates – handrails
 - e. nitrogen bases – steps

Example – DNA model, DNA lab

3. during mitosis/meiosis, chromosomes double and code is passed on to the new cells
 - a. haploid number – one of every kind of chromosome (i.e. – sex cells – sperm and egg)
 - b. diploid number – two of every kind of chromosome (i.e. – body cells – skin cells, brain cells, liver cells, etc.)

VII. Cytoplasm

a. Functions

1. gel-like material
2. contains large amounts of water
3. contains many chemicals
4. contains many structures that carry out the life processes of the cell
 - a. structures inside the cytoplasm of eukaryotic cells are called **organelles**
5. moves constantly or streams constantly

VIII. Endoplasmic reticulum

a. Functions

1. folded membrane
2. moves materials around in the cell
3. extends from nucleus to cell membrane
4. works like a conveyor belt

IX. Ribosome

a. Functions

1. makes proteins for the cell
2. receives directions from hereditary material in nucleus on how and when to make specific proteins

b. Locations

1. scattered throughout the cytoplasm
2. attached to endoplasmic reticulum
3. made in nucleolus

X. Golgi Body

a. Functions

1. package and secrete proteins outside of the cell
2. stacks of membrane-covered sacs

XI. Mitochondria

a. Function

1. breaks down glucose molecules and energy is released
2. a.k.a. – power house

b. Respiration

1. breaks down glucose and uses oxygen
2. occurs in the mitochondria

c. Fermentation

1. a form of respiration that converts energy from glucose when oxygen is insufficient
2. O₂ levels are low; the muscle cells convert energy from glucose by fermentation
3. lactic acid is formed; lactic acid causes the muscles to burn and to be sore and stiff
4. occurs in mitochondria

d. Example

1. Lab – p.82?

XII. Lysosome

a. Function

1. contain chemicals that digest wastes and worn-out cell parts as well as break down food
2. membrane around the cell keeps the chemicals in the organelle
3. breaks down food molecules

XIII. Cell wall (Plant cell)

a. Function

1. a rigid structure outside the cell membrane
2. supports and protects the plant cell
3. ONLY FOUND IN PLANT CELL
4. made up of bundles of tough cellulose fibers and other materials made by the cell

XIV. Chloroplasts (Plant cell)

a. Function

1. organelles in which light energy is changed into chemical energy in the form of sugar
 - a. photosynthesis
 - b. sun's energy is used to split water into oxygen and hydrogen
 - c. light energy is used to combine these hydrogen atoms and carbon dioxide to form sugar
2. contains chemical – chlorophyll
 - a. chlorophyll traps light energy
 - b. green pigment

XV. Vacuole (Plant cell and animal cell)

a. Function

1. stores water, food, waste, and other products from the cell
2. animal cells – small
3. plant cells – big – takes up most of space

XVI. Bacterial cell

- a. prokaryotic
- b. no membrane covered organelles
- c. has cell wall

- d. cytoplasm
- e. single chromosome

XVII. Cells differ

- a. sizes
 - 1. nerve cell
 - 2. human egg cell
 - 3. human red blood cell
- b. shape
 - 1. describes function
- c. examples
 - 1. p.52

XVIII. Organization of cells and definition of each

- a. Cells
- b. Tissues
- c. Organs
- d. Systems
- e. Organisms

QUESTIONS FOR REVIEW AT BEGINNING OF CLASS PERIOD AND DURING THE LAST 15 MINUTES OF CLASS PERIOD GIVEN BY BOTH TEACHERS.

Today (Yesterday), we studied (cell structure(s) named)

Describe what (cell structure(s) named) looks like.

What were their functions? /Describe what they do.

What would happen if (cell structure(s) named) did not exist?

What would happen to the cell?

What would happen if the cell had more than one of (cell structure named)?

Which of these structure(s) discussed would be more important?

APPENDIX G

TESTS GIVEN TO PARTICIPANTS

UNIT TEST ONE – UNIT LESSON ONE

(TEST ONE – cell membrane, osmosis, diffusion, active transport, nucleus, nuclear membrane, nucleolus, chromatin, chromosomes, cell parts, eukaryote, prokaryote, and cell theory.)

MULTIPLE CHOICE – Please write the letter of the best answer in the blank space.

- ____ 1. Materials enter and leave the nucleus through the ___. (2.3) (B)
- a. organelles
 - b. DNA (III. Nuclear membrane)
 - c. Nuclear membrane*
 - d. Chromatin
- ____ 2. The chromosomes in the nucleus of a cell contain a code known as ___. (4-2) (B)
- a. tRNA
 - b. mitosis (V. Chromatin)
 - c. meiosis
 - d. DNA*
- ____ 3. DNA does NOT contain the nitrogen base ___. (B)
- a. adenine
 - b. cytosine (V. Chromatin)
 - c. uracil*
 - d. thymine
- ____ 4. A cell that has two of every kind of chromosome is ___. (B)
- a. haploid
 - b. diploid* (V. Chromatin)
 - c. an egg
 - d. a sperm
- ____ 5. Haploid numbers of chromosomes are usually found in the ___ of an organism. (B)
- a. tissues
 - b. body cells (V. Chromatin)
 - c. sex cells*
 - d. zygote

- ___ 6. Each human skin cell has ___ pairs of chromosomes. (B)
- a. 13
 - b. 18 (V. Chromatin)
 - c. 23*
 - d. 46
- ___ 7. Substances too large to pass through the cell membrane enter the cell in a process called ___. (B)
- a. Endocytosis*
 - b. passive transport (I. Cell membrane)
 - c. exocytosis
 - d. active transport
- ___ 8. Active transport occurs when ___ is used to move substances through a membrane. (3-3) (B)
- a. osmosis
 - b. energy* (I. Cell membrane)
 - c. diffusion
 - d. plasmolysis
- ___ 9. The passive transport of water through a membrane is ___. (B)
- a. osmosis*
 - b. plasmolysis (I. Cell membrane)
 - c. equilibrium
 - d. active transport
- ___ 10. Which of these is selectively permeable? (B)
- a. door
 - b. window screen* (I. Cell membrane)
 - c. wall
 - d. mirror

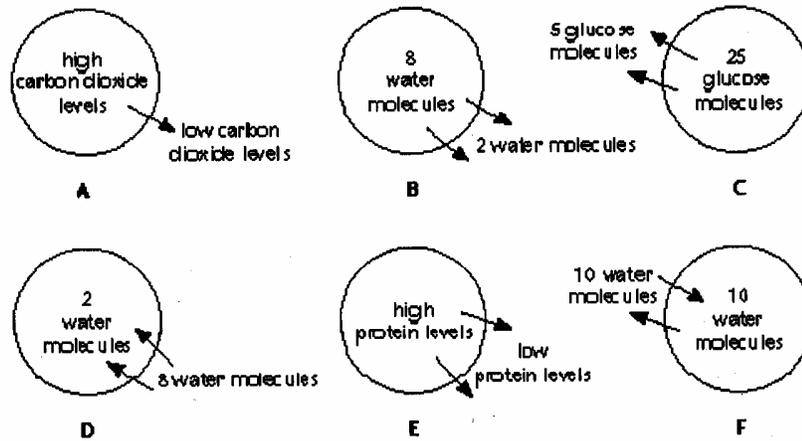


Figure 3-2

- ___ 11. Diagram A in Figure 3-2 is an example of ___. (3-5) (B)
- diffusion*
 - active transport (I. Cell membrane)
 - osmosis
 - equilibrium
- ___ 12. Diagram B in Figure 3-2 is an example of ___. (B)
- diffusion
 - active transport (I. Cell membrane)
 - osmosis*
 - equilibrium
- ___ 13. Diagram C in Figure 3-2 is an example of ___. (B)
- diffusion
 - active transport* (I. Cell membrane)
 - osmosis
 - equilibrium
- ___ 14. Diagram D in Figure 3-2 is an example of ___. (B)
- diffusion
 - active transport (I. Cell membrane)
 - osmosis*
 - equilibrium
- ___ 15. Diagram E in Figure 3-2 is an example of ___. (3-6) (B)
- diffusion
 - active transport* (I. Cell membrane)
 - osmosis
 - equilibrium

- ___ 16. Diagram F in Figure 3-2 is an example of ___. (B)
 a. diffusion
 b. active transport (I. Cell membrane)
 c. osmosis
 d. equilibrium*
- ___ 17. Which diagram(s) in Figure 3-2 show processes that require energy? (B)
 a. structure A
 b. structure B (I. Cell membrane)
 c. structures D and F
 d. structures C and E*

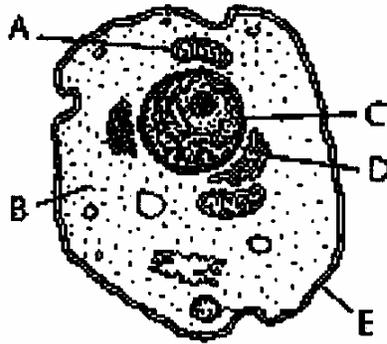


Figure 2-2

- ___ 18. In the animal cell, shown in Figure 2-2, structure C is the ___. Nucleus (B)
 (II. Nucleus)
- ___ 19. In the animal cell, shown in Figure 2-2, structure E is the ___. Cell membrane (B) (I. Cell membrane)

COMPLETION – Choose the best answer to fill in the blank. (Water, osmosis, equilibrium, diffusion, thymine, sex cells)

- ___ 20. Two ___ join to produce a new individual in sexual reproduction. (B) Sex cells
 (V. Chromatin)
- ___ 21. The amount of adenine in DNA always equals the amount of ___. (B) thymine
 (V. Chromatin)
- ___ 22. A plant wilts as a result of the process of ___. (3-6) (A) osmosis (I. Cell membrane)
- ___ 23. The compound that allows material to move through cell membranes is ___. (A) water (I. Cell membrane)

SHORT ANSWER

24. Why is the nucleus important to the cell? (A) The nucleus directs all the activities of the cell and contains proteins and DNA. (II)

25. What are the three parts of the cell theory? (B) **1) All organisms are made up of one or more cells. 2) Cells are basic units of structure and function in all organisms. 3) All cells come from cells that already exist.** (Prior knowledge)
26. What is the main difference between a prokaryotic cell and a eukaryotic cell? (B) **Prokaryotic cells have no membranes around their nuclear material. Eukaryotic cells have membrane-bound organelles including a nucleus.** (Cell parts/prior knowledge)
27. Would gene therapy be used to cure a common cold? (2-10) (A) **No, because gene therapy doesn't cure diseases, but replaces defective hereditary material in body cells.** (II)
28. By what processes do wastes leave cells?(3-9) (A) **Active transport, exocytosis, passive transport.** (I)
29. How is osmosis related to diffusion? (A) **Osmosis is the passive transport of water through a membrane by diffusion.** (I)
30. What is meant by the term *selectively permeable*? (B) **It allows some things to pass through it but not others.** (I)
31. Prokaryotic cells do not have a membrane-bound nucleus. Do prokaryotic cells undergo DNA copying? Explain.(4-6) (A) **Yes, they contain a single chromosome and ribosomes, so DNA copying is possible.** (V)
32. Where do the sugar, phosphate, and nitrogen bases needed to make new DNA come from? (A) **From the cytoplasm of the cell** (V)
33. An organism has 24 pairs of chromosomes in normal body cells. How many chromosomes do the organism's egg cells have? (A) **One half, or the haploid number – 24.** (V)
34. Why is the haploid number of chromosomes usually found only in the sex cells of an organism? (A) **Sex cells are produced by meiosis, which results in haploid cells.** (V)
35. What is the structure of DNA? What does DNA look like? (A) **DNA looks like a ladder that is twisted. The "handrails" of the ladder are sugar and phosphate molecules; the "stairs" of the ladder are nitrogen base pairs.** (V)

UNIT TEST TWO – UNIT LESSON TWO

(TEST TWO – cytoplasm, endoplasmic reticulum, Golgi body, mitochondria, lysosome, cell wall, chloroplasts, vacuole, bacterial cell, cell differences, and cell organization.)

- ___ 1. During periods of strenuous activity, muscle cells run low on ___. (3-4) (B)
- a. oxygen*
 - b. glucose (X. Mitochondria)
 - c. carbon dioxide
 - d. lactic acid
- ___ 2. The process that releases energy without using oxygen is ___. (B)
- a. photosynthesis
 - b. respiration (X. Mitochondria)
 - c. osmosis
 - d. fermentation*

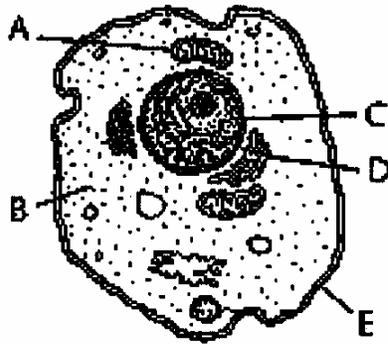


Figure 2-2

- ___ 3. In the animal cell, shown in Figure 2-2, structure A is the ___. (2-4)
mitochondrion (B) (X. Mitochondria)
- ___ 4. In the animal cell, shown in Figure 2-2, structure B is the ___. Cytoplasm (B)
(VI. Cytoplasm)
- ___ 5. In the animal cell, shown in Figure 2-2, structure D is the ___. Endoplasmic reticulum (B)
(VII. Endoplasmic reticulum)

MATCHING

Write the letter of the correct item in the space provided. (2-5)

- a. storage areas in cells (B)
 - b. outer boundary of a cell (B)
 - c. where glucose molecules are broken down (B)
 - d. rigid structure that supports plant cells(B)
 - e. packaging and secreting organelles (B)
 - f. genetic blueprints for cell operation (B)
 - g. gel-like material inside cell (B)
 - h. structures inside eukaryotic cells (B)
 - i. largest organelle in eukaryotic cell (B)
 - j. digest wastes (B)
 - k. cells divide to make new cells.
 - l. all animals are made up of cells.
 - m. store information in the cell (B)
 - n. changing light energy into chemical energy (B)
-
- ___ 6. lysosomes **J** (B) (XI. Lysosome)
 - ___ 7. vacuoles **A** (B) (XIV. Vacuole – Plant cell and animal cell)
 - ___ 8. mitochondria **C** (B) (X. Mitochondria)
 - ___ 9. nucleus **I** (B) (II. Nucleus)
 - ___ 10. organelles **H** (B) (VI. Cytoplasm)
 - ___ 11. cell membrane **B** (B) (I. Cell membrane)
 - ___ 12. cell wall **D**(B) (XII. Cell wall – Plant cell)
 - ___ 13. cytoplasm **G**(B) (VI. Cytoplasm)
 - ___ 14. chromatin **F**(B) (V. Chromatin)
 - ___ 15. Golgi bodies **E**(B) (IX. Golgi bodies)
 - ___ 16. nucleic acids (B) **A** (V. Chromatin)
 - ___ 17. photosynthesis(B) **B** (X. Mitochondria)

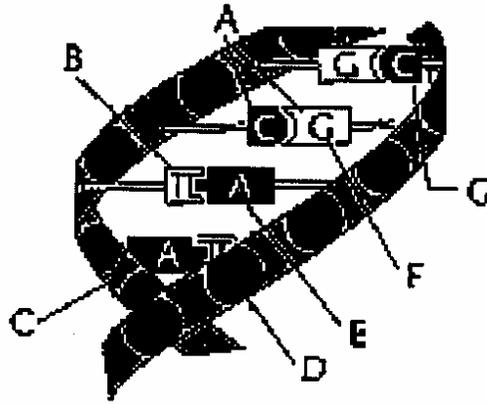


Figure 4-2

18. What structure is illustrated in Figure 4-2? (B) DNA (V. Chromatin)
19. What is Structure A in Figure 4-2? (B) Nitrogen bases (V. Chromatin)
20. What is Structure B in Figure 4-2? (B) thymine (V. Chromatin)
21. What is Structure C in Figure 4-2? (B) sugar (V. Chromatin)
22. What is Structure D in Figure 4-2? (B) Phosphate group (V. Chromatin)
23. What is Structure E in Figure 4-2? (B) adenine (V. Chromatin)
24. What is Structure F in Figure 4-2? (B) guanine (V. Chromatin)
25. What is Structure G in Figure 4-2? (B) cytosine (V. Chromatin)

SHORT ANSWER

26. How is a plant cell different from an animal cell? (2-7) (B)
Plant cells have cell walls and chloroplasts. (XIII, XIV)
27. How are tissue cells and one-celled organisms alike? (A) Both carry on all the functions necessary to life. (XVIII)
28. What is the organization of your own cells, starting with the smallest unit and going to the level of organism? (A) Cell, tissue, organ, organ system, organism. (XVII)
29. What is defined as a structure made up of different types of tissues that work together?(2-8)(B) An organ. (XVIII)
30. Why might a nerve cell in your leg be as long as 1m? (A) Nerve cells transmit impulses from the brain to the rest of the body – a long distance. (XVII)
31. Why is it important for human blood cells to be small and flexible?
(A) Human blood cells must be able to move through tiny blood vessels. (XVIII)
32. What is one difference between one-celled organisms and cells in an organ?
(A) One-celled organisms perform all life functions on their own; organ cells are organized to work together to do a particular job. (XVII, XVIII)

33. To organisms, what advantage is there in having cells organized into tissues? (2-9) (A) **Tissues are groups of similar cells that do the same sort of work. It may be more efficient for the organism to group cells together in this way.** (XVIII)
34. Why are mitochondria important to life? (A) **In mitochondria, enzymes break down glucose and release energy needed for life activities.** (X)
35. You are looking at a single cell. It is green in color. What do you look for to decide whether it is an animal cell, plant cell, or bacterial cell? (A) **If it is green, it is not an animal cell. If it has organelles, it is not a bacterial cell. If it is green and has organelles, it is a plant cell.** (XII, XIII, XIV)
36. If a bacterial cell has no nucleus, how does it direct its own activities? (A) **A bacterial cell has nuclear material, but it is not organized into an organelle (a nucleus).** (II, XVI)
37. Do prokaryotic cells release energy by fermentation or by respiration?(3-8) (A) **Fermentation, because respiration takes place in mitochondria and prokaryotic cells have no organelles.** (X)
38. Where does cell respiration take place? (A) **In mitochondria; they are organelles in eukaryotic cells where glucose molecules are broken down and energy is released.** (X)
39. Why is respiration opposite of photosynthesis? (A) **In photosynthesis, energy is used to make glucose from carbon dioxide and water and release oxygen. In respiration, oxygen combines with glucose to release energy, carbon dioxide, and water.** (X)

TEST THREE – (ONE-WEEK COMPREHENSIVE DELAYED POSTTEST)

MATCHING

Write the letter of the correct item in the space provided. (2-5)

- a. storage areas in cells (B)
- b. outer boundary of a cell (B)
- c. where glucose molecules are broken down (B)
- d. rigid structure that supports plant cells(B)
- e. packaging and secreting organelles (B)
- f. genetic blueprints for cell operation (B)
- g. gel-like material inside cell (B)
- h. structures inside eukaryotic cells (B)
- i. largest organelle in eukaryotic cell (B)
- j. digest wastes (B)
- k. cells divide to make new cells.
- l. all animals are made up of cells.
- m. store information in the cell (B)
- n. changing light energy into chemical energy (B)

- ___ 1. lysosomes J (B) (XI. Lysosome)
- ___ 2. vacuoles A (B) (XIV. Vacuole – Plant cell and animal cell)
- ___ 3. mitochondria C (B) (X. Mitochondria)
- ___ 4. nucleus I (B) (II. Nucleus)
- ___ 5. organelles H (B) (VI. Cytoplasm)
- ___ 6. cell membrane B (B) (I. Cell membrane)
- ___ 7. cell wall D(B) (XII. Cell wall – Plant cell)
- ___ 8. cytoplasm G(B) (VI. Cytoplasm)
- ___ 9. chromatin F(B) (V. Chromatin)
- ___ 10. Golgi bodies E(B) (IX. Golgi bodies)
- ___ 11. nucleic acids (B) A (V. Chromatin)
- ___ 12. photosynthesis(B) B (X. Mitochondria)

___ 13. Substances too large to pass through the cell membrane enter the cell in a process called _____. (B)

- a. Endocytosis*
- b. passive transport (I. Cell membrane)
- c. exocytosis
- d. active transport

___ 14. The passive transport of water through a membrane is _____. (B)

- a. osmosis*
- b. plasmolysis (I. Cell membrane)
- c. equilibrium
- d. active transport

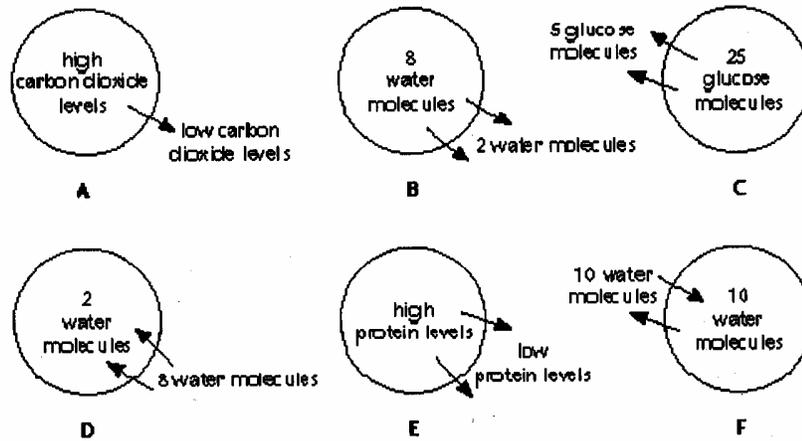


Figure 3-2

- ___ 15. Diagram A in Figure 3-2 is an example of ___. (3-5) (B)
- diffusion*
 - active transport (I. Cell membrane)
 - osmosis
 - equilibrium
- ___ 16. Diagram B in Figure 3-2 is an example of ___. (B)
- diffusion
 - active transport (I. Cell membrane)
 - osmosis*
 - equilibrium
- ___ 17. Diagram C in Figure 3-2 is an example of ___. (B)
- diffusion
 - active transport* (I. Cell membrane)
 - osmosis
 - equilibrium
- ___ 18. Diagram D in Figure 3-2 is an example of ___. (B)
- diffusion
 - active transport (I. Cell membrane)
 - osmosis*
 - equilibrium
- ___ 19. Diagram E in Figure 3-2 is an example of ___. (3-6) (B)
- diffusion
 - active transport* (I. Cell membrane)
 - osmosis
 - equilibrium

- ___ 20. Diagram F in Figure 3-2 is an example of ___. (B)
 a. diffusion
 b. active transport (I. Cell membrane)
 c. osmosis
 d. equilibrium*
- ___ 21. Which diagram(s) in Figure 3-2 show processes that require energy? (B)
 a. structure A
 b. structure B (I. Cell membrane)
 c. structures D and F
 d. structures C and E*

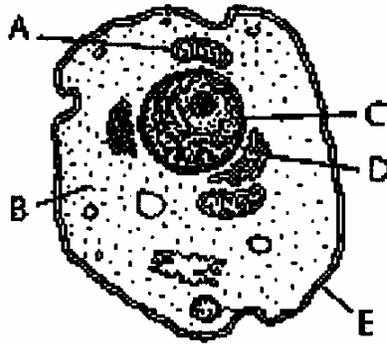


Figure 2-2

- ___ 22. In the animal cell, shown in Figure 2-2, structure C is the ___. Nucleus (B)
 (II. Nucleus)
- ___ 23. In the animal cell, shown in Figure 2-2, structure E is the ___. Cell membrane (B) (I. Cell membrane)
- ___ 24. In the animal cell, shown in Figure 2-2, structure A is the ___. (2-4)
mitochondrion (B) (X. Mitochondria)
- ___ 25. In the animal cell, shown in Figure 2-2, structure B is the ___. Cytoplasm
 (B) (VI. Cytoplasm)
- ___ 26. In the animal cell, shown in Figure 2-2, structure D is the ___. Endoplasmic reticulum (B)
 (VII. Endoplasmic reticulum)

SHORT ANSWER

27. How is a plant cell different from an animal cell? (2-7) (B)
Plant cells have cell walls and chloroplasts. (XIII, XIV)
28. Why is the nucleus important to the cell?(A) The nucleus directs all the activities of the cell and contains proteins and DNA. (II)
29. What are the three parts of the cell theory? (B) 1) All organism are made up of one or more cells. 2) Cells are basic units of structure and function in all

- organisms. 3) All cells come from cells that already exist.** (Prior knowledge)
30. What is the main difference between a prokaryotic cell and a eukaryotic cell? (B)
Prokaryotic cells have no membranes around their nuclear material.
Eukaryotic cells have membrane-bound organelles including a nucleus.
(Cell parts/prior knowledge)
31. What is one difference between one-celled organisms and cells in an organ? (A)
One-celled organisms perform all life functions on their own; organ cells are organized to work together to do a particular job. (XVII, XVIII)
32. Why are mitochondria important to life? (A) **In mitochondria, enzymes break down glucose and release energy needed for life activities.** (X)
33. You are looking at a single cell. It is green in color. What do you look for to decide whether it is an animal cell, plant cell, or bacterial cell? (A) **If it is green, it is not an animal cell. If it has organelles, it is not a bacterial cell. If it is green and has organelles, it is a plant cell.** (XII, XIII, XIV)
34. How is osmosis related to diffusion? (A) **Osmosis is the passive transport of water through a membrane by diffusion.** (I)

APPENDIX H

SURVEY FOR EACH GROUP

Outlining group: Please read each of the following statements. Circle the answer that best describes how you feel about outlining.

1. I liked outlining.

Strongly agree agree no concern disagree strongly disagree

2. I enjoyed creating an outline for the cell block.

Strongly agree agree no concern disagree strongly disagree

3. Using an outline for the cell block helped me organize information.

Strongly agree agree no concern disagree strongly disagree

4. Outlining helped me understand the structures and functions of the cell.

Strongly agree agree no concern disagree strongly disagree

5. I found outlining to be difficult.

Strongly agree agree no concern disagree strongly disagree

6. Another strategy should have been used for me to understand the structures and functions of the cell.

Strongly agree agree no concern disagree strongly disagree

7. I was given enough time to create the outline.

Strongly agree agree no concern disagree strongly disagree

8. I put a lot of effort into studying my outline notes for understanding the information on the structures and functions of the cell.

Strongly agree agree no concern disagree strongly disagree

(Goodnough & Woods, 2002)

Mind-mapping group: Please read each of the following statements. Circle the answer that best describes how you feel about mind mapping.

1. I liked mind mapping.

Strongly agree agree no concern disagree strongly disagree

2. I enjoyed creating a mind map for the cell block.

Strongly agree agree no concern disagree strongly disagree

3. Using a mind map for the cell block helped me organize information.
Strongly agree agree no concern disagree strongly disagree
4. Mind mapping helped me understand the structures and functions of the cell.
Strongly agree agree no concern disagree strongly disagree
5. I found mind mapping to be difficult.
Strongly agree agree no concern disagree strongly disagree
6. Another strategy should have been used for me to understand the structures and functions of the cell.
Strongly agree agree no concern disagree strongly disagree
7. I was given enough time to create the mind map.
Strongly agree agree no concern disagree strongly disagree
8. I put a lot of effort into studying my mind map notes for understanding the information on the structures and functions of the cell.
Strongly agree agree no concern disagree strongly disagree

(Goodnough & Woods, 2002)

Control group: Please read each of the following statements. Circle the answer that best describes how you feel about the unit on cells.

1. I liked taking notes on the cell.
Strongly agree agree no concern disagree strongly disagree
2. I enjoyed writing the information on the cell block.
Strongly agree agree no concern disagree strongly disagree
3. Using a cell block for the cell unit helped me organize information.
Strongly agree agree no concern disagree strongly disagree
4. Writing the notes on the cell block helped me understand the structures and functions of the cell.
Strongly agree agree no concern disagree strongly disagree
5. I found writing notes on the cell block to be difficult.
Strongly agree agree no concern disagree strongly disagree

6. Another strategy should have been used for me to understand the structures and functions of the cell.

Strongly agree agree no concern disagree strongly disagree

7. I was given enough time to study the cell block.

Strongly agree agree no concern disagree strongly disagree

8. I put a lot of effort into studying my cell block notes for understanding the information on the structures and functions of the cell.

Strongly agree agree no concern disagree strongly disagree
(Goodnough & Woods, 2002)

APPENDIX I

PARENT PERMISSION FORM

September 2004

Dear parent(s)/guardian(s):

I am a doctoral student at Texas Tech University in Lubbock Texas. In completion of a degree, I am required to conduct a study, which involves research. The purpose of this study is to see the effects of a note taking strategy – mind mapping – on recall and learning. Mind mapping is a study strategy and note taking strategy students can use. I am conducting this study to see if this strategy would be effective for teachers to utilize in the classroom and what implications it may have for students, teachers, and staff development.

The students who will participate will receive training in all the methods in September prior to being randomly assigned to one of three groups – mind map group, outline group, and a control group. Each group will receive training in a particular strategy before and while studying the unit on cells. This unit will last approximately fifteen days. The students involved will have no risks. They will be asked to participate, take notes, and study cells using the strategy, then take a test. This process is not any different than when attending school to learn.

As part of this project, I will need access to student records to review scores on standardized exams. These standardized scores will allow me to assess the random distribution of students' abilities among the groups. If permission is granted, your signature allows the researcher access to your child's records. Confidentiality will be maintained and only I will have access to these records.

Participation in this study is voluntary. If you refuse to allow your child to participate, no penalty or loss of benefits will occur. If your child participates, you may discontinue participation at any time without penalty or loss of benefits.

My supervisor is Dr. Charles Geer who will answer any questions you may have about the study. He can be reached at (806) 742-1997, Ext. 276. For questions about your child's rights as a subject in this study or about injuries caused by this research, contact the Texas Tech University Institutional Review Board for the Protection of Human Subjects, Office of Research Services, Texas Tech University, Lubbock, Texas 794091 at (806) 742-3884.

If you are interested in discussing any questions you have about the study, I will be available on September 16, 2004 from 5 p.m. to 6 p.m. or you may call 433-1300 and schedule an appointment between 10:18 a.m. to 11:12 a.m.

Sincerely,

Ms. Trevino

Please check the appropriate permission response, sign and give parent and student signature.

_____ Yes, my child, _____, has permission to participate in the study conducted by Ms. Trevino.

_____ No, my child, _____, does not have permission to participate in the study conducted by Ms. Trevino.

Parent signature _____ Date _____
(Permission letter was translated for Spanish speaking parents.)

Student permission granted:

I, _____, am a willing participant in this study conducted by Ms. Trevino.

I, _____, am **not** a willing participant in this study conducted by Ms. Trevino.

Student signature _____ Date _____

This consent form is not valid after August 31, 2005.

APPENDIX J

INSTITUTIONAL REVIEW BOARD PERMISSION FORM

**Texas Tech University
Institutional Review Board for the Protection of Human Subjects
Office of Research Services
203 Holden Hall / MS 1035
742-3884**

October 19, 2004

Charles Geer
Curriculum & Instruction
Mail Stop: 1071

Regarding: 100138 Mind Mapping and Outlining: Comparing Two Types of
Graphic Organizers for Learning Seventh-Grade Life Science*

Dr. Charles Geer:

The Texas Tech University Protection of Human Subjects Committee has approved Cynthia Trevino's doctoral dissertation proposal referenced above. The approval is effective from 09/24/2004 through 08/31/2005. This expiration date must appear on all of your consent documents.

You will be reminded of the pending expiration approximately six weeks prior to 08/31/2005 and asked to give updated information about the project. If you request an extension, the proposal on file and the information you provide will be routed for continuing review.

Best of luck on your project.

Sincerely,
Richard P. McGlynn, Chair
Protection of Human Subjects Committee

* Revised title of study as recommended by doctoral dissertation committee on March 10, 2005.