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A Comparison of Inquiry-based Teaching through Concept Maps and Traditional
Teaching in Biology

By

Sangeeta Gulati

B.Sc., Lucknow Christian College, 1991

B.Ed., Lucknow University, 1993

M.A.T, Northern State University, 1997

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the Requirements for the Degree of
Doctor of Education

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ABSTRACT

Sangeeta Gulati, Ed.D., Curriculum and Instruction
University of South Dakota, 2005

A Comparison of Inquiry-based Teaching through Concept maps and Traditional Teaching in Biology

Dissertation directed by Dr. Linda Reetz

The purpose of this study was to investigate affective outcomes and academic achievement for students enrolled in high school biology when instruction included concept-mapping. The research design was quasi-experimental and allowed for a comparison between an experimental group who constructed concept maps and a control group who received traditional biology instruction.

The subjects were 140 ninth-grade students, distributed into six intact biology classes, three honors and three general biology classes. Chapter tests and a textbook generated 9-week comprehensive posttest were used to measure achievement. ANCOVA analysis on the comprehensive posttest indicated no significant overall effect of concept mapping on biology achievement across the whole quarter when controlling for the quarter pretest. Chi-square analyses were performed to measure students' attitude toward biology class and activities. The experimental group indicated higher than expected tendency to be positive about the instructional methods, however, the control group indicated fewer than expected positive responses. T-tests were conducted to determine the differences between the experimental and control groups on chapter tests with or

without concept mapping. The group with concept mapping scored significantly better than those with traditional methods.

Honors class comparisons indicated a significant difference between groups at $p < .05$ level on the chapter pretest. There was also a significant difference on the chapter test after intervention, but this time at $p < .001$ level. Although the general class comparisons indicated no significant difference on the chapter pretest, the experimental group scored significantly better than the control group on the chapter test following intervention. This suggests that average ability students benefit from concept mapping more than traditional instruction.

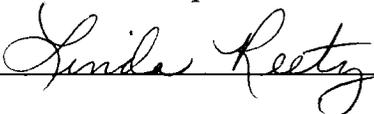
In narrative self-evaluations, only a small percentage of participants overall listed concept mapping as the review activity that helped them learn most. Recommendations for practitioners and future research were provided related to the use of concept mapping.

This abstract of approximately 350 words is approved as to form and content. I recommend its publication.

Signed *Linda Reetz*
Dr. Linda Reetz

DOCTORAL COMMITTEE

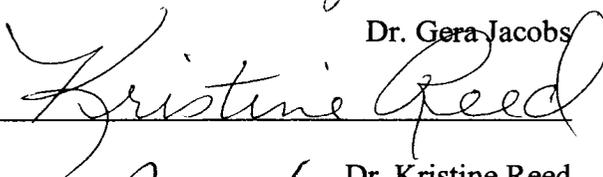
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find it satisfactory and recommend that it be accepted.



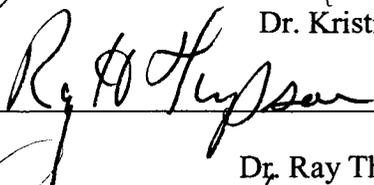
Dr. Linda Reetz, Chair



Dr. Gera Jacobs



Dr. Kristine Reed



Dr. Ray Thompson



Dr. Rosanne Yost

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CHAPTER 1

Introduction

There are many methods of teaching that are in use in our schools today. In a science course teachers are interested in teaching scientific principles, facts, theories and laws, and relating them to real life experience. According to Lazarowitz, Baird and Bowlden (1996), recent educational research on academic achievement and affective learning outcomes of students in biology classes provides the basis for the need to search for the most effective method to use in teaching biology.

A paradigm shift in the way biology is taught at the high school level has been advocated by the Nebraska State Board of Education. The Board advocates that senior high students should be able to understand scientific inquiry at increasingly higher levels of sophistication. Questions and issues relevant to students should form the basis of investigations. An adequate knowledge base and an understanding of the concepts that guide inquiry are needed to assure success. Students should learn how to analyze evidence and evaluate their own explanations and those of scientists (Title 94, Nebraska Administrative Code, Chapters 1 through 4). This study examined an inquiry-based method, concept mapping, which might contribute to student satisfaction of the biology class and achievement enhancement. Marzano, Gaddy, and Dean (2000) have designated concept mapping as one of the key instructional tools. In studies by BouJaoude and Attieh (2003) on chemistry education, Snead and Snead (2004) on science education, and Gordon (2002) on search behavior of tenth-grade biology concept mapping was found to result in improved instruction and student performance. The knowledge gained could

help to inform educators about the teaching methods that facilitate success for students in biology.

This study explored whether students show greater achievement of and attitude toward learning biology with the use of concept-mapping compared to traditional teaching styles when concept mapping is used as a chapter review instructional tool. Concept mapping may serve as an instructional method that could contribute to the possibility of developing and implementing effective science programs.

Background of the Problem

Traditional patterns of science education have remained largely unchanged for most of the last century. In fact, the organization of curriculum for high schools has remained essentially constant (Lazarowitz et al., 1996). The natural curiosity of children eager to understand their surroundings is often diminished by instruction that discourages inquiry and discovery. In upper grades science instruction especially becomes text-book centered. According to Sanchez (1994) even though laboratory experiences are included, students rarely are encouraged to use scientific methods to solve problems relevant to their perceptions of the world.

According to Lawson and Renner (1974), the traditional method of conducting laboratory activities is to introduce the concept in a lecture prior to the laboratory experience. The laboratory is then seen by the students to be a place to prove the teacher or textbook correct and not a place to conduct meaningful explorations. Traditional teaching methods embrace the notions that teaching is telling and being able to repeat something on an examination is evidence of understanding. This is contrary to the spirit

of inquiry that is investigating, questioning, exploring, searching, researching, studying, and analyzing (Gayford, 1988).

According to Mckenna and Hand, (1985), “Biology, like other sciences, develops from objective thought processes through observation and reasoning. However, the course is often presented in such a way that it is a series of somewhat sequential facts, so dissociated from everyday activities and functions of living organisms that students feel that it is uninteresting and boring”(p. 2).

In order for students to improve their achievement levels in science subjects and also develop their higher-order thinking skills to think through and solve complex problems in the real world, they need to be involved in inquiry (Osisioma, 1997). Biological science inquiry teaching model is a method used in the teaching-learning process. According to Lord (1998), inquiry is the way students learn when they are actively challenged through questions and scenarios that cause them to discover what they are taught. Modern educators have confidently endorsed Bruner’s (1960) conclusion that the “discovery method is the best way to develop desirable attitude toward learning and inquiry, toward the possibility of solving problems on ones’ own, attitude about the ultimate orderliness of nature and a conviction that can be discovered” (p. 16).

Ausubel (1963) said the discovery method is indispensable for testing the meaningfulness of knowledge and for teaching the scientific method and effective problem solving skills. According to Ausubel, Novak and Hanesian (1978), the philosophy of inquiry implies that the teacher views the learner as a thinker, actor, and

responsible person. The lessons taught are investigative and involve the students in critical thinking and science processes. Thus, the characteristics of the inquiry process are observation, measurement, experimentation, communication, and mental process. The mental processes necessary to use an inquiry model involve the ability to see relationships among concepts (Ausubel et al. 1978), which can be best taught through instruction in concept mapping.

Concept mapping is an instructional strategy developed by Novak and his associates in 1972. It is a meta learning strategy for organization of science concepts in a meaningful manner in order to facilitate meaningful learning. It is based on the premise that concepts do not exist in isolation but interrelate with others to make meaning. Organizing new concepts/information into a form that shows these interrelationships help learners make mental connections; therefore, representing their understanding of concepts more accurately (Ausubel, 1960 & 1963).

Burggraf (1998) proposed that the best concept maps are those that learners generate by themselves. Each learner has a slightly different view and grasp of the concept, and those differences will show up on the maps they create. Concept maps are extremely versatile across a wide range of student abilities. The steps in concept mapping were clearly explicated by Novak, Gowin, and Johansen (1983). Concept maps can play a remarkable role in curriculum development, evaluation, learning, and teaching in many disciplines. Burggraf (1998) suggests various uses of concept maps as study aids, assessments, reviews, homework assignments, small-group activities, portfolio materials, parts of tests and writing exercises.

Statement of the Problem

The purpose of this study was to investigate affective outcomes and academic achievement for students enrolled in high school biology when instruction includes the method of concept-mapping.

Research Questions

The following questions guided the study:

1. How do the pre and posttest achievement test scores compare between the students who receive biology instruction using concept maps vs. those who receive instruction via a traditional method?
2. What relationship exists between the method of teaching and students' attitude toward the biology class and class activities as measured on chapter surveys?
3. What are the differences between students' understandings of biology content as measured by chapter tests using concept mapping compared to a traditional method?
4. What are students' perceptions of review activities that helped them learn to use concept maps or traditional methods?

Significance of the Study

The vast majority of high school students may not be learning science because the way they are taught does not stimulate active learning. The dominant method of teaching high school science is traditional lecture. In fact, Angelo (1990) has shown that students remember only twenty percent of what they hear in a traditional lecture. Researchers and educators have suggested that one major reason for the lack of success of the traditional lecture method is that students do not use much energy thinking about what is being

discussed in a traditional lecture presentation. On the other hand, as suggested by Leonard (2000), an inquiry-based instruction provides plenty of opportunities for students to process, interpret, and internalize the concepts of science.

Concept mapping requires students to use active learning to look for relationships among science concepts. Marzano et al. (2000), reported that graphic organizers (concept maps) combine the linguistic mode and non-linguistic mode of communication by using words and phrases to highlight key points and symbols, and arrows to represent relationships. Graphic organizers can be used in classrooms in different ways. As suggested by Marzano et al., a teacher might give students completed graphic organizers as notes in order to highlight key issues and organize information students will be learning. The teacher might also ask students to complete graphic organizers to help them sort through and arrange information they are learning. This study examined student achievement and affective perspectives when taught using concept mapping compared to a traditional approach. The subjects for the study were the high school freshmen who participated in learning to make concept maps and take chapter surveys. The significance of this finding may affect the instructional practices in general and in science courses also.

Definition of terms

The following terms were used in this study. Citations are provided for definitions based on the review of literature. The researcher developed all definitions not accompanied by citation.

Achievement: A measured standard of performance on course tests and

assignments and determined by the course instructor's criteria.

Attitude: A mental position or opinion taken with respect to a psychological object (Moore, 1970).

Biology: A year long lecture and laboratory course required for freshman that covers diverse aspects of the study of life.

Concept: A regularity in events or objects that is designated by some label (Novak & Gowin, 1990).

Concept map: A two dimensional hierarchical diagram representing relationships between concepts in the form of prepositional knowledge statements (Novak & Gowin, 1990).

Concept mapping: A technique to integrate new ideas and concepts to the old ones.

Concept structure: Mental representation of different kinds of knowledge and information in an individual's long term memory (Ausubel, 1963).

Crosslink: One-or more word(s) that connect one segment of the concept hierarchy and another segment (Novak & Gowin, 1990).

Inquiry method: A method of teaching in which students engage in becoming more fluent and precise in asking questions, building concepts and hypotheses, and testing them.

Linking words: Words used to link concept labels together into proposition.

Meaningful learning: The act of new knowledge being consciously linked to existing specifically relevant concepts and propositions (Novak & Gowin, 1990).

Meta-learning: Term used to refer to the awareness of and knowledge about cognition and the control and regulation of cognition (Brown, Bransford, Ferrara, & Campione, 1993).

Proposition: Two or more concept labels linked by words in a semantic unit or a relationship between two concepts (Novak & Gowin, 1990).

Rote learning: Arbitrary verbatim incorporation of new information into one's cognitive structure (Ausubel, 1968).

Sponge activities: Activities at the beginning of a lesson that organize the content by focusing on major concepts to be learned or engage students in the topic by relating to their own experience and background knowledge.

Traditional method: A method of teaching in which the teacher dispenses knowledge and does most of the talking. Students are singled out to answer direct questions about the subject.

Limitations of the Study

There are several limitations in this study. They include the following:

1. The sample for the study will be selected based upon the computer scheduling of students. There will be no formal balancing of students based on interest or academic achievement although similar composites will be sought.
2. The participants in the study came from eight different middle schools which may have introduced the biology concepts covered in the chapters in different levels of depth.
3. The information gathered will be subject to respondents' comprehension of the

questions and their interest in the topic of each chapter.

4. The respondents may not answer the affective questions candidly.
5. The difference in the layout of content of the two chapters in the textbook may affect the students' interest in them.

Delimitations of the Study

The study has the following delimitations:

1. The investigation is limited to students enrolled in freshman biology in the researcher's classes.
2. The investigation is limited to only one inquiry-based method, concept mapping.
3. Measures of achievement and attitude are going to be obtained for an experimental period of nine weeks only; therefore long-term changes cannot be predicted.
4. The study is delimited to the extent that the instructor's knowledge, enthusiasm, and rapport will uniformly motivate students in both the groups on the chapters for which data will be collected and examined.

Assumptions

The assumptions of this study include:

1. It is assumed the respondents will answer the questions in a sincere and honest manner.
2. It is assumed that instruments will collect information that will address the research questions.
3. It is assumed that the sections of biology students who comprise the control

and experimental groups will be similar in ability and interest.

Organization of the Remainder of the Study

Chapter 1 has provided an overview of the study. The review of literature is presented in Chapter 2 and the methods and procedures used to implement the study are described in Chapter 3. Chapter 4 presents the data analysis for each of the research questions. Chapter 5 contains the summary, major findings, conclusions, discussion, and recommendations for practice and further study.

CHAPTER 2

Review of Selected Literature

Chapter two provides a selected review of literature and research related to methods of teaching science. The chapter is divided into sections that include the following topics: introduction, models of teaching, biological science teaching and concept mapping. The specific references that guided the study are Educational Resource Information Center (ERIC), Dissertation Abstract International (DAI), PALS. The facilities in which these resources were found are the I.D. Weeks Library located on the campus of The University of South Dakota, Vermillion and the Vermillion Public Library.

Introduction

The main objective of education is to prepare students for future responsibilities and success in life (Dewey, 1936). It is the teacher's challenge to organize learning situations to meet this objective. In order to effectively meet the challenge, the teacher's first step is to understand the models of teaching that bring about particular kinds of learning and to help students become more effective learners. Teachers need to be able to identify these models and select the ones that they will master in order to develop and increase their effectiveness (Jackman & Swan, 1996).

One way to determine whether or not the traditional method is more effective compared to an inquiry method is to examine the model of teaching a teacher uses in the classroom. Research indicates that scientific inquiry models achieve relevant effects well, but the traditional lecture or 'chalk and talk' methods of teaching are poor instruments for teaching the scientific method (Joyce, Weil & Showers, 1992).

Models of teaching represent the vehicle for delivery of instruction in the classroom. Joyce and Weil (1986; 1996) organized these models into four families: informational, social, personal and behavioral.

Models of Teaching

When teachers teach well, they help students learn well. This may depend on what model of teaching they use. According to Joyce and Weil (1986), a model of teaching is a plan or a pattern that can be used to design face-to-face teaching in classrooms or tutorial settings and to shape instructional material including books, films, tapes and computer-mediated programs and curriculum. There are various models of teaching, but each model guides the teachers as they design instruction to help students learn information and ideas and to develop academic and social skills, values, and knowledge about themselves and their environment. Thus, a good model of teaching helps in learning.

These models of teaching are found in abundance. Some of them have broad application while others are designed for specific purposes. They range from simple direct procedures that get immediate results to complex strategies that students can acquire only after patient and skillful instruction. These models can be adjusted to the learning styles of student and to the requirements of the subject matter. According to Joyce and Weil (1986) the models of teaching have been grouped into four families that share orientation towards human beings and how they learn.

The Information-Processing Family

The aim of information-processing family is to improve logical thinking processes. The models in this family emphasize ways of enhancing humans' innate drive

to make sense of the world by acquiring and organizing data, sensing problems and generating solutions to them, and developing concepts and language for conveying them (Joyce & Weil, 1986).

The models in this family include the following seven techniques. Concept attainment requires that students learn concepts for organizing information and thus become efficient at learning and creating concepts. The inductive thinking model introduces students to finding and organizing information skillfully as discoverers who test hypotheses and describe relationships among collected data. In inquiry training, students engage in becoming more fluent and precise in asking questions, building concepts and hypotheses, and testing them. Advance organizers provide students with a cognitive structure for comprehending material presented through lectures, readings, and other media related to students' prior knowledge. At the end of the lesson students summarize the lesson and/or provide new examples or relationships (Eby & Kujawa, 1994; Joyce, Weil, & Showers, 1992; Kauchak & Eggen, 1993; Orlich et al., 1994). Memorization employs mnemonic strategies for memorizing and assimilating information. These have been found to be the most effective in retention of knowledge (Joyce, Weil & Showers, 1992; Kauchak & Eggen, 1993). Developing intellect is used to help teachers adjust instruction to the stage of maturity of an individual student and to design ways of increasing the student's rate of development (Eby & Kujawa, 1994). Last, but not the least, is the scientific inquiry/ biological science inquiry model that teaches students how to think effectively by building concepts and hypotheses to test them. The purpose of such a model is to teach the scientific method and to teach the basic concepts of the disciplines and information necessary to understand the area (Joyce, Weil,

& Showers, 1992; Orlich et al. 1994).

The Personal Family

The personal family models develop internal resources to see things in new or different ways. These models of learning begin from the perspective of the individual. They attempt to shape education in order that students understand themselves better, take responsibility of their education, and learn to reach beyond their current development to become stronger, more sensitive and more creative in their search for quality lives. The models that constitute this family employ non-directive teaching in which the teacher endeavors to help the students understand how to play major roles in directing their own education. Therefore, students try to work out their problems. Second, synectics is designed to help students to generate fresh ideas and solutions to problems. It also develops creative writing and speaking skills and induces co-operative problem solving. Third, awareness training helps students expand their awareness of self and their capacity. Fourth is the classroom meeting model in which a group is responsible for establishing a social system appropriate to academic tasks but with room for individual differences and respect for the common tasks and the rights of others (Joyce & Weil, 1986).

The Social Family

According to Joyce et al (1992) in the social family, models create educational opportunities by exposing students to problems that they must solve together, therefore teaching social skills and communication. Group investigation is one model that is designed to lead students to define problems, explore various perspectives on the problems, collect relevant data and describe it, thus helping the students find and organize information and ensure that it is correct (Johnson & Johnson, 1994; Joyce, Weil, &

Showers, 1992; Kauchak & Eggen, 1993;). Role-playing is another model that asks students to “act out” conflicts, to learn to take on the roles of others, and to observe social behavior (Joyce, Weil, & Showers, 1992; Shaftel & Shaftel, 1982). Jurisprudential inquiry is created especially for secondary students in social studies. The students analyze the cases dealing with social problems and identify the public policy issues and the options that are available for dealing with them. The laboratory-training model is based on the ability of everyone to develop a setting where differences can be tolerated and accommodated, and where tasks can be coordinated. In social science inquiry, social processes develop social goals. It results in the learning of information and the building of concepts (Joyce & Weil, 1986).

The Behavioral Systems Family

The main goal of the behavioral systems family is to change the behavior of the learner and transmit the culture by teaching skills and knowledge. The social learning theory guides the design of the models in this family. The social learning theory is based on the concept that human beings are self-correcting communication systems that modify behavior in response to information about how tasks are navigated. This family constitutes several models. Mastery learning, direct instruction, and social learning theory model are based on instructional systems that organize material to be learned in relatively small sequential instructional modules that are presented to the students with assessments of progress embedded in them. A second model involves learning for self-control, simulation, use of programmed texts or computer drill in which students are presented with tasks and then given feedback about their performances. Students teach themselves by observing the results of their actions. A third model is assertive training that helps

analyze communication tasks and problems to develop social skills for handling ordinary and stressful situations (Joyce & Weil, 1986; Joyce, Weil, & Showers, 1992).

Biological Science Inquiry

This study discusses in detail the biological science inquiry-teaching model. According to Orlich, Harder, Callahan, and Gibson (1998), inquiry is a natural way through which humans learn. An inquiry session should begin with the presentation of a problem through a demonstration, a description of an intriguing phenomenon, or a problem posed by the use of prepared materials. Students are asked to gather data, which are used to formulate one or more theories. Activities such as observing, theorizing, experimenting, and theory testing help students find out about science phenomena through inquiry. The purpose of the activity is to gather enough information to put together theories that will make new experiences less strange and more meaningful. The key to the inquiry model proposed by Suchman (1966, p. 17) is providing “problem focus events”. When inquiry models of teaching are implemented they are very effective in enhancing student performance, attitudes, and skill development.

There are five models of inquiry teaching suggested by Orlich et al. (1998). First is unguided inquiry in which the students are allowed to discover the specifics themselves before they make any generalizations. Second is guided inquiry in which the teacher provides the data of facts or specifics but the students make generalizations. The teacher uses hands-on activities and presents the concept or principle. Third, in discovery learning the discoverer must communicate both the what and the how to others. Communication, content, knowledge, and fact are very much a part of the discovery strategy. Fourth, problem solving is based on the ideas of John Dewey (Orlich et al.

1998) who advocated a curriculum based on problems. Dewey defined a problem as anything that gives rise to doubt and uncertainty. This problem had to be important to the culture and it had to be important and relevant to the student. The teacher's role is as a clarifier or definer. Fifth, critical thinking is a multistage construction of meaning. It results in high levels of student achievement, as critical thinking involves application of the highest levels of Bloom's cognitive taxonomy, analysis and synthesis (Orlich et al. 1998).

Dale (1992) found that teachers are reluctant to use inquiry models in their classrooms. The reason may have to do with the teacher's educational background. It could be possible that many teachers have not been exposed to inquiry teaching models in their teacher preparation programs and therefore lack the skills and strategies to implement inquiry. Some teachers say inquiry models of teaching are only effective with bright students and cause too many problems with lower ability students. Teachers interviewed link inquiry with discovery and indicate that the reason students liked science was a result of the excitement in finding out about things, probing and exploring, which is inquiry (Orlich et al., 1998).

There are many approaches to help students understand science in addition to inquiry. Because there is more than one way to learn, there is more than one way to teach. There are other models of teaching also that are used for teaching science.

Meta-Paradigmatic Approach

Most recently specific philosophical or learning psychology theories have been applied to designs, models, tools or strategies to improve the teaching and learning of biology. These theories, however, do not present a clear integration of main constructs

involved in science learning to assist teachers in the design and development of tools and strategies to improve their teaching. According to Sanchez (1991), specific science inquiry models and cognitive learning theories have been selected and their theoretical rationales synthesized into a model particularly appropriate for development of science teaching strategies. It is called the meta-paradigmatic approach.

This model integrates three major cognitive learning theories: Piaget's theory of intellectual development, Ausubel's theory of assimilation and meaningful verbal learning, and Bruner's theory of cognitive development. Thus, some common thoughts from the inquiry models by a diverse set of scholars were taken into consideration as this model was developed. The concepts that are given special attention in practical application of biology in this model are the following:

1. Mental adaptation, assimilation, and accommodation derived from Piaget's theory of intellectual development,
2. Progressive differentiation and integrative reconciliation in sequential knowledge organization through linkage to prior knowledge as in Ausubel's theory, and
3. The concept of structure of knowledge proposed by Bruner (Sanchez, 1991).

According to Sanchez (1985), mental adaptation is psychological and physical change in behavior as a result of interaction of the processes of mental accommodation and assimilation. Assimilation refers to the application of an established behavior pattern to a familiar or new experience that later can be incorporated into cognitive structures. Accommodation is the tendency to change former behavior patterns in response to experience.

To enhance meaningful learning, more general and abstract concepts should be

presented to the student first, followed by progressively differentiated or less abstract content. In this way a concept is acquired progressively through greater refinement and particularization of the content presented. Thus, an abstract concept is presented and then its meaning is differentiated progressively through explication of sub-concepts.

Therefore, the structure of the meta-paradigmatic model consists of the following components: (a) biological topic or contents to be taught, (b) learning objectives or intended covert and overt student's behavior, (c) rationale that sets the framework for the content and inquiry emphasis of the lesson and how they are applied to meet the particular cognitive level of the students, (d) biolesson outline which is the critical part of the lesson and is divided into three parts: the way learning of new ideas should be initiated (pre-concept mapping), the way learning material should be organized (new ideas or concepts), and the way new ideas should be integrated to the old ones (post concept mapping); and finally, an integrative analysis of the lesson is given (Sanchez, 1991).

The innovative section of the lesson is the biolesson outline. The pre-concept mapping section applies to the use of a cognitive tool or concept map presented (Novak & Gowin, 1990). This is a way of ordering prior ideas and concepts in a meaningful way, thus constructing and ordering a mental schema or structure (Anderson, 1976). Thus, the student comes to understand concepts and their relationships with the ones already ordered in pre-existing mental structures.

This model is designed to bridge the gap between theory and practice in science teaching. Although it has been specifically used for biological content, Sanchez (1985) suggested that it is suitable for many disciplines, especially those within the natural

sciences. According to Sanchez, the major strength of this model is the synthesis of cognitive and science learning theories to facilitate acquisition and organization of science learning materials. The limitation of this model is that it does not deal directly with the critical constructs of science learning such as problem solving and reasoning. It focuses the learning and teaching of science more broadly with a solid theoretical basis, thus developing integrated patterns of thought.

Many teachers use a combination of models and integrate them into a personal model of teaching while others focus on one of these models and build their own favored approach. Recent research and trends in practice support an integrative view for formulating instructional plans, thus based on the combination of all the models of teaching (Joyce & Weil, 1986). Effective education requires a combination of personal, social, and academic learning that can best be achieved by using several appropriate models. Every teacher faces a wide range of challenges, and if he or she has an equally wide range of teaching models from which to draw, he or she can generate more creative and imaginative solutions to those problems (Orlich, Harder, Callahan, & Gibson, 1998).

Learning Theory

Research to improve biology teaching during the past three decades has been dominated by two major theories. The first, Ausubel's theory of verbal learning, has focused on attention on ways students acquire understanding of specific biology concepts (Ausubel, 1963; Ausubel, Novak, & Hanesian, 1978; Harty, Hamrick, & Samuel, 1985; Lehman, Carter, & Kahle, 1985; Novak, 1979). The second theory, Piaget's developmental theory, has focused attention on ways student acquire and use general scientific reasoning patterns (Flavell, 1963; Inhelder & Piaget, 1958; Karplus, 1977;

Lawson, 1985 & 1988; Lawson & Renner, 1974; Piaget, 1964 & 1972).

These two theories represent the best of available theory divided into the two major domains of knowledge recognized by cognitive scientists, that is, declarative knowledge, the specific facts and concepts that we know; and procedural knowledge, the general skills that we know how to perform (Anderson, 1980).

Concept mapping an instructional strategy to explore meaningful learning is rooted in Ausubel's theory of verbal learning. The key to Ausubel's theory is that it focuses on meaningful learning-defined as recognizing a relationship between new information and something else that the learner already knows (Ormrod, 2000).

Meaningful learning occurs when a learner can connect new knowledge to a preexisting cognitive framework. Niehaus (1994) refers to this process as grafting a plant stem into a different tree. The tree accepts the plant stem and the stem is nourished, grows and becomes a part of a tree. Likewise, ideas need to be linked to each other when several are presented at once that is, integrated into conceptual whole (Snead & Young, 2003).

Ausubel (1968) believes that three conditions must exist for meaningful learning to occur: (a) the learner must sense a relationship among the concepts to be learned; (b) the learner must possess specific relevant ideas to which this material can be related; and, (c) the learner must actually intend to relate these new ideas to ideas already possessed. This process of meaningful learning can be improved by concept mapping through which the learner creates a visual representation of concepts and connects each in a hierarchically arranged structure (Boyle & Yeager, 1997).

Boxtel, Linden, Roelofs, and Erkens (2002) suggest that concept mapping promotes meaningful learning as follows: (a) helps students become aware of and reflect

on their own (mis)understanding; (b) helps students to participate in developing meaning in learning concepts; (c) provides opportunity for student interaction, thus the more students talk about science concepts and the more elaborative the talk, the higher the learning outcomes.

Concept Mapping

Concept Mapping Characteristics

According to the National Science Education Standards (1996), “Scientific inquiry refers to the diverse ways in which scientists study the natural world and propose explanations based on the evidence derived from their work” (p.23). The standards call for students to develop the abilities and understandings that will enable them to engage in the method of concept mapping.

Concept mapping is an instructional strategy developed by Novak and his associates in 1972. It is a meta learning strategy for organizing information about science concepts in a meaningful manner in order to facilitate meaningful learning. It is based on the premise that concepts do not exist in isolation but interrelate with others to make meaning. Organizing new concepts/information into a form that shows these interrelationships help learners make mental connections; therefore, learners show their understanding of concepts more accurately (Ausubel 1960, 1963). Burggraf (1998) suggested that the best concept maps are those that learners generate by themselves. Each learner has a slightly different view and grasp of the concept, and those differences will show up on the maps they create. Concept maps are extremely versatile across a wide range of student abilities. The steps in concept mapping were clearly explicated by Novak, Gowin, and Johansen (1983). Concept maps can play an important role in

curriculum development, evaluation, learning, and teaching in many disciplines.

Burggraf suggests various uses of concept maps as study aids, assessments, reviews, homework assignments, small-group activities, portfolio materials, parts of tests, and writing exercises.

Achievement and Concept Mapping

According to Kinchin (2000), the use of concept mapping facilitated the planning of instructional sequences by providing a coherent structure to teaching materials and by making essential links explicit. The use of concept mapping in his biology classes helped students gain a more unified understanding of a topic, organize their knowledge for more effective problem solving, and understand the way in which they learn. He stated that concept maps also provided excellent summary and revision tools that condense large amounts of information. Moreover, concept maps can be used for summative assessment. David Brown (2002) recommended the use of concept mapping in science teaching and proposed that it to be presented as a creative activity.

Wallace and Mintzes (1990) stated that concept maps were vehicles for documenting and exploring conceptual change in biology. In their study, subjects in the experimental group showed evidence of significant and substantial changes in the complexity and propositional structure of their knowledge base, as revealed in the subjects' concept maps. Odom and Kelly (2001) explored the effectiveness of concept mapping, the learning cycle, expository instruction and a combination of concept mapping/learning cycle in promoting conceptual understanding of diffusion and osmosis. They concluded that the concept mapping/learning cycle and concept mapping treatment groups significantly outperformed the expository treatment group in conceptual

understanding of diffusion and osmosis. Therefore, it has been suggested by Wallace and Mintzes (1990) that concept mapping offers a valid and potentially useful technique for documenting and exploring conceptual change in biology.

Schmid and Telaro (1990) infused a concept mapping strategy within a high school biology course and determined that low ability learners' performance was facilitated. In addition, their data suggested that the process of creating a concept map is a more important factor than the resulting map.

BouJaoude and Attieh (2003) explored the effect of using concept maps as study tools on achievement in chemistry. The results showed that concept mapping helped low achievers achieve higher scores in chemistry and students exhibited positive attitudes toward using concept maps in chemistry. Their study also indicated that concept mapping provided a significant difference in achievement scores of female students, especially on questions at the knowledge and comprehension levels.

Snead and Snead (2004) examined the effects of concept mapping on the science achievement of middle grade science students. Analyses indicated no significant overall effects of treatment on science achievement. However, a statistically significant effect was found between concept mapping and student achievement among the average students. The results suggested that the effect of concept mapping on science was not clear, but that lower ability students appeared to have better success with concept mapping than higher ability students. Wang and Dwyer (2004) in their study found that concept mapping strategies can significantly improve student achievement of educational objectives.

According to Pankratius (1990), concept mapping was found to be a key to

organizing an effective knowledge base. He investigated the effect of the degree of concept mapping on achievement in a high school physics class. He concluded that for high school physics students mapping concepts prior to, during, and subsequent to instruction led to greater achievement as measured by posttest scores.

The study by Barenholz and Tamir (1992) described the use of concept mapping in design, instruction, and assessment related to microbiology lessons prepared for high school students. This study indicated that students utilizing concept mapping displayed an overall higher achievement than students in traditional classes. Fifty-five percent of high school students they polled claimed that concept mapping was very useful in organizing learning materials. In addition, they reported that in classrooms where the teachers were favorable toward concept mapping, students' attitude was reflected in the quality of maps drawn by them.

Through a meta-analysis, Horton, et al (1993) investigated the effectiveness of concept mapping as an instructional tool. Their results showed that concept mapping raised individual student achievement in the average student from the 50th to the 68th percentile. In addition, they documented that concept mapping had large positive effects on students' attitudes.

Elhelou (1997) assessed the effectiveness of the use of the concept mapping technique in the learning of science subjects by the students in a preparatory school. The results of his study indicated that the experimental class subjects achieved better than those of the control class.

According to Weisenberg (1997), concept mapping is an excellent group activity. In his study, Preszler (2004) found that the processes associated with constructing

concept maps in a cooperative learning format improves students' abilities to access information and use to answer challenging questions. He found significant improvements in students' understanding of biology as indicated by their performance on exams. He also suggested that combining concept mapping with cooperative learning allows students to use concept maps to facilitate communication about a knowledge domain, and through this communication to refine their understanding.

According to Boxtel, Linden, Roelofs, and Erkens (2002), concept mapping as a collaborative learning activity, was successful in provoking and supporting meaningful discourse among students. The results of these researchers are in agreement with the finding by Okebukola in 1992, that engaging in concept mapping alone or in collaboration with others makes a difference. Students working together cooperatively on the concept mapping tasks were found to attain meaningful learning better than students working individually. Furthermore, Okebukola and Jegede (1988) suggested that concept mapping promotes meaningful learning rather than learning by rote.

Ausubel (1960) states that meaningful learning results when a person consciously and explicitly ties new knowledge to relevant concepts or propositions he already possesses. Rote learning results when new knowledge is arbitrarily placed into the cognitive structure. Several studies (Horton, et al. 1993) have shown that concept mapping results in meaningful learning. Making a concept map helps learners become aware of and reflect on their own (mis)understandings; it helps students take charge of their own meaning- making (Boxtel, et al. 2002).

Concept mapping is an excellent activity to allow students to engage in extended science discourse. The maps provide students with a means to learn the language

patterns of science and construct scientific knowledge (Roth & Roychoudhury, 1992).

Therefore, it has been suggested by Lucy (1991) that the greater depth of understanding that comes from concept mapping utilization, in turn produces confidence in the learner's own abilities.

Summary

This chapter has presented a review of literature pertinent to the research topic.

Chapter 3 presents an explanation of how the study was conducted.

CHAPTER 3

Procedures

The vast majority of high school students may not be learning science as effectively as possible because the present way in which science is taught does not stimulate active learning. The dominant method of teaching is the traditional lecture in which students do not expend much energy thinking about what is being presented. In contrast, instruction with concept mapping provides a variety of opportunities for students to practice, interpret, and internalize the concepts of science. The purpose of this study was to investigate affective outcomes and academic achievement for students enrolled in high school biology by comparing concept mapping to traditional methods of teaching. The researcher studied students' satisfaction, perception of involvement and learning, and their understandings of the nature of science.

Research Questions

The following research questions guided the study:

1. How do the pre and posttest achievement scores compare between the students who receive biology instruction using concept maps vs. those who receive instruction via a traditional method?
2. What relationship exists between the method of teaching and students' attitude toward the biology classes and class activities as measured on chapter surveys?
3. What are the differences between students' understandings of biology content as measured by chapter tests using concept mapping compared to a traditional method?
4. What are students' perceptions of review activities that helped them learn to use concept maps or traditional methods?

Population and Sample

Freshman biology students from a metropolitan high school in the Midwest were used for this study. These students came from eight middle schools from the district. The sample selected included the 140 students assigned to the researcher's six classes. Two general biology sections and two honors biology sections were the experimental group and one general and one honors biology section were the control group. Students were assigned to these sections by building administrators and counselors without knowledge of the study. The researcher's advisor assigned sections from a hat to the control and experimental groups. The control group was taught by a traditional teaching method while the experimental group received instruction via concept mapping for the second chapter.

Instrumentation

There were six researcher designed instruments in this study: the two chapter pretests, two chapter posttests, a chapter questionnaire and a comprehensive posttest. Data were collected quarterly via researcher designed multiple choice and short answer pretest and posttest that addressed the content taught. The items for the pretest and posttest were adapted from a commercial text-based test bank from the textbook *Biology: The dynamics of Life 2004* (Biggs, Hagins, Kapicka, Rillero, Tallman, & Zike). An affective questionnaire for the intervention chapters was designed by the researcher to evaluate perceptions and interest of each group toward their present biology class and the teaching methods used. See Appendix A for sample chapter affective questionnaire. In addition, the adapted chapter tests from the textbook *Biology: The dynamics of Life 2004*, were used to measure differences of the experimental and control groups on the two

chapters covered during the nine weeks, the non-experimental chapter on ecology and the experimental chapter on cell parts and transport.

Treatment

Both groups received some standard instruction as required by the school district. These included sponge activities or anticipatory set that introduced the students to the topic, lecture, guided notes packets on which the students took chapter notes, laboratory exercises, worksheets and the chapter tests that were given at the end of each chapter. The experimental group also received instruction on how to construct a concept map (Appendix B) and finally chapter review was done by making a concept map. The control group worked through a study guide worksheet during the time devoted to concept mapping in the experimental group classes. Although both groups completed specific activities related to each chapter, these were modified for the experimental group to reflect the use of concept mapping. Table 1 outlines the instructional methods that the researcher employed.

Table 1

Instructional Activities for Experimental and Control Groups

Instructional Activities	Control Group	Experimental Group
Anticipatory set	X	X
Guided notes	X	X
Notes on concept cards		X
Concept mapping		X
Questioning	X	X
Pretest	X	X
Posttest	X	X
Worksheets	X	X
Projects	X	X
Labs	X	X
Review sheets	X	
Review games	X	X
Chapter surveys	X	X

The study was conducted during the fall semester of the school year. Two chapters were taught to the six sections of Biology covering a nine weeks period. A traditional method was used to teach the control and the experimental groups for the first half of the quarter. At the beginning of the quarter, the same pretest was administered to

the control and experimental groups. The pretest helped the researcher identify the pre-existing level of understanding of the concepts which were to be taught. In addition, it was used to evaluate the homogeneity of the entry knowledge level of the experimental and control groups. The researcher designed pretest, based on the textbook's commercial tests, required students to recall previous knowledge and apply basic principles and concepts to new or slightly different situations in order analyze information and draw conclusions.

For the second half of the quarter, the experimental group received the instructional interventions that involved concept mapping. The subjects in the experimental group learned to construct concept maps that helped them understand the concepts and their relationships with the ones already ordered in pre-existing mental structures. Guidelines to construct and practice these maps were given during classroom interactions by the researcher. See Appendix B for a description of how the concept mapping was introduced. Students' maps varied by the students' level of understanding of the information taught. See Appendix E for examples of student generated concept maps.

After the completion of each chapter, a posttest was administered to determine the level of achievement. The researcher generated posttest, evaluated students' ability to recall and interpret information, demonstrate understanding of facts and apply the basic principles and concepts learned to new situations. In addition, the researcher developed a questionnaire to elicit the attitudes that subjects had regarding their experience and their learning. At the end of the quarter the following data were available on each student: total points on overall pretests and quarter posttest, points on Ecology the unit with no intervention pretest and posttest, points on Cell transport intervention pretest and posttest,

and data on each item of the affective chapter questionnaire for cell transport. Table 2 presents the sequence of instruction and assessments completed during the quarter.

Table 2

Timeline for the Study

Week	Control	Experimental
1	Pretests Ecology	Pretests Ecology
2	T	T
3	T	T
4	CT Ecology +CQ	CT Ecology +CQ
5	Pretest Cell transport	Pretest Cell Transport
6	T	T + CM
7	T	T + CM
8	T	T + CM
9	CT Cell Transport +CQ	CT Cell Transport +CQ
10	T	T
11	T	T
12	Comprehensive Posttest	Comprehensive Posttest

T= Traditional Instruction

T + CM= Traditional + Concept Mapping

CQ= Chapter Questionnaire

CT=Chapter Test

Data Analysis

For research question one which asked “How do the pre and posttest achievement scores compare between the students who receive biology instruction using concept maps vs. those who receive instruction via a traditional method?” data were collected from the scores obtained on the overall quarter pre and post tests. The posttest achievement data were compared between the experimental and control groups using analysis of covariance for the pretest score. All control group classes were combined and compared with all experimental classes combined for this question. Throughout the study a significance level of $p < .05$ was used.

To answer question number two which asked, “What relationship exists between the method of teaching and students' attitude toward the biology classes and class activities as measured on chapter surveys?” the researcher constructed chapter survey questionnaires were used to determine students' attitudes towards biology and the learning of science concepts. The data were collected at the time of the chapter exam. The information from the chapter questionnaires was tabulated and analyzed for patterns of responses. The responses were computed for the yes/no type responses to the questionnaire items using a Chi square to determine if there was a relationship to the teaching method used.

The chi square test of statistical significance is a series of mathematical formulas which compare the actual observed frequencies of some phenomenon in the sample with the frequencies you would expect if there was no relationship at all between the two variables in the sampled population (Kirkpatrick, 2005). Therefore, chi square tests the actual results against the null hypothesis and assesses whether the actual results are

different enough to overcome a certain probability that are there due to sampling error.

Research question three asked about the students' understanding of biology content on the chapter tests comparing the control and experimental groups. Honors and general biology classes were analyzed separately for this question. A t-test for a significant difference on the mean chapter test scores between control and experimental groups were examined. Chapter pretest scores were also calculated to analyze homogeneity of the groups. Research question number four, which asked students' perceptions of their involvement and learning, was answered through analysis of narrative responses to the questions: 1. *What review activities helped you learn?* 2. *What will help you to be successful in taking the chapter test?* Descriptive evaluations of the comments from these questions were analyzed for similarities and differences in the experimental groups. The researcher looked for trends within and between the groups. These responses were tabulated into a table indicating the category of response and percentage of the students mentioning the category.

Human Subjects Approval

Human Subjects approval was sought and received from the University Research Compliance Office. Permission was also acquired from the appropriate representatives from the school district where the study was conducted. See Appendix C for consent letters and the University of South Dakota human subjects approval form.

Summary

Chapter 3 described the methods and procedures used to implement the study and analyze the data. Chapter 4 will present data interpretation and the results of the study.

CHAPTER 4

Results

Chapter 4 contains the results of the research questions posed in the study. The purpose of this study was to investigate affective outcomes and academic achievement for students enrolled in high school biology when instruction includes the method of concept-mapping. The experimental groups constructed concept maps, and control groups worked on review sheets for units under study.

Research Questions

1. How do the pre and posttest achievement scores compare between the students who receive biology instruction using concept maps vs. those who receive instruction via a traditional method?
2. What relationship exists between the method of teaching and students' attitude toward the biology class and class activities as measured on chapter surveys?
3. What are the differences between students' understandings of biology content as measured by chapter tests using concept mapping compared to a traditional method?
4. What are students' perceptions of review activities that helped them learn to use concept maps or traditional methods?

Description of the Student Population

The initial step in the study involved identification of 140 students from a public high school in the school district in the Midwest who were enrolled in freshman general and honors biology courses. Each of the selected students was a ninth grader (freshman) with an average age of fourteen years, with exception of four students: who were

sophomores or juniors.

All the six sections of the course were taught by the researcher. The experimental group consisted of two sections of general biology students and two sections of honors biology students. However, the two control groups included one general biology section and one honors biology section. Students were assigned to these classes by the School District counseling personnel with no knowledge of the study. The designation of control or experimental was determined by the researcher's advisor drawing the names of the class sections from a hat.

With the population of the study determined, the collection of data began. Appropriate arrangements were made between the researcher and the school district to conduct the study. There were 138 of the 140 students enrolled in these classes who completed all of the pretest, and chapter tests, and only 135 students who completed the post-tests used in this study. These data were used to answer research questions one and three. The chapter survey questionnaires were completed by 119 of the 140 students and this information was used for research question 2 and question 4. In some instances students did not respond to a specific item or marked between yes and no. This accounts for tables 8 through 14 having inconsistent participant numbers as only the "yes" and "no" responses were used.

All the data for the research study have been summarized in tables 3 through 25. Tables 3 and 4 summarize ANCOVA results on quarter posttest data. Tables 5 through 11 summarize chi square results on participants' interest levels on teaching methods and class activities. All participants' pre and posttest chapter test means are illustrated in tables 12 through 15. Honors classes chapter test mean comparisons are listed in tables

16 through 19. Finally, general biology class chapter test mean comparisons are illustrated in tables 20 through 23. Tables 24 and 25 depict the frequency distribution of review activities employed and the activities leading to success at taking the chapter test.

Research Question Data

Posttest Score Achievement Test Comparisons for Nine Weeks

The first research question examined how the pre and posttest achievement scores compare between the students who received biology instruction using concept maps and those who received instruction via a traditional method. To analyze this question, an ANCOVA (Analysis of Covariance) was used to compare the mean scores of the control and experimental groups on the posttest co-varying out the pretest score. The following results were achieved. Table 3 displays these data indicating there was no statistical difference overall when comparing posttest scores co-varying out the pretest score for the nine weeks when combining all control compared to all experimental groups. It should be noted that the experimental intervention occurred in only half of the quarter or one of the two chapters covered. Table 3 summarizes the adjusted posttest scores that indicated the students who used concept mapping did not differ significantly on the posttest from the students who did not receive instruction on concept mapping, $F(1, 132) = 0.722$.

Table 3

Adjusted Means for Posttest Scores on Analysis of Covariance with Posttest

Group	Posttest Mean	Adj. Posttest Mean	F	p
Control	103.98	105.192	.722	.397
Experimental	109.23	108.579		

Table 4 shows that there was a statistically significant interaction between total pretest and the groups: experimental and control, $F(1,132) = 58.36, p < .05$. However when controlling for the pretest, the results of the first research question confirm no statistically significant difference existed between experimental and control groups on the posttest.

Table 4

Covariance Analysis of Posttest Scores with Pretest Covaried

Source	Df	F	P
Between Groups			
Total Pretest	1	58.36	.000*
All Groups	1	.722	.397
Error	132		

* $p < .05$

Research question two asked, "What relationship exists between the method of teaching and students attitude toward biology class as measured on chapter surveys?" To answer this question a chi-square was used to compare the control and experimental groups' responses. There were seven different statements on the questionnaire. See Appendix A for the chapter survey questionnaire. A chi-square analysis was performed on each. The results of the analysis are as follows.

Data on the relationship of teaching method toward *fun and interest of the chapter* are summarized in Table 5. Results of the chi-square analysis indicated that a significant relationship existed between teaching method and *fun and interest of the chapter*, $X^2(6, N=119) = 119.337, p = .000$. More participants in the control group said 'yes' than expected, whereas less than expected said 'yes' in the experimental group. This indicates

that, the students receiving only traditional instruction found the chapter instruction fun and interesting at a higher frequency than expected.

Table 5

Relationship of Teaching Method toward Fun and Interest of Chapter

Responses	Groups	
	Control	Experimental
Yes		
Count	28.0	41.0
Expected	26.0	42.0
Std. Residual	0.4	-0.1
No		
Count	15.0	27.0
Expected	16.0	25.0
Std. Residual	-0.2	0.3

Data on the relationship of teaching method toward defining science concepts are summarized in Table 6. Results of the chi-square analysis indicated that a significant relationship existed between teaching method and students' perceived abilities of defining of science concepts, $X^2(6, N= 199) = 135.897, p = .000$. More than expected participants said 'yes' in the experimental group while fewer than expected said 'yes' in the control group. This means that more than the expected number of students receiving concept mapping said they could *define the science concepts in this chapter* and significantly fewer than expected perceived the same in the control group.

Table 6

Relationship of Teaching Method toward Defining Science Concepts

Responses	Groups	
	Control	Experimental
Yes		
Count	18.0	52.0
Expected	26.5	42.4
Std. Residual	-1.6	1.5
No		
Count	19.0	19.0
Expected	14.4	23.0
Std. Residual	1.2	-.8

Table 7 summarizes the results of the chi-square analysis on the relationship of teaching method toward students' perceived abilities at describing how science concepts were related. Results indicated that a significant relationship existed between teaching method and describing of science concepts in the chapter taught, $X^2(6, N=119) = 160.488, p = .000$. More than expected participants in the experimental or concept-mapping group said 'yes' to *I can tell how science concepts are related*, however, in the control group the opposite was true with more than expected saying they could not tell how the concepts were related.

Table 7

Relationship of Teaching Method toward Describing Science Concepts Relationships

Responses	Groups	
	Control	Experimental
Yes		
Count	4.0	47.0
Expected	19.3	30.9
Std. Residual	-3.5	2.9
No		
Count	28.0	23.0
Expected	19.3	30.9
Std. Residual	2.0	-7.8

Table 8 demonstrates the results of chi-square analysis on the relationship between teaching methods and students' perceptions of spending less time memorizing facts than in other science classes. Results indicated that a significant relationship existed between teaching method and less perceived time spent on memorizing science facts, $X^2(6, N=119) = 133.102, p = .000$. It is demonstrated that less than expected said 'no' and more than expected said 'yes'. More than the expected number of students in the experimental group said they did spend less time memorizing science facts, however, in the control group more than the expected number said they did not.

Table 8

Relationship of Teaching Method toward Less Time Spent on Memorizing Facts

Responses	Groups	
	Control	Experimental
Yes		
Count	2.0	24.0
Expected	9.8	15.7
Std. Residual	-2.5	2.1
No		
Count	41.0	47.0
Expected	33.3	53.2
Std. Residual	1.3	-.9

Data on the relationship of teaching method toward student perceived enjoyment working on the cell analogy assignment are revealed in Table 9. Results of the chi-square analysis demonstrated that a significant relationship existed between teaching method and student response to *I enjoyed working on cell analogy assignment*, $X^2(6, N=119) = 123.488, p = .000$. In both groups, slightly more than expected students said “yes” to this statement. Although significant, it should be noted there was a very little practical difference in the two groups in both the cases.

Table 9

Relationship of Teaching Method toward Enjoy Working on Cell Analogy Assignment

Responses	Groups	
	Control	Experimental
Yes		
Count	40.0	63.0
Expected	38.9	62.3
Std. Residual	0.2	0.1
No		
Count	3.0	8.0
Expected	4.2	6.7
Std. Residual	-0.6	0.5

Data on the relationship of teaching method toward thinking that the sponge activities activated interest in the lesson are revealed in Table 10. Results of the chi-square analysis demonstrated that a significant relationship existed between teaching method and thinking that the sponge activities activated interest in the lesson, $X^2(6, N=119) = 122.584, p = .000$. There were more 'no' responses than the expected in the experimental group indicating fewer than expected perceived the sponge activities activated their thinking. The opposite was true of the control group.

Table 10

Relationship of Teaching Method toward Sponge Activities

Responses	Groups	
	Control	Experimental
Yes		
Count	26.0	30.0
Expected	21.2	33.9
Std. Residual	1.0	-.7
No		
Count	17.0	40.0
Expected	21.6	34.5
Std. Residual	-1.0	.9

Table 11 reveals the results of chi-square analysis on the relationship of the teaching method toward the chapter test being easy. Results indicated a significant difference existed between chapter test being easy and teaching method, $X^2(6, N=119) = 128.284, p = .000$. More than expected participants in the experimental group said 'yes' to the statement: *The chapter test was easy for me*, while fewer than expected in the control group responded "yes" to this item.

Table 11

Relationship of Teaching Method toward Chapter Test being Easy

Responses	Groups	
	Control	Experimental
Yes		
Count	12.0	38.0
Expected	18.9	30.3
Std. Residual	-1.6	1.4
No		
Count	31.0	29.0
Expected	22.7	36.3
Std. Residual	1.7	-1.2

Chapter test differences between experimental and control groups

Question three asked, “What were the differences between students’ understandings of biology content as measured by chapter tests with concept mapping compared to a traditional teaching method?” To answer this question, t-tests were conducted to determine the differences between the experimental and control groups. Three sets of data analyses were used to respond to this question. Initially tested were the chapter test differences between all control vs. all experimental classes. Subsequently, data from the general biology classes and the honors biology classes were analyzed separately for this question.

Combined general and honors biology class comparisons

Two chapter tests were completed during the nine weeks. There was no intervention during instruction prior to the first chapter test which was on ecology. The concept maps

were used for review prior to the second chapter test for the experimental group which was on cell parts and transport. Table 12 and Table 13 display the mean performance of the combined general and honors biology control and experimental groups and the t-test comparison of these means. To demonstrate that the experimental and control groups were similar, data follow regarding the first chapter exams prior to concept mapping in Tables 12 and 13.

Table 12

Differences on Ecology Pretests Prior to Concept Mapping for All Participants
N=138

Group	N	M	SD	t	p
Control	47	9.02	1.661		
				.551	.582
Experimental	91	9.21	2.003		

p > .05

Data from Table 12 demonstrated that there was no significant difference between the control and experimental groups of combined general and honors biology classes at the pretest. Data from Table 13 demonstrated that there was no significant difference between the control and experimental groups on the ecology test taken by them after traditional instruction. This was the chapter prior to intervention.

Table 13

Differences on Ecology Posttest Prior to Concept Mapping for all Participants
N=138

Group	N	M	SD	t	p
Control	47	41.60	9.349		
				.693	.490
Experimental	91	42.70	8.660		

p > .05

Tables 14 and 15 include the data from the pretest of the chapter including the concept mapping intervention. Data in Table 14 demonstrated that there was no significant difference between the control and experimental groups on the cell transport pretest. These data were generated to demonstrate that the combined general vs. honors classes were similar in their knowledge on the topic.

Table 14

Differences on Cell Transport Pretest for all Participants
N=138

Group	N	M	SD	t	p
Control	47	7.09	1.932		
				.849	.397
Experimental	91	7.42	2.295		

p > .05

Data from Table 15 compare the mean chapter exams between the experimental and control groups combined following the concept mapping intervention. Results demonstrated that there was a significant difference in the mean scores between the control and experimental group using concept mapping. The mean for the experimental group was 26.45 out of 35 total points compared to 22.14 points for the control group.

Table 15

*Differences in Cell Transport Chapter test with Concept Mapping for all Participants
N=138*

Group	N	M	SD	t	p
Control	47	22.14	6.580		
				4.226	.000*
Experimental	91	26.45	3.271		

* $p < .05$

Chapter test differences between control and experimental honors classes

Data from Table 16 were used to analyze whether there were differences in the honors student groups prior to any intervention. The results in Table 16 indicate that there was no significant difference between the control and experimental honors groups on the ecology pretest.

Table 16

*Differences in Ecology Pretests Prior to Concept Mapping for Honors Biology Classes
N=74*

Group	N	M	SD	t	p
Honors Control	26	9.31	1.543		
				-1.456	.150
Honors Experimental	48	9.83	1.449		

$p > .05$

Table 17 reveals the data comparing the control and experimental honors groups on the ecology chapter posttest prior to intervention. Again, there was no significant difference between the two groups on the ecology test as indicated by Table 17 taken prior to concept mapping intervention in either honors group.

Table 17

*Differences on Ecology Posttest Prior to Concept Mapping for Honors Classes**N=74*

Group	N	M	SD	t	p
Honors Control	26	44.69	5.248		
				-1.303	.197
Honors Experimental	48	45.95	3.055		

p>.05

The following analyses compare the honors classes for the chapter in which the intervention occurred for the experimental group. Table 18 shows the cell transport chapter pretest scores between honors control and honors experimental groups. It was demonstrated in the table that there was a significant difference between the honors control and experimental groups before the concept mapping intervention on their knowledge of cell transport. The experimental group had higher scores than the control group.

Table 18

*Differences on Cell Transport Pretest for Honors Classes**N=74*

Group	N	M	SD	t	p
Honors Control	26	6.77	2.065		
				-2.586	.012*
Honors Experimental	48	8.13	2.199		

**p<.05*

Table 19 subsequently indicated that there was also a significant difference between the control and experimental honors groups on the cell transport posttest when using

concept mapping. Because of the differences in knowledge of the topic prior to intervention, these findings must be interpreted cautiously.

Table 19

Differences in Cell Transport Posttest with Concept Mapping for Honors Classes
N=74

Group	N	M	SD	t	p
Honors Control	26	25.40	4.304		
				-2.655	.003*
Honors Experimental	48	27.84	2.518		

* $p < .05$

General Biology Class Comparisons

Table 20 displays scores of the ecology pretest between control and experimental groups for general biology classes. The ecology chapter was used as a baseline to indicate similar knowledge and growth of the control and experimental groups. The data indicated that there was no significant difference between the groups following traditional methods without concept mapping.

Table 20

Differences in Ecology Pretest for General Biology Classes Prior to Concept Mapping
N=62

Group	N	M	SD	t	p
General Control	21	8.67	1.770		
				-.349	.695
General Experimental	41	8.44	2.324		

$p > .05$

After completing the unit on ecology the control and experimental groups took a

chapter posttest on the unit. Table 21 demonstrates the results indicating that there was again no significant difference between the groups following traditional methods without concept mapping.

Table 21

Differences on Ecology Posttest without Concept mapping for General Biology Classes
N=62

Group	N	M	SD	t	p
General Control	21	37.76	11.777		
General Experimental	41	38.63	11.229	.285	.777

$p > .05$

The next chapter on cell functions and transport was the experimental chapter. The general class control and experimental groups took a pretest on the cell functions and transport unit prior to concept mapping intervention. Table 22 shows the results between the two groups revealing that there was no significant difference.

Table 22

Differences on Cell Transport Pretest for General Classes on Chapter with Concept Mapping
N=62

Group	N	M	SD	t	p
General Control	21	7.48	1.721		
General Experimental	41	6.54	2.169	-1.724	.090

$p > .05$

When the cell functions and transport unit was completed by the general class groups, they took a chapter test on it. Table 23 results show a statistically significant difference

between the control and experimental groups. The experimental group scored significantly better ($M = 24.78$) than the control group ($M = 18.10$) on the posttest following the concept mapping intervention. Because there was no difference on the prior chapter, this is a statistically significant difference.

Table 23

Differences in Cell Transport with Concept Mapping for General Classes
N=62

Group	N	M	SD	t	p
General Control	21	18.10	6.737		
General Experimental	41	24.78	3.373	4.281	.000*

* $p < .05$

Research question four asked, “What are students' perceptions of review activities that helped them learn using concept maps or traditional methods?” To answer this question participants responses to the questions: *What review activities helped you learn?* and *What will help you to be successful in taking the chapter test?* were analyzed to look for trends within the groups. These questions were also part of the chapter survey questionnaires used for analysis of question two.

Table 24 displays the review activities that helped the participants learn the information in the chapters. It was determined that the review games were listed most frequently by the participants 31% as the activity that helped them learn the information taught. Only 5% participants recorded concept mapping as the activity that helped them learn. There were 9% participants who did not respond to this question on the survey. See Table 24 for other responses.

Table 24

Frequency Distribution of Review Activities that Helped Participants Learn for All Participants

Activity	N	%
Review Games	23	31
Worksheets	9	12
Labs	7	9
Sponge Activities	6	8
Concept Maps	4	5
Foldables	4	5
Taking Notes	3	4
Videos	2	3
Flashcards	2	3
Other Individual Response	8	11
No Response	7	9

Note: Some participants indicated more than one activity accounting for percentages greater than 100.

Table 25 displays the activities that participants perceived helped them to be successful in taking the chapter test. Results demonstrated that 32% students stated that simply “studying” will help them to succeed in taking the chapter test. Only 6.6% wrote that making concept maps would help them to be successful in taking the chapter test. See Table 25 for other activities.

Table 25

Frequency of Activities Leading to Success at Taking Chapter Test

Activities	N	%
Study	24	32.0
Review my notes	14	18.8
Review games	8	10.7
Review sheets	6	8.0
Concept Maps	5	6.6
Paying Attention	5	6.6
Other Individual Response	9	12.0
No response	4	5.3

Note: Some participants indicated more than one activity accounting for percentages greater than 100.

Summary

This chapter provided the statistical results and explanations of the results for each of the research questions. The results of ANCOVA, the t-tests and chi-square analyses were provided. In addition, descriptive statistics were provided. Chapter 5 will discuss the findings and conclusions of the research study as well as provide recommendations for future research.

CHAPTER 5

Summary

A summary of the study, major findings based upon the results, conclusions, related discussion, and recommendations for practice and further study are provided in this chapter.

Statement of the Problem

The purpose of this study was to investigate affective outcomes and academic achievement for students enrolled in high school biology when instruction includes the method of concept-mapping.

Research Questions

1. How do the pre and posttest achievement scores compare between the students who receive biology instruction using concept maps vs. those who receive instruction via a traditional method?
2. What relationship exists between the method of teaching and students' attitude toward the biology class and class activities as measured on chapter surveys?
3. What are the differences between students' understandings of biology content as measured by chapter tests using concept mapping compared to a traditional method?
4. What are students' perceptions of review activities that helped them learn to use concept maps or traditional methods?

Review of Literature on Research

Concept maps were first developed from the cognitive learning theory of David Ausubel in 1960s and 1970s and later popularized by Novak and Gowin. As graphic organizers, concept maps show how concepts are related or linked to each other.

According to Burggraf (1998) the best concept maps are those that students generate by themselves. Each student has a slightly different view and grasp of concepts, and those differences will show on the maps they create. These maps are personal to the students and give the teacher a direct look into students' understanding. Also, concept maps can play an important role in curriculum development, evaluation, learning and teaching in many disciplines (Novak et al., 1983).

In studies by BouJaoude and Attieh (2003) on chemistry education, Snead and Snead (2004) on science education, and Gordon (2002) on search behavior of tenth-grade biology students, concept mapping was found to result in improved instruction and student performance. According to Kinchin (2000), the use of concept mapping facilitated the planning of instructional sequences by providing a coherent structure to teaching materials and by making essential links explicit. He stated that concept maps also provide excellent summary and revision tools that condense large amounts of information.

Schmid and Telaro (1990) infused a concept mapping strategy within a high school biology course and determined that low ability learners' performance was facilitated. In addition, their data suggested that the process of creating a concept map is the more important factor, not the resulting map. Wang and Dwyer (2004) in their study found that concept mapping strategies can significantly improve student achievement of educational objectives. Pankratius (1990) investigated the effect of the degree of concept mapping on achievement on high school physics classes. He concluded that for high school physics students mapping concepts prior to, during and subsequent to instruction led to greater achievement as measured by posttest scores.

Barenholz and Tamir (1992) indicated that students utilizing concept mapping displayed an overall higher achievement than students in traditional classes. Fifty-five percent of high school students they polled claimed that concept mapping was very useful in organizing learning materials. They also reported that in classrooms where the teachers were favorable toward concept mapping students' attitude was reflected in the quality of maps drawn by them. Horton et al. (1993) showed that concept mapping raised individual student achievement in the average student from the 50th to the 68th percentile. In addition, they documented that concept mapping had large positive effects on students' attitudes.

Preszler (2004) suggested that combining concept mapping with cooperative learning allows students to use concept maps to facilitate communication about a knowledge domain, and through this communication to refine their understanding. Concept mapping is an excellent activity in allowing students to engage in extended science discourse. The maps provided students with a means to learn the language patterns of science and construct scientific knowledge (Roth & Roychoudhury, 1992). Therefore, it has been suggested by Lucy (1991) that the greater depth of understanding that comes from concept mapping utilization, in turn produces confidence in the learner's own abilities.

Methodology

Freshman biology students from a metropolitan high school in the Midwest were used for this study. Six biology classes: two general biology sections and two honors biology sections were the experimental group and one general and one honors biology section were the control group, based on random assignment. The 140 students were

assigned to individual classes by the school counselors and administrators without knowledge of the study. By drawing class periods from a hat, classes were assigned to control and experimental groups.

For the ecology chapter during the nine weeks of the quarter, both groups received the same instruction as required by the school district. This instruction included sponge activities or anticipatory set that introduced the students to the topic, lecture, guided notes packet on which the students took chapter notes, laboratory exercises, worksheets and the chapter tests that were given at the end of each chapter. At the beginning of the quarter, a quarter pretest was administered to the control and experimental groups. The pretest helped the researcher to identify the pre-existing level of understanding of the concepts which were to be taught.

During the last half of the nine weeks, instruction was modified for the experimental group. They received an instructional intervention that involved concept mapping as part of the chapter review process. The control group was taught by the traditional teaching methods used for the ecology chapter. The subjects in the experimental group learned to construct concept maps that helped them understand the concepts and their relationships. Guidelines to construct and practice these maps were given during classroom interactions by the researcher. The experimental group constructed concept maps for chapter review of key concepts while the control group used a review sheet to review.

Data were collected via researcher designed multiple choice and short answer pretests and posttests that addressed the content taught. The items for the pretest and posttest were adapted from a commercial text-based test. An affective chapter survey

questionnaire for the intervention chapters was designed to evaluate students' perceptions and interest toward their present biology class and the teaching methods used. See Appendix A for the chapter affective questionnaire. In addition, the adapted chapter tests from the textbook *Biology: The dynamics of Life 2004* were used to answer research question 3.

The achievement data to answer question 1 was compared between the two groups using analysis of covariance for the pretest score. Once the data had been collected, the information from the chapter questionnaires was tabulated and analyzed for patterns of responses for the question 2. The responses were computed for the yes/no type responses to the questionnaire items using a Chi square and narrative comments were combined to look for trends in the data qualitatively. To analyze question 3 a t-test for a significant difference on the mean chapter test scores between control and experimental groups was examined. Research question 4 analyzed narrative responses to the questions asked in the chapter survey. A descriptive evaluation of the comments from these questions was analyzed for trends within experimental groups. The results were summarized and compiled into tables as reflected in Chapter 4.

Major Findings

Research question 1: "How do the pre and posttest achievement scores compare between the students who receive biology instruction using concept maps vs. those who receive instruction via a traditional method?" Analysis of Covariance was used to compare the mean scores of the control and experimental groups on the posttest co-varying out the pretest score. The results indicated no statistical difference between the scores of students' with or without concept mapping across the whole quarter. The

adjusted posttest scores indicated that the students who used concept mapping did not differ significantly on the posttest from the student who did not receive instruction on concept mapping, $F(1, 132) = 0.722, p > .05$. It is important to note that this included the chapters with and without concept mapping. This may indicate students receiving concept mapping did not generalize the review skill across the review for the whole quarter.

Research question 2: “What relationship exists between the method of teaching and students’ attitude toward the biology class and class activities as measured on chapter surveys?” Results of the chi-square analysis indicated a significant relationship existed between teaching method and experimental group participants’ attitude toward biology class and class activities. There were seven different statements that were analyzed. The first statement was on the relationship between the method and fun and interest of the chapter. The results indicated that more than the expected number of students receiving traditional instruction found the chapter instruction fun and interesting. The second statement was on defining the science concepts in the chapter. The results were that more than the expected number of experimental group students said they could define the concepts while significantly fewer than expected in the control group said they could define the concepts.

The third statement on the questionnaire that was analyzed was on the relationship of teaching method toward students’ perceived abilities at describing how science concepts were related. In the experimental group more than expected said ‘yes’ and the opposite was true for the control group. The fourth statement was on the relationship between teaching method and students’ perception on spending less time memorizing facts than other science classes. Again, more than expected students in the experimental

group said they spent less time memorizing science facts. The fifth statement asked about the students' perceived enjoyment working on the cell analogy assignment. Both the groups said 'yes' more often than expected, but there was a very little practical difference between the actual and expected numbers. When asked about the relationship of teaching method toward thinking sponge activities activated interest in the lesson, results revealed fewer than expected participants in the experimental group perceived sponge activities activated their thinking, however, the opposite was true for the control group.

Finally, the relationship of teaching method toward the chapter test being easy was explored. More than expected participants in the experimental group said 'yes' while fewer than expected in the control group said 'yes' to this statement. A majority of experimental group participants had a higher than expected tendency to indicate a positive overall attitude toward the teaching methods used except for the sponge activities. This was not true, however, for the control group who indicated fewer than expected positive responses on many of these same items.

Research question 3: "What are the differences between students' understandings of biology content as measured by chapter tests using concept mapping compared to a traditional method?" T-test analyses were conducted to determine the differences between the two groups. Initially, the pretest data between all control vs. all experimental classes demonstrated no significant difference, therefore, combined general vs. honors classes were similar. On the chapter exam with no concept mapping, no differences were noted between groups. However, the mean scores on the chapter exam between the experimental and control group following concept mapping intervention

demonstrated a significant difference. The mean correct responses for the total experimental group was 26.45 out of 35 total points compared to 22.14 points for the total control group.

T-test analyses were also done to determine the differences between the honors and the general biology groups. A comparison of the control and experimental honors groups' experimental chapter pretest means indicated that there was a significant difference between groups at the $p < .05$ level. There was also a significant difference on the chapter test after intervention, but this time at the $p < .001$ level. Because there was a difference on the pretest, the posttest difference may or may not be due in part to the intervention.

General biology class comparisons indicated no significant difference on the chapter pretest prior to intervention. There was, however, a statistically significant difference between general class experimental and general control groups following the concept mapping. The experimental group scored significantly better ($M = 24.78$) than the control group ($M = 18.10$) on the chapter test following concept mapping intervention. As there was no difference on the prior chapter test or the chapter pretest, this is a significant difference attributable to concept mapping.

Research Question 4: "What are students' perceptions of review activities that helped them learn using concept maps or traditional methods?" Thirty-one percent of the participants responded that review games *helped them learn* and only five percent wrote concept mapping helped them. Other frequently mentioned activities identified as helping them learn included: worksheets (12%), labs (9%), sponge activities (8%), and foldables (5%). Thirty-two percent of the participants said studying will *help them to be*

successful in taking the chapter test and again only 6.6% stated concept mapping.

Other activities that the participants perceived helped them to be successful were reviewing notes (18.8%), review games (10.7%), review sheets (8%) and paying attention (6.6%).

Conclusions

The following conclusions have been drawn from analysis of the data and findings of the study:

1. Instruction in concept mapping did not result in significant differences on the comprehensive biology test nine week performance for the experimental group. There was no significant difference in achievement between the experimental and control groups on the posttest across the whole nine week period. This may mean that experimental students when compared with the control group did not generalize concept mapping skill over the entire quarter. They probably did not apply their knowledge of concept mapping to the review for the comprehensive posttest which was on the information covered for the full nine weeks.

2. The teaching method did have a positive effect on the students' attitudes towards the biology class and class activities for students receiving concept mapping instruction. More than the expected number of the experimental students indicated positive feelings about the class activities, their knowledge, and interest in the content. The differences in performance of the honors experimental students following concept mapping was limited when compared to the honors control group.

3. Concept mapping instruction had a positive impact on achievement particularly for the average ability or general biology students. Although there was some

for the average ability or general biology students. Although there was some improvement for the honors class students, it was not as evident.

4. Concept mapping was more effective for biology students when compared with students using review sheets to prepare for the chapter exam in biology.

5. Students in both general and honors classes were able to produce concept maps that categorized and linked key biological concepts.

6. Overall, ninth graders preferred review games over concept mapping to study for the tests. There were a few who found concept mapping helpful for review.

Discussion

When considering all participants (honors and general), the data indicated that concept mapping had no statistical significant effect on the experimental group when controlling for pretest scores, as measured by the 9 week comprehensive posttest. Several researchers (Lehman et al., 1985; Novak et al., 1983; Pankratius, 1990; Snead & Snead, 2004) concur with findings of the study. They found no significant difference between groups using concept mapping and groups that did not receive instruction in concept mapping. Prater and Terry (1988) concluded that key concept mapping enhances comprehension of factual/informative text but has no effect on written comprehension.

However, after making closer inspection of the data in this study there appear to be some important findings among participants' ability groups and achievement, as measured by chapter tests and affective chapter survey questionnaire. When looking at the data for honors (above average) students, concept mapping did not have much effect on the achievement scores for the intervention chapter (cell transport) test. There was a significant difference between honors experimental and control groups before the concept

mapping intervention on their knowledge of cell transport. This confounded interpretation of the only slightly greater difference between the groups on the chapter test. Schmid and Telaro (1990) offer a possible explanation for these findings, suggesting that with high ability students, the focus was likely to be on learning the technique of concept mapping rather than learning the concepts. Therefore, this group may have spent more time acquiring the concept mapping skills than learning the concepts.

A study by Pankratius and Keith in 1987 reveals a weak correlation between concept mapping scores and achievement. Stensvold and Wilson (1990, 1992) reported consistent findings. They suggested that concept maps might have limited the perception of high ability students because they might have had their own successful strategies for studying which were not applied when they used concept maps.

General (average) biology students' comparisons on the cell transport chapter test showed a statistically significant difference between the control and experimental groups. As there was no significant difference on the prior chapter test or the intervention chapter pretest, this was statistically significant. These findings are consistent with those researchers (BouJaoude & Attieh, 2003; Lehman et al., 1985; Novak et al., 1983; Schmid & Telaro, 1990; Snead & Snead, 2004) who reported improved achievement scores for average and low ability achievers using concept mapping.

According to Novak and Gowin (1984), concept mapping enables students to make interrelationships among concepts and link them to concepts already known to them. Heinze-Fry and Novak (1990) suggested that concept mapping reduces errors for students and helps them better organize and retain concepts. Thus, concept mapping was

students in the control group.

There was a significant difference between the teaching method and students' attitude towards biology class and class activities. This is consistent with the studies by BouJaoude and Attieh (1990) and Horton, McConney and et al. (1993); they all documented that concept mapping had large positive effects on students' attitudes. Novak et al. (1983) reported that concept mapping enhanced student motivation. Concept mapping gave the learners an opportunity to become active learners.

In reviewing the students' responses to the question, "What review activities help you learn?" it was determined that the review games were listed most frequently. This may be attributed to the fact that high school freshmen felt challenged through competition. The other question reviewed was "What activities will help you succeed in taking the chapter test?" Results indicated that thirty-two percent listed studying. It is evident that ninth graders understand the fact that studying before the test is essential. Although many students did not indicate that the concept maps helped them learn, it did appear to impact their overall achievement, particularly among the average ability group.

Recommendations for Practice

Assuming that these findings can be replicated with similar populations, the following recommendations are presented.

1. Concept maps appear to have a positive effect on student achievement for the general biology students and should, therefore, be used with such students in other schools.
2. Allow students ample time to become familiar with the concept mapping strategy. Provide students with sample concept maps for their perusal, and provide

2. Allow students ample time to become familiar with the concept mapping strategy. Provide students with sample concept maps for their perusal, and provide feedback on the concept map they construct.
3. Provide students with the key concepts to organize into a concept map as a review procedure.
4. The less-proficient mappers within groups should work with skilled mappers to avoid negative attitudes regarding concept mapping by some students.
5. Allow students to collaborate on concept mapping tasks. Many mappers in this study stated collaboration as a strategy that enhanced their concept mapping and understanding of concepts. Concept mapping provided opportunity for student discourse which served as a means to clarify and review course material.

Recommendations for Further Study

Additional studies could be conducted to investigate the following questions:

1. Does concept mapping influence achievement over the long term?
2. Does heterogeneous, cooperative grouping for concept mapping tasks enhance participants' achievement and attitudes?
3. Are traditional objective tests sensitive enough to detect differences in student achievement when using concept mapping?
4. What is the relationship between concept mapping and student learning styles?
5. Can concept mapping be applied to laboratory exercises?
6. What are the possible benefits of using computers to construct and present concept maps on student learning and motivation?

REFERENCES

- Anderson, R. O. (1976). *The experience of science*. New York: Teachers College Press
- Anderson, J. R. (1980). *Cognitive psychology and its implications*. San Francisco: W.H. Freeman and Co.
- Angelo, T. A. (1990). Classroom assessment: Improving learning quality where it matters most. *New Directions for Teaching and Learning*, 42, 71-82.
- Ausubel, D. P. (1960). The use of advance organizers in learning and retention of meaningful verbal material. *Journal of Educational Psychology*, 51, 267-272.
- Ausubel, D. P. (1963). *The psychology of meaningful learning*. New York: Grune and Stratton.
- Ausubel, D. P. (1968). *Educational psychology: A cognitive view*. New York: Holt, Rinehart, and Winston.
- Ausubel, D. P., Novak, J., & Hanesian, H. (1978). *Educational psychology: A cognitive view* (2nd ed.). New York: Grune and Stratton.
- Barenholz, H., & Tamir, P. (1992). A comprehensive use of concept mapping in design, instruction and assessment. *Research in Science and Technological Education*, 10(1), 37-52.
- Biggs, A., Hagins, W. C., Kapicka, C., Rillero, P., Tallman, K., & Zike, D. (2004). *Biology: The dynamics of life*. Columbus, OH: The McGraw Hill Companies, Inc.
- BouJaoude, S., & Attieh, M. (2003). *The effect of concept maps as study tools on achievement in chemistry*. Awka Nigeria: Nnamdi Azikiwe University. (ERIC Document Reproduction Service No. ED47730)

- Boxtel, C., Linden, J., Roelofs, E., & Erkens, G. (2002). Collaborative concept mapping: Provoking and supporting meaningful discourse. *Theory into Practice, 41*(1), 40-46.
- Boyle, J. R., & Yeager, N. (1997). Blueprints for learning: Using cognitive frameworks for understanding. *Teaching Exceptional Children, 29*(4), 26-31.
- Brown, A. L., Bransford, J. D., Ferrara, R. A., & Campione, J. C. (1983). *Handbook of child psychology: Cognitive development*. New York: John Wiley and Sons.
- Brown, D. S. (2002). Creative concept mapping. *Science Education, 69*(3), 58-61.
- Bruner, J. S. (1960). *The process of education*. Cambridge, MA: Harvard University Press.
- Burggraf, R. W. (1998). *Thinking connections concept maps for life science*. Pacific Grove, CA: Critical thinking books & software.
- Dale, D. E. (1992). A program excellence in physics and physical science teaching. *Journal of Science Teacher Education, 3*, 109-114.
- Dewey, J. (1936). *How we think*. Boston: D C Heath and Co.
- Eby, J. W., & Kujawa, E. (1994). *Reflective planning, teaching, and evaluation: K-12*. New York: Merrill, an imprint of Macmillan Publishing Company.
- Elhelou, M. A. (1997). The use of concept mapping in learning science subjects by Arab students. *Journal of Educational Research, 39*, 311-317.
- Flavell, J. H. (1963). *The developmental psychology of Jean Piaget*, New York: D. Van Nostrand.
- Gayford, C. G. (1988). Biology and human biology courses: Pupils experience and attitudes of different types of teaching and learning activity. *International*

Journal of Science Education, 10(1), 71-88.

- Gordon, C. A. (2002). Methods of measuring the influence of concept mapping on student information literacy. *School Library Media Research*, 5 (ERIC Document Reproduction Service No. EJ656193).
- Harty, H., Hamrick, L., & Samuel, K. V. (1985). Relationships between middle school students' science concept structure interrelatedness competence and selected cognitive and affective tendencies. *Journal of Research in Science Teaching*, 22, 179-191.
- Heinze-Fry, J. A., & Novak, J. D. (1990). Concept mapping brings long-term movement toward meaningful learning. *Science Education*, 74, 461-472.
- Horton, P. B., McConny, A. A., Gallo, M., Woods, A. L., Senn, G. J., & Hamelin, O. (1993). An investigation of the effectiveness of concept mapping as an instructional tool. *Science Education*, 77(1), 95-111.
- Inhelder, B & Piaget, J. (1958). *The growth of logical thinking from childhood to adolescence*. New York: Basic Books.
- Jackman, D. H., & Swan, M. K. (1996). *Instructional models effective in distance education*. (ERIC Document Reproduction Service No. ED398867).
- Johnson, D. W., & Johnson, F. P. (1994). *Joining together-group theory and group skills*. Boston: Allyn and Bacon
- Joyce, B., & Weil, M. (1986). *Models of teaching* (3rd ed.). Englewood Cliffs, NJ: Prentice Hall, Inc.
- Joyce, B., Weil, M., & Showers, B. (1992). *Models of teaching*. Boston: Allyn and Bacon.

- Karplus, R. (1977). Science teaching and the development of reasoning. *Journal of Research in Science Teaching*, 14, 169-175.
- Kauchak, D. P. & Eggen, P. D. (1993). *Learning and teaching: Research based methods* (2nd ed.). Boston: Allyn and Bacon.
- Kinchin, I. M. (2000). Concept mapping in biology. *Journal of Biological Education*, 34(2), 61-68.
- Kirkpatrick, L. A. (2005). *A simple guide to SPSS for windows: For version 12*. Belmont, CA: Thompson/Wadsworth Co.
- Lawson, A. E. (1985). A review of research on formal reasoning and science teaching. *Journal of Research in Science Teaching*, 22, 569-618.
- Lawson, A. E. (1988). A better way to teach biology. *The American Biology Teacher*, 50, 266-274.
- Lawson, A. E. & Renner, J. W. (1974). A quantitative analysis of responses to Piagetian tasks and its implications for curriculum. *Science Education*, 58, 454-559.
- Lazarowitz, R., Baird, H. N., & Bowlden, V. (1996). Teaching biology in a group mastery learning mode: high school students' academic achievement and affective outcomes. *International Journal of Science Education*, 18, 447 – 462.
- Lehman, J. D., Carter, G. J., & Kahle, J. B. (1985). Concept mapping, vee mapping, and achievement: Results of a field study with black high school students. *Journal of Research in Science Teaching*, 22, 663-673.
- Leonard, W. H. (2000). How do college students' best learn? *Journal of College Science Teaching*, 29, 385-388.
- Lord, T. (1998). Cooperative learning that really works in biology teaching. *American*

Biology Teacher, 60, 580-588.

- Lucy, E. (1991). *Get your hands on concept mapping*. Workshop presented at the National Science Teachers Association Annual Meeting, Houston, TX, March 27-30.
- Marzano, R. J., Gaddy, B. B., & Dean, C. (2000). *What works in classroom instruction?* Aurora, CO: Mid-continent Research for Education and Learning.
- McKenna, H. J., & Hand, M. (1985). *A guidebook for teaching biology*. Newton, MA: Allyn and Bacon, Inc.
- Moore, N. (1970). Teaching teachers. *National Elementary Principal*, 48(4), 30-41.
- National science education standards* (4th ed.). (1996). Washington, DC: National Academy Press.
- Niehaus, J. (1994). Learning by frame working: Increasing understanding by showing students what they already know. *Journal of College Science Teaching*, 24(2), 22-25.
- Novak, J. D. (1979). Applying psychology and philosophy to the improvement of laboratory teaching. *The American Biology Teacher*, 41, 466-470.
- Novak, J. D., & Gowin, D. B. (1990). *Learning how to learn*. Cambridge: Cambridge University Press.
- Novak, J. D., Gowin, D. B., & Johanson, G. T. (1983). The use of concept mapping and knowledge vee mapping with junior high school science students. *Science Education*, 67, 625-645.
- Odom, A. L., & Kelly, P. V. (2001). Integrating concept mapping and the learning cycle to teach diffusion and osmosis concepts to high school biology students. *Science*

Education, 85, 615-635.

Okenbukola, P. A. O., & Jegede, O. J. (1988). Cognitive preference and learning mode as determinants of meaningful learning through concept mapping. *Science Education*, 72, 489-499.

Education, 72, 489-499.

Okebukola, P. A. O. (1992). Can good concept mappers be good problem solvers?

Educational Psychology, 12, 113-129.

Orlich, D. C., Harder, R. J., Callahan, R. C., Kauchak, D. P. & Gibson, H.W. (1994).

Teaching strategies: A guide to better instruction (4th ed.). Lexington, MA: D. C. Heath and Co.

Orlich, D. C., Harder, R. J., Callahan, R. C., & Gibson, H.W. (1998). *Teaching*

strategies: A guide to better instruction (5th ed.). Boston, MA: Houghton Mifflin Co.

Ormrod, J. E. (2000). *Educational psychology: Developing learners* (3rd ed.). Upper Saddle River, NJ: Prentice-Hall, Inc.

Osioma, U. N. (1997). *Remediation of gender inequity in science in a developing country: An experiment with cooperative concept mapping*. (ERIC Document Reproduction Service No. ED406169)

Pankratus, W. J., & Keith, T. M. (1987). *Building an organized knowledge base:*

Concept mapping in secondary school science. Paper presented at the Annual Meeting of the National Association for Science, Washington, DC, March 26-29.

Pankratus, W. J. (1990). Building an organized knowledge base: Concept mapping and achievement in secondary school physics. *Journal of Research in Science*, 27, 315-333.

- Piaget, J. (1964). Cognitive development in children: Development and learning. *Journal of Research in Science Teaching*, 2, 176-186.
- Piaget, J. (1972). *The psychology of intelligence*, New Jersey: Littlefield, Adams and Co.
- Prater, D. L., & Terry, A. (1988). Effects of mapping strategies on reading comprehension and writing performance. *Reading Psychology*, 9(2), 101-120.
- Preszler, R. (2004). Cooperative concept mapping. *Journal of College Science Teaching*, 33(6), 30-35.
- Roth, W. M., & Roychoudhury, A. (1992). The social construction of scientific concepts or the concept maps as conscription device and tool for social thinking in high school science. *Science Education*, 76, 531-537.
- Sanchez, J. (1985). A model of biology lesson design based on a synthesis of modern learning theory and science inquiry techniques (Doctoral dissertations, Columbia University Teachers College, 1985). *Dissertation Abstracts International*, 46-09A, AAG8525514.
- Sanchez, J. (1991). The construction of biology lessons: A meta-paradigmatic approach. *The American Biology Teacher*, 53, 410 – 415.
- Schmid, R. F., & Telaro, G. (1990). Concept mapping as an instructional strategy for high school biology. *Journal of Educational Research*, 84(2), 78-85.
- Shaftel, F. R., & Shaftel, G. (1982). *Role playing in curriculum* (2nd ed.). Englewood Cliffs, NJ: Prentice Hall, Inc.
- Snead, D., & Young, B. (2003). Using concept mapping to aid African American students' understanding in middle grade science. *Journal of Negro Education*, 72, 333-343.

- Snead, D., & Snead, W. L. (2004). Concept mapping and science achievement of middle grade students. *Journal of Research in Childhood Education, 18*, 306-317.
- Stensvold, M. S., & Wilson, J. T. (1990). The interaction of verbal ability with concept mapping in learning from a chemistry laboratory. *Science Education, 74*, 473-480.
- Stensvold, M. S. & Wilson, J. T. (1992). Using concept maps as a tool to apply chemistry concepts to laboratory activities. *Journal of Chemical Education, 69*, 230-232.
- Suchman, J. R. (1966). *A model for analysis of inquiry: Analysis of concept learning*. New York: Academic Press.
- Wallace, J. D., & Mintzes, J. J. (1990). The concept map as a research tool: Exploring conceptual change in biology. *Journal of Research in Science Teaching, 27*, 1033-1052.
- Wang, C. X., & Dwyer, F. (2004). Effect of varied concept mapping strategies on student achievement of different educational objectives. *International Journal of Instructional Media, 31*, 371-381.
- Weisenberg, R. C. (1997). Appropriate technology for the classroom using "Post-it Notes" as an active learning tool. *Journal of College Science Teaching, 26*, 339-344.

Appendix A
Chapter Questionnaire

Questionnaire

Use this evaluation to assess your experience with the chapter, "Cell Parts and Transport". This evaluation will tell how you feel about it. The score will not affect your grade. Read each statement carefully and pick yes or no that best describes how you feel about the statements.

- | | | |
|---|-----|----|
| 1. The chapter, 'Cell Parts and Transport' was interesting and fun. | Yes | No |
| 2. I am able to define the science concepts in this chapter. | Yes | No |
| 3. I can describe how the science concepts are related in this chapter. | Yes | No |
| 4. I spent less time memorizing facts than I have in other science classes. | Yes | No |
| 5. I enjoyed working on cell analogy assignment. | Yes | No |

One thing I learned in doing cell analogy worksheet _____

- | | | |
|---|-----|----|
| 6. I enjoyed the 'Basic Unit of Life' lab | Yes | No |
|---|-----|----|

One thing I learned from the lab was _____

- | | | |
|--|-----|----|
| 7. I learned from the questions asked by the teacher during the discussion of the chapter. | Yes | No |
| 8. I think the sponge activities activated my interest in the lesson that followed. | Yes | No |
| 9. What review activities helped you learn?
_____ | | |

- | | | |
|---|-----|----|
| 10. The chapter test will be easy for me. | Yes | No |
|---|-----|----|

What will help you to be successful in taking the chapter test?

Appendix B

Instructions on how to construct a concept map

Introduction to Concept Mapping

Today we are going to learn how to make a concept map. A concept map is a diagram that shows how ideas (concepts) are organized and related. We are going to learn, what is a plant and functions of its parts. The students will be given a stack of index cards with the following concepts on one side of the card and their definitions on the other: Plants, food, green, flowers, seeds, color, stems, petals, leaves, and roots. The students will be given some time to read the definitions on the back of the cards. The following steps are going to be followed: First, we are going to ask ourselves a question, "Is there a main idea(s) or an important idea (concept) to which all other concepts are related"? "Yes and in this lesson it is "Plants". The card with plants written on it can be placed in center on the top in your work area. Second, go through the stack again and decide which concepts or ideas you think are most important or how these are related to our big idea like stems, leaves, flowers, roots, seeds. Third, place these cards under or around the main idea. Fourth, look for arrows with link-words on them; these were given to the students along with the cards. The ideas will be connected with the arrows that have a word or phrase that explains the meaningful connection between and among them. Fifth, think how these ideas can be related to our big idea. Read the definitions and look for link-words or phrases like composed of (have) or made of, includes, produces, example or type, depends on, characteristic, is affected by, stores, function or causes. Finish linking all the concepts starting with the most general to the most specific terms. For example, plants are composed of roots, leaves and stems. Sixth, read the definitions on the back of the cards again. Keep adding more cards and connect them with the link words. Finally, look for cross-links (arrows) that show some relationships other than the initial one. For example, flowers produce seeds and seeds store food.

The Steps summarized below:

1. Read the concept cards.
2. Select the most important term or main idea to which all the other concepts can be related by reading definitions on the back. Put this card at the top or center of your work area.
3. Reread the definitions and identify the ideas that can be ranked from most general to most specific.
4. Arrange the ideas.
5. Link the ideas using the linking words.
6. If an idea relates to other ideas in another portion of the map show relationship by using a cross-link.

During the intervention, the students did this for cell parts and for cell transport which were the two main topics. It was introduced with 3X5 index cards but the students used their notes to identify the concepts and create their own concept maps to review.

Appendix C

Human Subjects Approval

UNIVERSITY OF SOUTH DAKOTA
HUMAN SUBJECT COMMITTEE

CERTIFICATION OF REVIEW/APPROVAL

PROJECT TITLE: A Comparison of Inquiry-Based Teaching Through
Concept Maps and Traditional Teaching in Biology

TRACKING NUMBER: 100-02-012

PROJECT DIRECTOR: Linda Reetz, Sangeeta Gulati

DATE APPROVED: August 12, 2002

PROJECT PERIOD: August 12, 2002 – August 11, 2003

TYPE OF REVIEW: Exempt

RISK INVOLVED: Minimal

APPROVAL/COMMENTS: This protocol was reviewed and approved for a period of one year from the date of approval.

FOLLOWUP REVIEW OF THIS PROPOSAL IS SCHEDULED FOR: August 2003

YOU MUST OBTAIN PRIOR APPROVAL FOR ANY SIGNIFICANT CHANGES IN YOUR RESEARCH PROTOCOL.

THIS REVIEW WAS CONDUCTED IN ACCORDANCE WITH THE PROCEDURES STIPULATED BY THE UNIVERSITY OF SOUTH DAKOTA'S ASSURANCE OF COMPLIANCE WITH US DHHS REGULATIONS FOR THE PROTECTION OF HUMAN RESEARCH SUBJECTS. (45 CFR 46)

CERTIFICATION OF 'EXEMPT' REVIEW ACTION:

Howard Cohen emc
USD Research Compliance Officer

08-12-02
Date Approved

Campbell, Barbara

From: Campbell, Barbara
Sent: Thursday, July 22, 2004 8:38 AM
To: 'sgulati@usd.edu'
Cc: Reetz, Linda
Subject: project continuation

Thank you for filing the continuation request for the human subject research project entitled "A Comparison of Inquiry-Based Teaching through Concept Maps and Traditional Teaching in Biology." The information has been reviewed and the continuation request added to the file. Your project has been continued until **August 11, 2005**. The official letter of continuation will be sent to you via campus exchange mail in care of Dr. Reetz in the near future. Thank you for keeping us informed.

Barbara Campbell
Secretary
USD Research Compliance Office
301 Pardee
677-6184

July 22, 2004

Sangeeta Gulati
Dr. Linda Reetz
School of Education
Division of Curriculum & Instruction
University of South Dakota

PROJECT TITLE: A Comparison of Inquiry-Based Teaching Through Concept Maps and
Traditional Teaching in Biology

Dear Ms. Gulati, Dr. Reetz:

We have received your request for continuation of the above referenced project.

When this study is completed please submit a Closure Form to the IRB. You may close your project when contact with the subject has ended. You must obtain **PRIOR** approval for any changes in your research protocol.

The forms to assist you in filing your closure form, progress report, or amendments are available at: www.usd.edu/oorsch/Compliance%20Forms.

If you have any questions, please contact me: lkorcusk@usd.edu or (605) 677-6184.

Sincerely,



Lisa Korcuska
IRB Manager
Associate Director-Research Compliance
University of South Dakota
Institutional Review Boards

The University of South Dakota IRBs operate in compliance with federal regulations and applicable laws and are registered with the Office for Human Subject Protections (OHRP) under FWA # 00002421.

Appendix D

Request Forms

XX. XXXX XXXX
Principal
XXXX High School
XXXX, NE.

August 2004

Dear Dr. XXXXX,

I am requesting permission to conduct the study entitled "A Comparison of Inquiry-based Teaching through Concept Maps and Traditional Teaching in Biology" at XXXX High School. I am a biology teacher at XXXX High School. I am also a doctoral student at the University of South Dakota, Vermillion, SD. This research study is a part of my dissertation.

The purpose of the study is to explore whether students will show greater achievement of and appreciation for biology with the use of inquiry-based learning methods. The study will be conducted at XXXX High School on a random sample of my biology classes and will cover a period of nine weeks during fall of 2004. In addition to the traditional methods and departmental guidelines, two classes will receive inquiry-based lessons and two classes will serve as control groups. The achievement data from all four classes will be used in my study.

I will need a letter of permission from you to complete the study at XXXX High School for the University of South Dakota, Human Subjects Office.

Your prompt attention to this request will allow me to begin the actual research. I want to thank you in advance for your time and assistance.

Sincerely,

Sangeeta Gulati
Phone #: (402) 557-3264
Home: (402) 651-6978
Email: sangeeta.gulati@ops.org

The study is being done under the direction and with approval of my doctoral advisor in the Division of Curriculum and Instruction at the University of South Dakota.

Dr. Linda J. Reetz
Associate Dean, School of Education, USD.
Phone # (605) 677-6072
Email: lreetz@usd.edu

XX. XXXXX XXXXX
Superintendent of Schools
XXXXX XXXX XXXXX
XXXX, XX.

August 2004

Dear XX. XXXXX,

I am requesting permission to conduct the study entitled "A Comparison of Inquiry-based Teaching through Concept Maps and Traditional Teaching in Biology" at XXXX High School. I am a biology teacher at XXXX High School. I am also a doctoral student at the University of South Dakota, Vermillion, SD. This research study is a part of my dissertation.

The purpose of the study is to explore whether students will show greater achievement of and appreciation for biology with the use of inquiry-based learning methods. The study will be conducted at XXXX High School on a random sample of my biology classes and will cover the three chapters for a period of nine weeks during fall of 2004. In addition to the traditional methods and departmental guidelines, two classes will receive inquiry-based lessons and two classes will serve as control groups. The achievement data from all four classes will be used in my study.

I will need a letter of permission from you to complete the study at XXXX High School for the University of South Dakota, Human Subjects Office.

Your prompt attention to this request will allow me to begin the actual research. I want to thank you in advance for your time and assistance.

Sincerely,

Sangeeta Gulati
Phone #: (402) 557-3264
Home: (402) 651-6978
Email: sangeeta.gulati@ops.org

The study is being done under the direction and with approval of my doctoral advisor in the Division of Curriculum and Instruction at the University of South Dakota.

Dr. Linda J. Reetz
Associate Dean, School of Education, USD.
Phone # (605) 677-6072
Email: lreetz@usd.edu

XXXXXX
Director of Research
XXXXXX Public Schools
XXXXXX

August 2004

Dear XX. XXXXX,

I am hereby submitting my research proposal for conducting the study entitled "A Comparison of Inquiry-based Teaching through Concept Maps and Traditional Teaching in Biology" at XXXXX High School. I am a biology teacher at XXXXX High School. I am also a doctoral student at the University of South Dakota, Vermillion, SD. This research study is a part of my dissertation.

As requested, I have enclosed the required documentation. I have also contacted XX. XXXX XXXXX, principal, XXXX High School to grant me permission to conduct the study.

Your approval to this request will allow me to begin the actual research. I want to thank you in advance for your time and assistance.

Sincerely,

Sangeeta Gulati
Phone #: (402) 557-3264
Home: (402) 651-6978
Email: sangeeta.gulati@ops.org

The study is being done under the direction and with approval of my doctoral advisor in the Division of Curriculum and Instruction at the University of South Dakota.

Dr. Linda J. Reetz
Associate Dean, School of Education, USD.
Phone # (605) 677-6072
Email: lreetz@usd.edu

Appendix E

Samples of concept maps made by students

