AN ASSESSMENT OF APPLIED BIOLOGY/CHEMISTRY CURRICULUM AS COMPARED TO TRADITIONAL BIOLOGY CURRICULUM

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Submitted to the Faculty of the
Graduate College of the
Oklahoma State University
in partial fulfillment of
the requirements for
the Degree of
DOCTOR OF PHILOSOPHY
December, 1994

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ACKNOWLEDGMENTS

I would like to express my sincere appreciation to the many people who made this graduate study possible. First, I would like to thank my advisor Dr. Terence Mills. Dr. Mills' patience, encouragement, and his sharing of expertise were major components in the success of my research project. Secondly, I would like to express my gratitude to Dr. James Key, for his guidance, assistance, and sense of humor. Also, I would like to express my appreciation to the other members on my committee, Dr. S. L. (Bud) Burkes and Dr. Margaret Ewing.

A special thanks goes to the teachers and administrators of Edmond Public Schools. Their support, hard work, and belief in me made my research possible.

I would like to thank my mother, Doralee Miles, and my grandmothers, Eula Miles and Zalia Holman for never doubting my abilities and for making it possible for me to continue my education.

A most sincere appreciation goes to my children for sharing the burden of responsibilities and for offering support throughout my educational career.

Lastly, a special thanks goes to Randy Kirk. His companionship, support, and assistance made this research project a reality.

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CHAPTER I

INTRODUCTION

Educators have the very complicated task of providing instruction to large numbers of students, with wide ranges of abilities, while still maintaining high quality studies. Naveh (1985) stated that the "schools of today aim at educating the society of tomorrow, and this same society will determine the tomorrow of the world" (p. 85). The researcher further stated that education should envision the future, thereby, providing students with the ability to find "better solutions to new problems" (p. 85) through the development of attitudes and increased abilities. This challenge is complicated by the variation in student personality, maturity, intelligence and learning styles. This study addresses the issue of learning styles, how they affect the child's ability to retain abstract information regarding science phenomena, and the use of application of curricular concepts as a learning tool.

Davidson (1990) defined learning styles as "the unique ways whereby an individual gathers and processes information and are the means by which an individual prefers to learn" (p. 36). He proposed that through identification of each student's learning style, the instructor could match his/her teaching method to the appropriate learner's style. Secondly, he stated that this knowledge can increase the diversity of the techniques used for instruction. Davidson also premised that the students will benefit by being aware of their own needs and be able to control, to some degree, their own learning experience. Lastly, the researcher believed that through learning style identification, an observable "diversity of styles" (p. 38) will be recognized; thereby producing a means to increase awareness and acceptance of those who are different.

Curricular areas requiring abstract thought and reasoning produce problems for some students which affect their ability to learn effectively. One area of study that many students have difficulty with is science. Finley (1991) believed that texts are primarily responsible for this difficulty due to their lack of adequate description and explanations regarding natural phenomena, adequate description and explanations. Pace (1986) believed that science curriculum has been written by authors with backgrounds in content area only, hence, little instruction or "assistance" is offered in understanding science concepts (p. 1). Walker and Wilson (1991) believed that imagery can be used as an alternate learning tool which could provide science concept information and eliminate the confusion and complexity which exists today. The researchers stated that by "Using familiar images, teachers can prompt students to elaborate on textbook analogies and thus improve students' understanding of unfamiliar scientific explanations" (p. 160). Ewing and Mills (1994) have pursued this approach in teaching biology.

Knuttgen (1991) explained that "scientific literacy" (p. 1) is an umbrella term which greatly affects "contemporary society" (p. 1). Science education is of greater importance today as it affects many aspects of our daily lives including, "environment, health, medicine, agriculture, food production, and technology" (Roberts, 1983 in Knuttgen, 1991, p. 1). However, recent studies have shown that students within the United States score lower on science assessments than students in other countries. Knuttgen, therefore, emphasized the need for a revision of science instruction and suggested the use of alternative, non-traditional teaching methods as a way to increase science concept retention rates.

One non-traditional teaching method being investigated is applied academics. In 1984, Roghoff and Lave (in Raizen, 1989) investigated the development of "a completely different line of inquiry" (p. 36). The line of inquiry involved a problem solving process using mental activities with the addition of the "social and physical context" (p. 36). The following statement summarized the researchers' belief that academic instruction and learning should include problems facing people in the real world:

> Students need much more than abstract concepts and self-contained examples. They need to be exposed to the use of a domain's conceptual tools in authentic activity-to teachers acting as practitioners and using these tools in wrestling with problems of the world . . . Classroom tasks . . . can completely fail to provide the contextual features that allow authentic activity. At the same time, students may come to rely, in important but little noticed ways, on features of the classroom context, in which the task is now embedded, that are wholly absent from and alien to authentic activity. Thus, much of what is learned in school may apply only to the ersatz activity, if it was learned through such activity (Brown et al. in Raizen, 1989, p. 36).

It was the goal of this research to provide support of the theory that application integrated into academic curricula, through Applied Biology/Chemistry (ABC), is an integral part of the educational system. It is believed that without the use of application as a teaching technique and learning style, some portion of the student population is not being educated to its maximum potential. Piaget and Paivio (in Greeson & Zigarmi, 1985) stated that alternate learning styles are very important in the education of the young and play a definite role in supplying a concrete aspect to figural parts of the environment.

Problem Statement

"There has been a growing realization that the meanings for words and views of the world that even high school and college students bring with them to science lessons may have an inordinate effect on learning science" (Osborne and Cosgrove, 1983, p. 825). Mills (1990) stated that it is possible for students to pass high school and college science classes and still not have basic concepts that are transferable to the understanding and application of science-related phenomena. If these concepts are not fully understood, then the basic understanding of science-related concepts and the application of those concepts will not be passed to future generations and will affect the existence of the world as is known today.

Significance of Study

The most important goal of an educator is to provide curriculum, instruction, and a climate so that the maximum educational experience can occur. This includes identifying the needs of every student within the classroom. Scientific phenomena has been found to be a weak area of study within the educational system. Therefore, instructors need to identify the sources of the problem and provide curriculum which will increase understanding and retention rates of scientific concepts. In order to accomplish this goal, educators must understand different learning styles and provide experiences which fulfill the needs of each learner.

Definition of Terms

The following definitions were used for the purpose of this study:

Applied Method of Teaching--an application based instructional method using curriculum and instruction developed through the application of concepts to "real-world" problems through the use of hands-on laboratories, text-based activities, and video-assisted activities (CORD, 1993, p. T-2).

Applied Biology/Chemistry (ABC)--integrates biology and chemistry concepts by applying the concepts to "real-world" issues (CORD, 1993, p. T-3).

Biology Concepts- measured by the National Association of Biology Teachers/National Science Teachers Association (NABT/NSTA) Biology Test; measures the performance of students regarding biological knowledge. The NABT/NSTA has a normed performance standard deviation of 13.77, standard error at .46, coefficient of variance 30.54, a mean score of 45.09, and a range of 67.

Environmental Attitudes--measured by the Ecology Attitudes Inventory (EAI); "measures the predisposition of an individual in the evaluation of some psychological object as it relates to the sum total physical, chemical, biological, social economic, political, aesthetic, and structural surroundings for organisms" (Willard, 1976; Knapp, 1972; Katz, 1960 in Mosely, 1993, p. 25). The instrument is divided into subunits of verbal commitment(VC), actual commitment (AC), affect (A), and knowledge (K). The Pearson reliability coefficients were .91, .93, .92, and .89 respectively.

ITBS/TAP--Iowa's Test of Basic Skills (K-8 series) and Tests of Achievement and Proficiency (9-11 series); a nationally normed aptitude assessment. The science portion of the assessment primarily identifies the ability to understand the "nature of science and secondarily to specific concepts relating to earth science, life science, and physical science" (Riverside Publishing Co., 1986, p. 4). Internal consistencies and equivalent-form reliability coefficients are in the range of .80-.90.

Learning Styles--measured by Learning Styles Assessment by the 1976 revised edition by Kolb; is described as the "educational conditions under which a student 'is most likely to learn' and is characterized by the students' conceptual level of development" (Hunt, 1979 in Hyman and Rosoff, 1984, p. 37). The internal reliability as measured by Cronbach's alpha's (n=268) is concrete experience (CE) .82, reflective observation (RO).73, abstract conceptualization (AC) .83, active experimentation (AE) .78, abstract-concrete (AC-CE) .88, and active-reflective (AE-RO) .81.

Rural Area Schools--schools located in a community with a population less than 25,000 (Mosely, 1993, p. 27).

Science Attitudes--measured by the Attitude Towards Science Assessment (ATSAA) authored by Germann; measures how students "feel" about science in relation to school (Germann, 1988). Reliability was greater than Cronbach's alpha at 0.95; discrimination was demonstrated by norm-total correlations ranging between 0.61 and 0.89.

Suburban Area Schools--schools located in a community with a population greater than 25,000 (Mosely, 1993, p.27) and located directly outside of the inner city.

Traditional Biology Curriculum--theory based presentation of biology concepts primarily using lecture as the teaching method of instruction. The curriculum was based on Holt-Reinhart's text, Biology.

Traditional Teaching Method--theory based presentation of curriculum primarily using lecture as the teaching method of instruction. Newport (1986) described this teaching method as teaching a unit of course material in a specific block of time where the teachers are primarily concerned with subject matter only.

Purpose of the Study

The purpose of this study was to compare the Applied Biology and Chemistry (ABC) curriculum with the traditional biology curriculum. This study tried to determine if students learn biology concepts and/or environmental concepts and exhibited a better attitude towards science and/or the environment using the ABC curriculum as compared to students who were taught with a traditional biology curriculum.

Assumptions

1. The teachers, instructed in the use of the applied academics, administered the ABC science curriculum in a similar manner.

2. The teachers, instructed in the use of traditional teaching methods, administered the traditional science curriculum in a similar traditional method.

3. The teachers recorded data accurately and honestly.

4. The classroom climate was similar.

5. The students underwent treatment on the same day.

6. The ABC instructors completed a two week workshop on how to administer the ABC curriculum.

Limitations

1. The students in the control group were chosen through their enrollment into already existing biology classrooms.

2. The students in the experimental group were selected according to the following criteria: learning style, overall GPA, previous science grade, reading level, TBS score in science, and career interest.

3. The experimental group was primarily comprised of ninth grade students and the control group was primarily comprised of tenth grade students.

4. The experimental group's previous class was earth science and the control group's previous class was physical science.

5. The experimental and control groups were not randomly selected. The students were selected through intact classes.

Research Questions

The research attempted to answer the following research questions:

1. Does the students' ability to understand biology concepts increase through the use of ABC?

2. Does the science aptitude regarding biological concepts of students increase through the use of ABC?

3. Does the attitude of students towards science change through the use of ABC?

4. Does the attitude of students towards environmental issues change through the use of ABC?

5. Does the science aptitude of students increase through the use of ABC?

6. Does the students' knowledge regarding environmental concepts increase through the use of ABC?

7. Do students with specific learning styles learn biology concepts better using the ABC curriculum?

8. Does the ABC curriculum fill the needs of suburban students better than the needs of rural students?

Organization of the Study

Chapter I identifies the task of educating today's youth. It documents the need for the identification of student learning styles, the need for non-traditional teaching methods in instructing abstract curriculum, e.g., science concepts, and the use of the

ABC curriculum in teaching biology concepts. Chapter I also provides a purpose for the research study and lists the research questions that are answered in Chapter V. Chapter II provides a historical review of American education, a description of educational curriculum, cites research previously conducted regarding learning styles, describes hemispheric brain differences, explains methods of teaching science concepts, identifies obstacles in teaching science concepts, reviews environmental education, notes attitudes towards science and environmental education, and identifies the use of application as a learning tool. Chapter III identifies the null hypotheses, a description of the research design including the population being studied, instrumentation, and the method used in conducting the research. Chapter IV provides quantitative and qualitative data, tables, and an analysis of the collected data. A summary of the study, followed by the conclusions, recommendations, and implications are located in Chapter V.

CHAPTER II

REVIEW OF LITERATURE

Introduction

All nations are facing issues of survival; therefore, societies must strive for perfection using past knowledge and spirit. Educational tools of today and tomorrow must be designed to support all human life. The tools should include educational philosophy regarding science curriculum, be designed to give an awareness of global environmental issues, teach students how to become problem solvers, and lifelong learners.

This review of literature begins with the history of American education and is followed by a description of educational curriculum, learning styles, hemispheric brain differences, teaching science concepts, obstacles in teaching science concepts, environmental education, attitudes towards science and environmental education, and the use of application as a learning tool.

History of American Education

The history of America's educational system must be reviewed in order to understand the needs that have demanded its establishment. As Pulliam (in Shepherd and Ragan, 1982) stated, "Its main significance, however, lies in building a foundation from which made our schools and the critics who wish to alter them" (p. 418). The historical goal of education has primarily been to bring societal needs into better context and understanding. Shepherd and Ragan described schools as being both "tools of society" and "tools for society" (p. 461), i.e., school's are designed primarily for society's maintenance, growth, and change. It is believed that the "dominant society" (p. 461) lays the foundation for the curriculum which is used in the schools. Society contributes information to the schools in the areas of religion, ethics, politics, and nationalism. These contributions to the educational system maintain the present needs of society and prepare the next generations for the changes needed for survival.

Shepherd and Ragan (1982) cited reform movements that have highly influenced the educational system:

1647-1776	Dependence to Independence
1776-1876	Independence to Nationalism
1876-1929	Agriculture to Industry
1929-1945	Depression to Hiroshima
1945-1957	Peace to Sputnik
1957-1969	Assertion to Apollo II
1969-1978	Exploration to Inflation
1978-present	Inflation to Conservatism

The evolution of America's educational system has been noted as being due to outside forces and not from professionals inside the institution; again due to the needs of the dominant society. Curriculum has been established to meet the needs of the time and social climate. Shepherd and Ragan used a parable to describe man's plight developing the next era of curriculum for America's educational system.

> Man first stood as a toolmaker. He patterned tools from the models he found within himself. His first implements were fashioned to magnify the strength of muscles; spears, hammers, bows and . . . He became a user and victim of these muscle-expanding tools. Man then fashioned tools to extend his senses; telegraph, telephone, television . . . . He became a user and victim of the brain-extending tools. Man has been and will continue to be a tool builder, user, and victim . . . A victim to be destroyed in body by the power to overkill, in mind by the power of medically and chemically induced adjustment (p. 454).

Educational Curriculum

Shepherd and Ragan (1982) believed that the economy of the nation influences society and have classified the current era of human times as being in "disequilibrium" (p. 4). The needs of society not only influence but mold the curriculum and instruction within the educational system. The researchers defined curriculum as the "sum of all the experiences of children for which the school/educator accepts responsibility by creating plans, selecting activities, establishing procedures, and providing reinforcements" (p. 1). It is stated that at times of disequilibrium, numerous alternate forms of curriculum emerge. These alternate forms can and should lead to the development of curricula which meet the needs of the students; thereby, creating an environment where students can achieve a self-awareness through their educational experiences. Therefore, the ultimate goal of the educational system is to establish groundwork and to provide pathways in order to "perpetuate the structure of society" (p. 4).

Liner (1992) noted that currently the educational system is faced with a society of diverse family backgrounds. The family structures include poverty, latchkey children, abandonment, single parent families, confrontations from gangs, drugs, drug users, and transient lifestyles. Graves (in Liner, 1991) expressed his concerns: "86% of the new jobs require problem-finders . . . 46% of high school seniors are unfit for all but 17% (or maybe 2%) of the jobs . . . We can no longer prepare kids for a world that will no longer exist-and in fact does not exist now" (p. 8). Liner identified six aspects of learning:

1) Immersion-Students must have an opportunity to have an abundance of materials at their disposal.

2) Demonstration-Teachers model the skill and learn with the student.

3) Engagement-Students become involved in their learning; thereby, internalization occurs. Three components are seeing the task as do-able, seeing themselves as thinkers, and seeing the task as purposeful to their lives.

4) Expectation-Students learn what they are expected to learn.

5) Responsibility-Students must have the opportunity to have a choice of what to learn (within a large boundary.)

6) Approximation-Students should be free of risk and should be allowed to fail, i.e., learning can come from attempting to accomplish a task.

Liner (1992), Simmons and Resnick (1993), and Raebeck (1994) all believed that current curriculum and tools for assessment are not conducive to today's societal, hence, educational needs. Raebeck condemned the use of the bell-shaped curve. The researcher noted that with this form of evaluation process, in order for students to succeed other students must fail. This leads to students who leave the educational system never having experienced success.

Schools provide the basis or foundation for the future lives of all students. Therefore when students leave schools never having been successful, they carry a self-prophecy of failure into future family and career situations. Raebeck believed that schools must change by instituting the philosophy that every one can be successful. The new paradigm will create an atmosphere where students and staff both experience success.

Simmons and Resnick (1993) characterized the current academic system as being from the 1920's and not sufficient for the 1990's. They believed that a revision of tools used for assessment could establish a basis for educational change. The research identified the use of performance based standards for evaluating student success. These standards will be developed through a consortium called the New Standards Project (NSP) which is comprised of 17 states and several leading school districts. The tasks or standards being developed are designed to resemble real life situations or job related tasks and evoke wanted behaviors. It was stated that the establishment of a performance based assessment was one alternative method created to encourage equity by providing tasks developed by a diverse group of people. The NSP believes that their standards would meet the needs of today's society through the implementation of a new innovative approach to curriculum design, student assessment, and instruction designed to meet "world-class standards" (p. 15).

Glasser (1990) identified the need to promote high quality work from both businesses and schools. Deming (in Glasser, 1990) assisted the Japanese in their paradigm shift from an elitist society with low quality work to a society where everyone provided high quality products. Glasser uses this philosophy to describe a Deming-based school system where all students would experience the feeling of success and the ability to produce high quality work. The researcher believed that the students, after seeing that they are successful and productive, will want to strive for even greater quality and success.

Learning Styles

Learning styles are defined as "the way that students of every age are affected by their a) immediate environment, b) own emotionality, c) sociological needs, d) physical characteristics, and e) psychological inclinations when concentrating and trying to master and remember new or difficult information or skills" (Carbo, Dunn, & Dunn, 1986, p. 2) and supported by Dunn, Shea, Evans, and MacMurren (1991). Students who are allowed to learn their own learning styles attain higher achievement and attitude scores. Research conducted at a North Carolina elementary school comprised of a high percentage of poor African American children witnessed a gain in the CAT scores from the 30th percentile to the 83rd percentile after implementing the Dunn and Dunn model of learning style (LS). A second study conducted at a middle school in Columbia, Missouri studied reading gain scores. Prior to the implementation of the LS model, only 12% of the students obtained a nine month growth or better within a 12 month period whereas after the LS model implementation, 64% of the students obtained a four month or more growth rate within a four month period (Dunn, 1990 in Dunn, Shea, Evans, & MacMurren, 1991). A third study by Orsak (1990 in Dunn, Shea, Evans, & MacMurren, 1991; Marshall, 1990) recorded that 27 students from Corsicana High School had previously failed math classes throughout their high school careers and had failed three times on the state mandated exit exams. All 27 students successfully completed the required math competency test after being instructed with their preferred learning style.

Redden in 1991 identified different learning strategies and defined them as "one parameter of how a student perceives, interacts, and responds to the environment" (p. 26). It was found that some terms used synonymously with other frequently used terms actually have very different meanings. For example, it was cited by Keefe (in Redden, 1991) that cognitive style involves "processing habits involving perception, problem solving, and remembering," (p. 3) affective style involves "attention, emotion, and valuing,"(p. 3) and physiological styles are genetically influenced either through "gender, personal nutrition, and physical environment reactions" (p. 3); hence, the terms do not have the same meaning. A second identified problem was in the definition of ability as related to skills. In Redden's research the term ability is related to general capacities of the students including coordination, visual imagery, and kinesthetic abilities.

Redden's research explored the use of specific teaching styles to identified student learning styles. The research addressed Anshel's (1988) and Anshel and Ortiz's (1986) studies which stated that when instructors allow students to use different learning styles, the students increased their academic performance and "enhanced learning efficiency" (p. 1). The tool used in learning style identification was a survey called the HIP (Human Information Processing Survey by Torrance, Taggart, & Taggart, 1984). One hypotheses dealt with the students' ability to visualize, and the students' preference. The results showed that there was no relationship between preference and the use of imagery. The researcher's rationale of this phenomena included the fact that perhaps the students were ignorant of their preferred learning style and that their choice was skewed due to the familiarity of a specific style. The results of this study were inconclusive; however, the researcher believed that there was sufficient data to continue work in this area.

Marshall (1990) believed that "success in learning is basic to success in life" (p. 62). At-risk students commonly do not have their needs met; instead they are faced with more pressure to succeed in an environment designed to enhance their failure. The researcher's motto was, "If students don't learn the way we teach them, then we will teach them the way they learn" (p. 62). Marshall's philosophy has shown to be the catalyst for student success, e.g., La Porte, Texas, and Corsicana, Texas.

The use of learning styles as an educational tool was supported by Dunn and Griggs (1989). The researchers conducted observations at schools in Florida, Illinois, Indiana, Minnesota, New York, Pennsylvania, Texas, Washington, and Wyoming.

Teachers identified individual learning styles specific for all students. Individual classrooms were either redesigned or the students were able to accommodate their learning style in the traditional classrooms. Computerized programs were established which allowed the students to print out individual assignments or activities which paralleled their learning style. In other schools, alternate days were used in order to rotate morning and afternoon classes. Instruction at eight schools was converted into diversified forms; thereby, accommodating the different styles of learning. The teachers reported to the researchers that the students felt less like "rejects" (p. 42), were experiencing success, and the at-risk students were coming to school and performing in "their" (p. 42) way. Also, the teachers expressed the fact that they felt as if their teaching style or instruction had "come alive" (p. 42).

Matching learning styles to teaching styles is called "learning style based education or LSBE" (Hyman and Rosoff, 1984, p. 34). The researchers pointed out that teaching styles are defined not by student personality or I.Q., but by characteristics which relate to the teachers actions, e.g., articulation, tone, organization of materials, and assessment modes. Hunt (1979 in Hyman, & Rosoff, 1984) defined learning style as the amount of structure a student requires to learn. Learning styles was conceptually defined by Hunt (1977-78 in Hyman & Rosoff, 1984): "Conceptual level is a characteristic based on developmental personality theory that describes persons on a developmental hierarchy of increasing conceptual complexity, self-responsibility, and independence" (p. 36). The researchers identified five factors involved in teaching:

teacher, student, subject matter, environment, and time. The following six recommendations were listed for teachers:

1) Educators must "accept a more inclusive perspective on teaching" (p. 39).

2) Educators must realize that the educational environment is constantly changing.

3) Educators must look at learning styles not as ability but as an action.

4) Educators must realize that learning is more comprehensive than cognitive performance.

5) Educators must accept that they can control only their actions.

6) Educators must eliminate their unilateral approach to teaching and rely upon an approach which consists of "mutuality, jointness of purpose, and bilateralism" (p. 41).

The following five recommendations were given for students:

1) Students must take a "critical approach in the examination of educational issues or classroom problems" (p. 42).

2) Students must omit traditional classroom norms.

3) Students must develop ownership of their classroom and understand rationales for "school regularities" (p. 42).

4) Students must learn to accept their own experiences and prejudices.

5) Students must learn to "examine critically the processes of their own socialization as teachers (Zeichner, 1981-82 in Hyman & Rosoff, 1984, p. 42).

In summary, the researchers addressed the complexity of the act of matching learning styles to teaching styles. In addition, Hyman and Rosoff stressed the importance of the concept by stating that matching learning styles to teaching styles is essential in order to effectively educate all students.

Davidson (1990) supported the theory that educators should match learning styles to teaching styles. The researchers believed that due to logistic problems, educators must not only try to match students to teachers; students must be taught how to effectively use this information in regular classroom settings. The study of learning styles should provide students with the information to become aware of the "cognitive and affective diversity among students" (p. 37); the ability to control their "learning situations" (p. 37); and to be able to understand diversities of people. In summary, due to the current lack of research regarding learning styles, they should only be used as a "framework to describe the cognitive and affective diversity of students and, in turn, promote a diversity of instructional methods to support and enhance variations among students" (p. 38).

Critics of the American educational system have stated that today's youth are unable to "compete in the global market place" (Dunn, Shea, Evans, & MacMurren, 1991, p. 93) in part due to the current practice of teaching in primarily one style. State and federal governments are bound by law regarding the fifth and fourteenth amendments which address equal protection. In 1954, the court case Brown v. Board of Education called for education "to all on equal terms" (p. 94). Clearly stated, the educational system is bound by law via legislation and court rulings to educate all students; therefore, teaching styles must be provided to meet the needs of all students. By providing adequate opportunities for students, the different individuals will successfully learn by their learning styles or by learning how to utilize their strengths and weaknesses.

Hemispheric Brain Differences

The brain is an organ constructed of white, myelinated nerve fibers and gray matter with few nerve cell bodies, nonmyelinated nerve fibers and nerve cell bodies, which form three lobes. The three lobes are the forebrain, midbrain, and the hindbrain. The forebrain develops into two lateral outgrowths called the cerebral hemispheres which form the major portion of the adult brain. A longitudinal fissure, a deep groove, divides the cerebrum into two functional hemispheres called the right and left hemispheres and are connected by the great commisure (Langley, Telford, & Christensen, 1969). These hemispheres are "mirror twins" (Jacob & Francone, 1966, p. 194), each having nerves for sensory and motor activities, determining reason, memory, and intelligence. Each hemisphere primarily deals with one side of the body; however, in some instances, if one side of the brain is damaged, the corresponding area on the other hemisphere can develop control of those specific functions in the damaged area (Jacob & Francone, 1966).

The brain functions as a transmitter of electrical and chemical impulses conducted through nerve impulses (Langley, Telford, & Christensen, 1969). Eccles (1970, in Naveh, 1985) described learning as a process which involves chemical change. This deduction evolved from the fact that if "learning is defined in terms of 'behavioral change' and brain function in terms of 'chemical change,' then learning which takes place in the brain (mind), must involve chemical change" (McGraw-Hill, 1969, p. 48).

Research conducted by Ragle (1984), concerning the theory of differential specialization of the two hemispheres, found that research has been conducted since World War I and II. Goldstein (in Ragle) found that early neurophysiological studies showed that when the left hemisphere was damaged, speech was affected and when the right hemisphere was damaged, speech was not affected; however, "perception to space, distance, direction, etc., and patterns, faces and geometric forms were not recognized" (p. 38). Ragle stated that there was some indication of individual differences being created due to the differential development between the two hemispheres (p. 39). Sperry and Myers (in Naveh, 1985) performed similar studies with cats and primates. It supported the concept that the brain does have bilateral functions; therefore, the brain acts like it has "two brains" (p. 51). This theory is further supported by Johnson and Mykelbust (1967 in Ragle, 1984) through the findings that some learning disabilities may be caused by either the dysfunction of one of the hemispheres or by the lack of integration between the two hemispheres.

Pelletier (1978 in Ragle, 1984) believed that research over simplifies the theories of right-left brain hemisphericity. The researcher believed that the cerebrum works more unitarily than dualistically. Naveh (1985) stated that if the two hemispheres are left intact, i. e., not severed where it is necessary for the two halves to adapt differently, the right and left hemisphere will work as a whole. This theory supports the principles of holistic learning, "the education of the whole person" (p. 15).

Dean and Gray (l985) designed and implemented research which was associated to learning and the differences between the neuro-stimuli received by the two hemispheres of the brain, i.e., neuropsychological factors. Pavio (1971 in Dean & Gray, 1985) identified "two distinct yet interactive memory systems" (p. 3) which are associated with the brain. The left hemisphere processes abstract-verbal information more than the right hemisphere. The researchers cited studies conducted by Broca (1895) and Jackson (1874) which involved the use of diseased brains; both concluded that the left hemisphere was more efficient with the aspects of speech and language. In 1969, Sperry, Gazzaniga, and Bogen (in Dean & Gray, 1985) concluded that the left hemisphere associates linguistic functions while the right hemisphere associates visual-spatial data. Gazzaniga (1978) further emphasized that the "left hemisphere was found to be specialized for analytic and verbal processing, while the right hemisphere is specialized for holistic, synthetic, perceptual processing" (in Naveh, 1985, p. 52). In summary, the research stated that the right hemisphere of the brain processes visual cognitive stimuli more efficiently than the left. However, the functions of the brain are very complex and are unique for every individual (Dean & Hua 1983; Levy, 1969). Naveh (1985) listed the following individual differences which produce individuality: 1) genetic structure, 2) critical periods of growth, 3) levels of stimulation, 4) gender, 5) culture, 6) ontogeny, and 7) genetics.

Dean and Gray (1985) conducted an experiment to further analyze the hypotheses regarding bilateralization of the brain. The research supported the theory that there is a "dual coding strategy" (p. 8) which follows the theory of "hemispheric specialization line" (p. 9). It also supported the theory that there are individual differences which affect the encoding of abstract stimuli. This theory was also supported by Johnson (1976 in

Naveh, 1985) who described the findings of Gardner and Orenstein's studies: the left hemisphere was responsible for "language, planning, verbal expression, and mathematical computation...; therefore, resulting in inductive and deductive reasoning" (p. 55) and the right hemisphere was primarily responsible for "spatial orientation, artistic and musical endeavors, crafts, body image, recognition of focus and intuitive creative thought" (p. 55). Dean and Gray summarized that due to the differences between individuals and to the neuropsychological factors, learning difficulties may occur as a result of the integration of visual and verbal learning strategies used during the instruction of material.

Carbo, Dunn, and Dunn (1986) identified that the two hemispheres of individuals have different "arousal levels" (p.19). This is supported by Levy (1982 in Carbo et al., 1986) as being related to cognitive and affective aspects. They contributed the difference in learning styles to the difference in arousal levels. For example, the left brained person may succeed better using an analytical method of learning while the right brained person will be more successful using a sight method. The research supported this theory using Dunn, Cavanaugh, Eberle and Zenhausern's (1982) theories regarding environmental observations which affect left and right brained learners differently, e.g., right brained learners are less distracted by sound, bright light, informal design, and nonconventional schools. They are also less tenacious, like cooperative learning, and excel with tactile and kinesthetic learning methods.

Teaching Science Concepts

In America's effort to reach the moon in the 1960's, the educational system turned its efforts to increasing the amount of math and science curriculum within the school system. Jim Uphoff (in Willis, 1993) stated that because of the launching of the Sputnik by the Russians, school age children were instructed to do "oodles of sit-still, pencil-and-paper work" (p. 2) which was not age level appropriate. The goal was to produce scientists which could help America beat the Russians. Today, the United States has put the first man on the moon, the Cold War is over, and technology has empowered all aspects of civilization; therefore, the needs of society have changed. The educational system must conform to those changes and it must prepare all youth to become lifelong learners and productive citizens in an ever-changing world. This goal can be accomplished through the development of a science and technology curriculum which meets the needs of a diverse and changing society.

Fort (1993) noted that the field of science has become extremely complex as a result of the rapid expansion of knowledge. The author stated, "Biology, chemistry, physics, geology have been fractioned into 40,000 research fields represented by more than 70,000 journals...high school teachers who do not do their homework this weekend will be 3,000 discoveries behind on Monday morning" (p. 675). Understandably, people cannot be expected to understand all scientific knowledge; however, they can be expected to learn basic scientific concepts. The author noted that scientific data is being compounded by the influence of creationism and astrology. Today 61% of the students believe in the theory of creationism in contrast with only 50% in 1988.

Fort (1993) believed that "scientific savvy" (p.675) can be attained through the changing of public attitude by creating an awareness of how science and technology affect human population. Science and technology can positively influence scientific investigation and offer a "chance for the planets' survival" (p. 676). Citizens must be made aware that the world has become a "global village" (Fort,1993, p. 676).

> a thug in the Persian Gulf can bring a quarter of a million Americans to Saudi Arabia, ruin the area's ecology, provoke the use of billions of dollars of weapons to take thousands of lives, and remain in power . . . a memo penned in Iowa City can be read in Moscow just minutes later . . . a nuclear accident in Chernobyl can affect 400 million people . . . as far away as 2,000 kilometers.

Over one-half of Congressional laws deal with scientific or technological issues. If voters are to make informed decisions then they must have some "scientific savvy" (p. 675). Scientific awareness can be constructed by offering an "enriched environment" (p. 680) where students who are otherwise turned-off from science will become turned-on. The science curriculum should offer real world situations and an opportunity to use problem-solving skills that will be needed for a world largely changed by technology. The role of the scientific curriculum should help to form the citizens of the world and give them the knowledge to make informed decisions.

Carey and Smith (1993) noted that science curriculum must allow students to "understand the nature of the scientific enterprise itself" (p. 235). In other words, with the ever-increasing amounts of scientific knowledge, it is impossible to teach students every science concept in existence plus all of the new knowledge that is being documented daily. Therefore, science education should provide opportunities for students to experiment, critique experts, ask questions, and engage in learning activities. The researchers believed that students should be taught through a "more constructivist epistemology of science" (p. 236) i.e., develop an understanding that scientific knowledge is a "consequence of successful conjecture, rather than its precursor" (p. 236).

Carey and Smith cited data established through research by Broughton (1978); Chandler (1987); Kitchener and King (1981); Kuhn, Amsel, and O'Loughlin (1988); and Perry (1970). In summary, the researchers believed that individuals progress through developmental stages as they acquire knowledge. The transformation begins with young children establishing a "common sense epistemology" (p. 237) through the experiences collected via his/her sensory modalities "arising unproblematically from observations" (p. 237) and through the acceptance that knowledge is a "collection of many true beliefs" (p. 237). Adolescents obtain information via "perceptial experiences" (p. 238) or through information which is given to them. The late adolescent enters into a phase where they begin noting differences between the ways individuals interpret data, including what they believe to be experts. This can create an "epistemological crisis" (p. 238), i.e., the late adolescents believe that there is "no true knowledge and everybody is free to believe whatever they want" (p. 238). Mature learners enter into a third stage where knowledge must be justified via "patterns of data" or "interpretative frameworks"

(p. 238) and that beliefs can be merited. Wellman (1990) and Sodian and Wimmer (1987, in Carey & Smith, 1993) critiqued these findings. They expanded the definition of the young child's and the young adolescent's abilities to note differences in the knowledge, assumptions, and values of individuals.

Carey and Smith (1993) noted that scientific knowledge is usually taught traditionally using the scientific method which includes "observation, classification, measurement, conducting controlled experiments, and constructing data tables and graphs of experimental results" (p. 244). At this level students are allowed to gather facts with a belief that there is only one truth to reality. Knowledge is gained unproblematically and may lead to the establishment of misconceptions regarding scientific knowledge. The researchers believed that the adolescents are mature enough to progress to the next level of understanding where the students delve into scientific knowledge problematically by using models as tools "in the construction and testing of scientists' theories about the world" (p. 242). This transformation of levels can be accomplished by teaching process skills through the exploration, development, and evaluation of their own theories regarding scientific phenomena. In summary, Carey and Smith believed that scientific knowledge at the adolescent ages should go beyond teaching the scientific method and include the inquiry method of instruction.

Obstacles in Teaching Science Concepts

Researchers have observed that there are difficulties in teaching science phenomena due to the many obstacles that educators must overcome. One of the major obstacles in teaching is that the teacher is often unaware of preconceptions that students bring with them into the classroom. Teachers must be able to identify the students' views and design their teaching accordingly. If these errors are not addressed, students' ideas will not change or will change in unanticipated ways (Osborne & Cosgrove, 1983). The preconceptions become reinforced and can follow the student into college. Mills' (1990) research indicated that many of the misconceptions held by the elementary students are the same as the college students who are studying to become teachers. This creates a cycle where misconceptions begin at the elementary level, travel to the secondary level, continue into college, and branch out to textbook curriculum and starting the cycle once again by influencing students at the elementary level.

Wilson (1988) recognized the fact that teachers miss clues that students give during classroom activities when misunderstanding a concept. This lack of response to students' signals may be due to the lack of knowledge teachers have in areas of science phenomena. This lack of teacher understanding leads to the teaching of misconceptions to students. A research study conducted by Smith and Lott (1983) outlined four aspects which have been found to be common to the instruction of scientific phenomena and to teachers who have great difficulty in picking up students' signals:

(1) empirical ambiguity,

(2) ambiguity in discourse,

(3) loose framing of important issues, and

(4) attacking wrong perceptions.

If experienced teachers fail to respond or interrupt the students' misconceptions then it can be implied that most teachers may be making similar judgment errors (Wilson, 1988).

McJunkin (1990) stated that if teachers want to teach for conceptual change then they must focus on the students' ideas and their predictions and explanations of phenomena. An important key in promoting this conceptual change is to establish a non-threatening environment where students do not have a fear of having an exchange of ideas with the teacher. Lessons must be constructed to contradict students' alternative frameworks, allow them to become dissatisfied with their own views and direct them to search for new and better ones (Smith & Neale, 1989). Alternative frameworks which students hold should direct how science curriculum should be taught (McJunkin, 1990). A new conceptual view of learning includes incorporating theories, facts, concepts, and principles in a new or already existing conceptual framework. Learning occurs when this conceptual change results in the student abandoning their misconceptions and accepting new and correct scientific alternatives. If the misconceptions are not corrected into a new framework, then science teaching will fail.

A reality that previously did not exist is created when we impose a level on a phenomenon: "For better or for worse, when names are learned we see what we had not seen" (Condon, 1968, p. 31). A person's vocabulary knowledge is an outward indicator of general aptitude (Anderson & Freebody, 1981); however, the memorization of a word does not mean the learner has the basic concepts of the phenomena occurring. The primary source of information in an average classroom is the textbook. The textbook companies do not take into consideration in their curriculum development the fact that students have misconceptions of scientific phenomena. Therefore, even with proper definition and science teachers with excellent teaching techniques, seldom do textbook companies provide adequate information to help the teacher identify and address alternate ideas to which children are strongly committed (Slinger, 1983).

Water education began to emerge in the 1960's due to the increased interest in environmental education. Recent studies have shown that about one-third of students, from elementary grades to college students, have only a rudimentary understanding of the transformation of water in the water cycle (Mills, 1983). Words stand for concepts which begin very small and develop into complex ideas through maturity and education. "For example, when a third grader thinks of evaporation he might think of the disappearance of water from a puddle. A high school student's ideas of evaporation might involve molecules, heat, and water vapor. The 'word' for the concept never changes, but the concept is fluid and dynamic" (McJunkin, 1990, p. 17).

Students may have confused understandings of concepts due to everyday language. Misconceptions are due to metaphors and analogies whereas preconceptions are due to personal experiences and are oftentimes limited and naive (Wilson, 1988). Students can also form verbal concept chains which have no relationship to the actual phenomena occurring. The student can use terms in a sentence; however they cannot visualize a model of the concept (McJunkin, 1990). This lack of model visibility is often due to the fact that scientific concepts are primarily abstract. Lawson and Renner (1975) believed that the concrete-operational can verbalize concrete concepts; however, they cannot totally comprehend the total concept until they have developed formal operation.

They suggest that elementary students have first-hand experience and concrete problems in order to develop concrete thinking, thereby eliminating failed attempts to reconstruct memory models and the production of words alone to give meaning to scientific concepts.

Researchers believed that learning is concerned with ideas, their structure, and the evidence of them (Wilson, 1988). Before the teaching of new science concepts can be accomplished, teachers must understand how students' existing concepts affect their understanding of the phenomena being introduced. Wilson believed that students must change their preconceived ideas and develop a way to conceptualize scientific concepts in real-world situations; thereby, internalizing the subject area. Posner (1982) outlines four conditions that must be met before new concepts can be understood:

(1) a dissatisfaction with the existing concept, i.e., the student can no longer use existing misconceptions to solve problems,

(2) the new concept must be intelligible and students must achieve minimal understanding,

(3) the new concept must have the capacity to solve problems, and

(4) the students must see the new concept as useful in a variety of situations.

Students must be made aware of the gap between their misconceptions and the true meaning of a concept. Wilson (1988) reported that the students oftentimes are satisfied with their perceptions, therefore they must be made aware of problems that are created. Nussbaum and Novick (1982) believed that the first step in making students aware of their preconceptions and misconceptions is to begin with an event which involves the students, allowing them to become aware of their own preconceptions. The next step would be to encourage the students to explain the concepts in terms of their preconceptions. This method of exploration allows for the exploring of alternate frameworks, stimulates conflict, and prompts discussions of the different misconceptions among the students in the classroom. The second step is for the teacher to create an event thereby creating a conflict between existing preconcepts and an observed phenomenon which the student cannot explain. Nussbaum and Novick believed this type of action would encourage students to accept a new conceptual model which is more consistent with actual scientific knowledge.

McJunkin (1990) stated that students visualize scientific concepts as nodes of information stored in the mind. The students have labels for individual concepts; however, they cannot move into a higher order of learning, which is the ability to analyze and synthesize relationships which apply to multiple term concepts. An example of this would be weather which uses the multiple concepts of: condensation, evaporation, water vapor, ground water, and precipitation. The student must learn the terms as a chain of concepts which form the desired principle. The student can then form a mental picture or model of the total process involved for the concept. Knowledge of this concept is gained when the student can demonstrate or use the concept in various problem-solving situations. McJunkin (1990) believed that the student's ability to demonstrate the specific scientific phenomena or concept is more important than the student properly identifying the term from rote memorization.

Environmental Science Education

Roth (1993) defined environmental literacy as "the capacity to perceive and interpret the relative health of environmental systems and take appropriate action to maintain, restore, or improve the health of those systems" (p. 1). The primary objective of the school system is to prepare future citizens of society; therefore, the goal of environmental education is to produce citizens which are globally productive and globally responsible. Peters (1981 in Roth, 1993, p. 2) noted that "environmental problems do not stop at national boundaries." Roth and Peters both believed that environmental literacy should be incorporated throughout the educational system as part of a core curriculum. Roth identified Hungerford, Tomara, Volk, McClaren, Marcinkowski, the Tbilisi document (Federal Interagency Committee on Education, 1978), the Environmental Literacy subcommittee of ASTM's TO4 Committee on Environmental Education, and the use of a modified Delphi process as the basis for establishing a definition regarding environmental education. The definition established that three levels of accomplishment and four stages of progression were necessary to define environmental literacy. This definition should be used to promote quality communication among all parties of the educational system.

The three levels of accomplishment include:

1) Nominal environmental literacy-Individuals at this level have a fundamental understanding and are developing an awareness of the environment along with a respect for it.

2) Functional environmental literacy-Individuals at this level have more of an understanding of the environment and human interactions and have the skills needed to promote and implement change.

3) Operational environmental literacy-Individuals at this level act locally to globally; have a sense of ongoing investment; portray a sense of responsibility for "preventing or remediating environmental degradation both personally and collectively" (p. 16).

The four stages which individuals progress through as they become environmentally literate include:

1. Awareness-"Perception of human/nature interactions and consequences in general or around a particular issue" (p. 16).

2. Concern-"Perception of real or potential negative consequences of a set of human/nature interactions and a feeling that some changes in those interactions need to occur" (p. 16).

3. Understanding-"Acquisition of detailed information about the present and future implications and consequences of current human/nature interactions and alternative interactions" (p. 16). "Acquisition of thinking and decision-making skills and their use in processing acquired information" (p. 17).

4. Action-"Application of understanding to individual and corporate behavioral changes that alter human/nature interactions in what is perceived as a responsible way that reduces or eliminates negative consequences" (p. 17).

Roth summarized his research by issuing the proclamation that it is the responsibility not only of the school system but of the community, media, family and church to promote environmental literacy for all individuals. The implementation of an integrated environmental curriculum within the school system is only a rudimentary beginning. The researcher believed that all humans from every population of the world must strive to reach environmental literacy at the operational level. Roth believes that if this goal is not met, then the human species may be destroyed as the planet will be in such degradation it will not be able to support human life.

Roth (1991), citing an example of the current situation regarding environmental education, stated that America's students generally recognize basic terms when discussing water and the environment. This understanding, however, is limited to terms, i.e., "nominal environmental literacy" (p. 43). Students and teachers must work towards "functional environmental literacy" (p. 43) which would allow the students to formulate positions on water issues currently being exhibited in their daily lives. Strategies must be developed to help them achieve knowledge, learn concepts, and develop thinking skills (Mills, 1991). Mills (1990) believes that these skills can be obtained through the use of Roth's four stages of environmental literacy. Mills concluded that knowledge alone is not a key to environmental literacy and that environmental awareness alone is not a key to environmental literacy. Research has supported the theory that environmental literacy can only be reached when all four components are united, resulting in "a broad spectrum of human/environmental action" (p. 44).

Ivanova (1986) stated that there needs to be a balance between the growing need for natural resources, which has been created due to increasing numbers of humans in today's world, and the need for the development of a favorable environment which can sustain these populations. This equilibrium can be achieved through a scientifically-based system which can largely be supplied by environmental education. Ivanova believed that by identifying the goal of environmental education and by focusing on our responsibilities to the environment and the utilization of its resources, a solution to saving the environment can be determined. The role of educating the masses touches a vast number of people in diversified sectors of life. The educational system should include provisions for providing solutions to problems and enhancing productivity.

Ivanova cited Russia as an example of how an educational system can address the issue of educating the masses. Russia's curriculum is designed to continuously educate their students in environmental education. They call this continuing education, "recycling of graduates" (p. 102). Ivanova believed that Russia's recycling of graduates is very important for the progression of environmental education. The recycling of graduates concerning environmental studies begins in kindergarten, continues to high school, and then proceeds through their higher education.

> In general, programmes in environmental education seek to acquaint the student with scientific bases of the protection of natural environment, with measures for preventing pollution of the atmosphere, of water resources, of the soil and of bioresources, and with other questions, including the

development of technological processes which avoid or cause only minimal pollution (pp. 102-103).

The educational program includes not only text studies but games, seminars, and tours. Life situations are used for problem studies which require an analysis and synthesis of the problem. The primary goal is to produce concrete solutions to problems. Problems have been identified within this system; however, the program developed by the Russians has been found to be very productive.

Moss (1986) believed that the teaching of environmental problems should be integrated. The primary goal of integrating environmental education into all disciplines is to "establish a conceptual link between the main focus of that programme and environment, even if the environmental component is seen simply as a part of a general studies element in the curriculum" (p. 92). A key person in the creation of an environmental program is the instructor. The instructor must have more than a small interest in the area; he/she must be an ideal role model and also have knowledge and interest in the field of study the students are pursuing. This link in principle is unproblematic, for example, the discipline of humanities can be integrated with environmental education by defining the "exploration of the environmental dimension in literature" (p. 93).

Emmelin (1986) identified the fact that there is an opposition to environmental education; however, he stressed that the need for it provides a stronger argument. He proposed four types of need:

1) the integration of environmental matters, where relevant, into

education and training at all levels of formal and non-formal education and training;

2) the creation within curricula of interdisciplinary courses or units aims at giving students an overview of environmental problems;

3) environmental education and training for specialists, technicians and others whose work is directly related to environmental matters; and

4) the complementing of education and training of professionals with substantial environmental education components (p. 56).

In addressing the second point, integration, Emmelin identified a very realistic problem: teachers of other disciplines are not knowledgeable in this field. This problem is magnified by textbook companies which do not provide sufficient information necessary for interdisciplinary studies. Therefore, it is proposed that the next step in the integration process would be the development of a series of educational materials which will provide the much demanded and needed information.

Lacy (1987) proposed that, in general, people tend to agree that the value and validity of knowledge and understanding of current major issues is a crucial part of education. This understanding can lead to major debates; environmental issues have become the subject of world-wide debate. Lacy stated that, "the acquisition of knowledge and understanding confers power while the lack of it signifies the weakness of ignorance" (p. 17). It is believed that the educational system lacks the understanding of "alternate choices" (p. 17) in its curriculum. Thus, as Lowen (in Lacey, 1986) pointed out, this lack of information allows for the management of understanding and ignorance by dominate global powers. Lowen asserted that: "People must be educated to understand the linkages between the arms race and global economic problems, as well as the deteriorating quality of their own lives. People must be made indignant at the subversion of technology and science" (p. 18).

Fortner (1991) believed that environmental education (EE) should be implemented via an "infusion approach" (p. 103) where the EE curriculum belongs to the "total curriculum" (p. 103). He identified that the study of all sciences began with the study of Earth and that they have strayed away from the core concept. The researcher listed methods of integrating EE back into the current curriculum. The first method would be to use a thematic approach such as using water or energy as topics to create interdisciplinary teaching. A second method is the development of an Earth Systems Education (ESE) where students focus on their "feelings toward the Earth system, the way in which they experience and interpret those feelings, they are drawn into a systematic study of their planet" (p. 104). The ESE is designed to be taught K-12 through an interdisciplinary approach to curriculum, and encompasses three core curricular areas, as identified in A Nation At Risk, humanities, science, and technology. Fortner concluded by citing Mayer (1991).

> As a first step it provides for infusing planet Earth concepts into all levels of the K-12 science curriculum. For the long run it provides an organizing theme for a K-12 integrated science curriculum that could effectively serve the objectives of scientific literacy and the same time provide a basis for recruitment of talent into science and technology careers, helping to ensure

appropriate economic development consistent with maintaining a quality environment (p. 20).

Ramsey, Hungerford, and Volk (1992) looked at the problems that Earth Day 1990 addressed: What can humans do to promote the quality of life and the quality of the environment in order to perpetuate the human species? The researchers attempted to provide a "conceptual framework" (p. 35) by which to implement environmental education (EE) into an integrated K-12 curriculum. The curriculum of EE should meet the needs of a changing technological world, provide global awareness, and provide the skills needed for individuals to become active participants in the struggle to improve and maintain the environment. Ramsey, et al., followed the guidelines set by the Tbilisi Declaration (Conference declaration in 1977), i.e., awareness, knowledge, attitudes, skills and participation. The researchers established four levels of cognitive knowledge:

a) "ecological foundations;

b) issue awareness;

c) investigation and evaluation; and

d) issue resolution" (p. 36).

Two methods which have been used in pilot studies include the use of infusing case studies into already existing curriculum and issue investigation which was "designed to stand alone, requiring insertion into grade 6-12 curriculum" (p. 37). The insertion method of using investigation skills strategies was believed to be more effective; however, with today's already overloaded curricular agenda it was not thought to be practical. The infusion method is thought to be the most practical and there are several supplemental materials available for use, such as, Project WILD, Project Learning Tree, and Nature Scope.

Mayer and Armstrong (1990) documented the 1988 conference held in Washington, D.C. which was attended by educators and geoscientists. The conference was sponsored by the National Science Teachers Association and the American Geological Institute. The purpose of the conference was to determine the goals of a K-12 curriculum which would provide the minimum ecological concepts regarding Planet Earth that every child should know after high school graduation/pre-college. It was determined that a second conference was essential. At this second conference, representatives from the scientific community were invited to identify concepts regarding Planet Earth and educators were invited to provide the knowledge necessary to establish developmentally appropriate educational goals.

Rutherford (in Mayer & Armstrong, 1990), Director of Project 2062 of the American Association for the Advancement of Science, directed the group to discuss curriculum and to establish earth concepts and not to identify specific courses or to "buy in to the status quo of the existing curriculum structure but to consider the place of earth concepts in the total purview of science" (p. 50). Rutherford characterized the current science curriculum as being "bloated and overstuffed" (p. 50). He stressed the need to minimize trivia and guided them to identify necessary facts which would contribute to the goals of the educational system, i.e., social and economical needs. Rutherford's criteria included:

1) What is the scientific significance? Will the concept or fact still be around in the next generation?

2) What is the human significance of the idea? How does it affect or influence citizens?

3) What is the philosophical power of the idea? How does it contribute to our understanding of the world?

4) What is its current importance to personal enrichment? Does it make the world of the pre-18-year-old more interesting? (p. 158).

The overall consensus established K-12 curricular objectives that would be more interesting, would show how science applies to Earth concepts, would provide methods and ideas instead of rote memory, and would be open ended allowing for the addition of new concepts. Mayer and Armstrong explained that the groundwork was laid and that educators, textbook companies, curriculum specialists, and assessment writers must work together to implement the objectives the conference established.

Singletary (1992) believed that environmental education should not be infused into already existing curriculum but that it should be taught within the boundaries of its own curriculum/class. He explained that environmental education was difficult enough to define and that it is especially difficult when the curriculum is integrated into other subject areas (Engleson, 1985; Simmons, 1989; Gigliotti, 1990 in Singletary,1992). Singletary, in order to understand how and what is being taught in the nation's environmental education classes, used a case study approach to determine a descriptive background for the already existing programs. The case studies included teacher interviews, assessment materials, and actual class observation. The schools were all selected from secondary schools located in Illinois. The criteria of the seven teachers selected was that they must have previously taught a minimum of three years in an environmental education class. The data collected noted:

1) the teachers primarily stressed the cognitive and not the affective;

2) the curriculum did not try to modify student behavior regarding environmental concerns;

3) there was not a satisfactory text;

4) the classes were deemed the dumping ground for students who could not be successful in physics or chemistry;

5) and, they did not integrate opportunities for "hands-on activities, problem solving, and civic action" (p. 39).

Singletary, in his conclusion, expressed the need for the establishment of objectives, development of materials, and expansion of environmental education programs K-12.

Attitudes Towards Environmental Science and Science Education

A growing awareness of environmental issues has arisen which can be contributed to "long standing national commitments to growth, resource exploitation, and reliance upon the technological fix" (Albrecht, Bultena, Hoiber, & Nowak, 1982,

p. 39). In the past humans have viewed themselves as the center of the universe, hence, life. Albrecht, et al., characterized Americans as being arrogant toward nature which has been witnessed throughout history, beginning in the sixteenth century with the European expansion, the growth of Christian beliefs, i.e., "man's dominion over other creatures" (p. 39), the growth of capitalism, and the expansion of technology. This anthropocentric belief has been called the "Dominant Social Paradigm (DSP)" (Albrecht et al., p. 39). However, today's beliefs are changing. The movement is called the "New Environmental Paradigm (NEP)" (Albrecht et al., p. 39) which identifies the need for humans and nature to live in equilibrium. Environmental researchers believed that the New Environmental Paradigm or a new environmental attitude could be adopted through the development of an environmental education program. It was noted that the growth of environmental awareness in society is multifaceted and is influenced by numerous factors.

Schoenfeld (in Fortner & Lyon, 1985) stated that the "mass media has played an educational role . . . in reflecting and shaping the changing American mind," (p. 12). Societal attitudes concerning environmental education have been influenced by the media which includes television, newspapers and weekly magazines. Stamm (in Fortner & Lyon, 1985) cited evidence that showed a strong relationship between media exposure and the level of knowledge that citizens possess concerning those issues. Fortner and Lyon researched attitudinal changes after sample groups viewed a Cousteau program. The conclusion provided a hypothesis which identified a definite shift in attitudes towards environmental issues. However, these shifts in attitudes appeared to be temporary in most instances.

Fortner and Lyon's research study's conclusions placed the participants into two different categories, "moralistic" and "ecologistic" (p. 18). The moralistic person exhibited strong feelings of "right and wrong" (p. 18) regarding the way animals are treated. An example of this would be the killing of dolphins in order to market tuna, i.e., the moralistic person would quit buying tuna until the dolphins were no longer threatened by the tuna fish market. The moralistic person is genuinely concerned with the exploitation and cruelty towards animals. The ecologistic attitude encompasses the population of people whose primary concern deals with the "interrelationships between wildlife species and natural habitats" (p. 18), i.e., the environment. The key to the development of either position lies in the ability to determine the level of awareness the subjects are currently at and then the ability to add to that awareness a "new set of memorable data" (p. 18).

Maloney and Ward (1973) supported the belief that environmental problems are being created by the increasing population and the need for increasing food supplies. The researchers believed that the answer to this growing problem should be addressed through the science of psychology and not technology. They postulated that environmental problems must be viewed as intrinsic issues. Therefore, the development of programs should be guided by individual behaviors identified by psychological institutions.

In setting the guidelines for reform programs, terms of the problem must be stated in individual behaviors. Researchers can conduct need assessments through surveys to determine what the populations actually know about ecological issues and problems. For example, Maloney and Ward (1973) developed an 130 item ecology scale subdivided into four categories: verbal commitment (VC), actual commitment (AC), affect (A), and knowledge (K). Reliability was obtained using Pearson reliability coefficients: VC=.91, AC=.93, A=.92, and K=.89. Results of the attitudinal survey showed that the population of students participating in the study (Sierra Club, college students, and non-college students) say that they want to help fight environmental problems and are fairly emotional. However, in actuality they provide little action and do not have the knowledge. The researchers concluded that the problem lies in educating society. It is believed that if human behaviors are to change, then people must be educated on a global level.

Mosely (1993) conducted research which involved using the affective domain in developing an effective environmental education program. The program was designed to recognize the immediate, intermediate, and long term effects of a three-week long environmental education academy. The population consisted of a select group of 24 high school junior and senior high students recruited from different schools throughout the state of Oklahoma. The students actively participated in a three week environmental education academy in two phases. Phase one used classroom instruction, laboratory activities and field experiences. Phase two included "home town activities" (p. 74) as used to enhance phase one objectives. The objectives were to increase the students' awareness of "major environmental issues and problems, to become knowledgeable about the ecological concepts that connect the issues, problems, and solutions, and to be able to identify and willing to take action and make personal commitment to environmental issues" (p. 66).

The researcher found that the students who participated in the academy showed a significantly higher mean gain score on the Environmental Attitude Assessment than the students who did not participate in an environmental academy. Mosely concluded that the "Environmental Science Academy has the potential of developing a responsible environmental citizenry from the youth of today" (p. 189). The research further stated that, through guidance of environmental education programs, tomorrow's citizens can productively live in the world through their willingness to maintain and remediate while being guided by numerous lifestyle changes.

Barrington and Hendricks (1988) conducted a study to determine the attitudes of students towards science and the scientific knowledge of students. The student population of 143 was drawn from the third, seventh, and eleventh grades. There was an equivalent number of gifted students and average intelligence, and male and female subjects. Data were collected from the students via a questionnaire developed by Yager and Bonnstetter (1984) regarding "NAEP affective items" (p. 681) and by Yager and Yager, (1984) regarding a "measure of content knowledge" (p. 681). The reliability coefficients included Cronbach's alpha for science attitude at .78.

The researchers found that there was an increase in the knowledge gained between the third, seventh, and eleventh grades and that the attitudes regarding science education were effected by two factors, the science class and the teacher. No significant difference was found when the scores of males to females were compared. There was a significant correlation between student ability and student attitude especially at the eleventh grade level. It was found that gifted students scored higher than the average students in several of the areas which could be attributed to the specific science programs previously studied. The authors recommended that the gifted and average intelligence students be taught using different academic instruction for all disciplines.

Gifford, Hay, and Boros (1982) noted that differences between individuals is a better predictor of environmental attitude than participation in an environmental education class. The two major differences dealt with personality (Borden & Schettino in Gifford, Hay, & Boros, 1982) and gender, i.e., females having a more "verbal commitment" (Borden & Schettino in Gifford, et al., 1982, p. 19). These factors can not be controlled by educators; therefore, the researchers' study involved only those factors which could be controlled within the school system. Environmental attitude was measured via a 45 item questionnaire which included the following areas: verbal commitment, actual commitment, affect, and knowledge components. The population of 136 students was drawn from a British Columbia university. One hundred students were randomly selected and 36 were selected on the criteria that they had taken an environmental education class or were currently enrolled in an environmental education program.

Gifford, Hay and Boros' (1982) data listed the following results:

1) males have more environmental knowledge than females

2) environmental education students report more actual commitment than other students

3) natural science majors have more environmental knowledge than those in social sciences or non-sciences

4) environmental education students express more verbal commitment than non-environmental education students

5) natural science students show more emotion about the environment than social sciences and non-sciences students

6) females express greater affect about the environment than males

7) environmental education students have more knowledge than others

8) females report more verbal commitment than males (p. 22).

The researchers concluded that the study provided support that environmental education programs had a positive influence in developing students knowledge, verbal commitment, and actual commitment to environmental issues. Further, it was believed that the differences in gender, i.e., males had a greater knowledge of environmental issues and females had a greater verbal commitment, were due to gender stereotyping and not to any "inherent defect in woman" (p. 23). The researchers concluded by acknowledging that the differences among individuals should be noted and taken into consideration regarding environmental attitudes when developing curriculum for environmental programs.

Kinsey and Wheatley (1984) stated that the need to identify the relationship between cognitive and attitude change regarding environmental education has been an issue with many researchers (Perkes, 1973; Winston, 1974; Bowman, 1974; Ramsey & Rickson, 1976; Williams, 1968; Coobs & Meux, 1971; & Stronck, 1974 in Kinsey & Wheatley, 1984). The researchers designed a study to determine the "effect of taking an environmental studies course on the defensibility level of one's value judgment toward environmental issues: Do students utilize information learned in an environmental studies course to support their stated attitudes toward environmental issues?" (p. 676). The instrument used was the Environmental Issues Attitude Defensibility Inventory (EIADI). The population of students was drawn from the University of Maryland for Phase I and from the State University College at Buffalo for Phase II. Phase I compared two undergraduate zoology courses to two undergraduate environmental studies sections and two graduate science education courses with two graduate environmental studies courses. Phase II assessed the differences between the pre-test/post-test scores of two undergraduate environmental studies classes to determine "entering and exiting defensibility levels" (p. 677).

The researchers' data showed that there was no significant change in attitude regarding environmental issues as measured by the EIADI in Phase I. It was noted that attitudes were a function of complex forces which may/may not be measurable by current value judgment assessments. The defensibility variable "which relates to the degree with which an expressed attitude can be 'defended' with the use of informational supports" (p. 682) did show a significant difference regarding entering and exiting scores. Kinsey and Wheatly concluded that the research, though inconclusive, supported Williams' theory (1968) that there are "connective vectors" (p. 682) between Krathwohl's affective domain and Bloom's cognitive domain. Also, Rokeach's (1968) theory was supported which established that attitudes can be changed through the addition of information.

The Roper Organization Inc. characterized public attitudes and individual behavior regarding the environment. The data was published in a report which identified that Americans are becoming "Green" (p. 31). Attitudes favoring "Green" characteristics were exhibited especially during elections where environmental concerns were an issue; however, consumer practices show less commitment. The degrees of attitude and commitment are vast among the current population:

1. Basic Browns-28% of the population-Individuals who do not believe that humans can make a difference nor do they want to try to make a difference.

2. Grousers-24% of the population-Individuals who "rationalize" (p. 33) their lack of involvement via excuses and then chastise others for their lack of involvement.

3. Sprouts-26% of the population-Individuals who express concerns and exhibit behaviors to environmental issues.

4. Greenback Greens-11% of the population-Individuals who "strongly support regulation . . . are less willing to spend more of their time on environmental causes" (p. 320) i.e., willing to pay higher prices but not time.

5. True-Blue Greens-11% of the population-Individuals who are very dedicated to the environmental movement and exhibit Green movement behaviors.

Applied Academics as a Learning Tool

Roller (in Renner, Cate, Grzybowski, Atkinson, Surber, & Marek, 1985) described science as being based on the philosophy that "science is the quest for knowledge, not the knowledge itself" (p. ii). Einstein (in Renner et al., 1985) described the field of science as the coordination of experiences in order to bring them into a "logical system" (p. ii). Renner, et al. believed that students must experience science concepts through a cycle, created by Dr. Robert Karplus and Dr. Jean Piaget, deemed the "learning cycle" (p. iii). Three stages are involved in this process:

1. Exploration-The assimilation of experiences provided by a series of activities which allows the students to explore ideas.

2. Conceptual invention/The Idea-The students gather data in order to arrive at an agreement with the teacher regarding the concept which was to be learned.

3. Expansion of the Idea-A series of activities, readings, and discussions are used to expand the concept which were previously discovered.

Atwell (in Liner, 1992) stated, "Curriculum just doesn't fit anymore. A curriculum puts limits on learning, kids' and teachers', spelling out what may be covered as orchestrated from behind a big desk" (p. 6). Willis (1993) believed in age appropriate curriculum or educational activities which should be led by the use of "natural learning experiences-direct, sensory experiences of their world-which form the foundation for later, more abstract learning" (p. 3). Willis characterized the teacher as being a facilitator and not the provider of all facts. The teacher needs to take the role of an experimenter by allowing the students to participate in numerous learning experiences, e.g., "hands-on things" (p. 8), manipulatives, and technology.

Raizen (1989) explained that a new line of research is being conducted by cognitive scientists who specialize in sociology and anthropology. Raizen's research goal was to measure the ability of workers to problem solve while on the job. The knowledge being studied went beyond the traditional level of knowledge, i.e., "knowing what" (p. 33) to the level of "knowing how" (p. 33). The research focused on the "social and physical context" (p. 36) on which a problem is created instead of on the "individual mental activity" (p. 36). The data can be used to develop new curriculum which emphasizes "didactic instruction and individual performance and assessment" (p. 36), e.g., applied academics.

The curricula used in most traditional schools does not emphasize or suggest any application where the student might apply the specific concepts being taught. Brown et. al. (1989) stated (in Raizen, 1989, p. 36):

> Students need much more than abstract concepts and self-contained examples. They need to be exposed to the use of a domain's conceptual tools in authentic activity--to teachers acting as practitioners and using these tools in wrestling with problems of the world . . . . Classroom tasks . . . can completely fail to provide the contextual features that allow authentic activity . . . . Thus, much of what is learned in school may apply only to the ersatz activity, if it was learned through such activity.

Scribner (1984 in Raizen, 1989) reinforced this research. The author believed that the environment should be a major component in problem-solving systems and that practical thinking goes beyond context material. Raizen stated that this type of applied learning parallels vocational education in that memorization is limited and practical experience is the motivator for student success.

An applied academic curriculum was developed by AIT (Agency for Instructional Technology) and CORD (Center for Occupational Research and Development). The curriculum attempted to develop and integrate the application of math and science concepts to the real world while still providing the academic objectives required by state and federal mandates and college entrance requirements. Pepple and O'Connor (1992) conducted a study to determine the success of the applied academic curriculum in the areas of student success and occupational preparedness. The experimental population consisted of 234 students from five area vocational schools (118 students) and five comprehensive high schools (131 students). The control group consisted of 118 students enrolled in general math and were drawn from six comprehensive schools.

The instructors of the applied academic classes administered a pre-and post-tests which consisted of 63 questions each. The data showed that students in the experimental group had more than twice the gain as the control group. The researcher concluded that the data supported the theory that the Applied Academic Curriculum allows students to achieve higher success rates than the traditional methods regarding the area of mathematics and applied communications.

Beadles (1992) participated in a pilot program which used the Applied Biology and Chemistry curriculum developed by the Center for Occupational Research and Development. Data was collected via a pre-and post-test to assess the success of the students and their attitude regarding science. The study collected data from students who were taught in a non-traditional format, i.e., cooperative learning, and using the Applied Biology and Chemistry curriculum. The experimental group was compared to a control group which consisted of students who where taught with a traditional instructional method, i.e., lecture, using contextual material.

The research showed that there was no significant difference in the mean gain scores or in the attitude of students being taught by the applied academic method as compared to the students being taught by the traditional method of instruction and curriculum. The researcher did observe a greater enthusiasm for the concepts being taught when being presented material through the applied instruction. It is believed that enthusiasm will create a "greater appreciation and understanding of science and technology as it is used in the real world today" (p. 70). Beadles' conclusion stated that it is the duty of the educational system to present instruction and materials that will provide enthusiasm and quality programs in science and technology, thereby, creating a "catalyst for the successful workforce development in the 21st century" (p. 70).

Summary

Research has indicated that student and teacher misconceptions and preconceptions are the basis for scientific phenomena illiteracy. In order to promote scientific literacy educators must become more aware of alternative concepts. Educators must also become proficient in identifying actions which might provide clues which will assist them in identifying student misconceptions. In addition to increasing teacher awareness, the textbook companies must provide more effective teaching strategies, better prepared textbooks, curricula and teaching methods that are more directly related to the students' learning abilities (Wilson, 1988).

The understanding of any concept lies in the students' pre-school experiences, formal school experiences, and cognitive development (McJunkin, 1990). Every aspect of the educational world must be designed to promote positive educational experiences for every student. The researchers believed that today's educational institutions must encourage the use of different learning styles, provide an environment where the student can take ownership of his/her own learning, and provide experiences for the application of the learned concepts. If the educator is successful in providing these needs then he/she has given every student the ingredients needed to learn formal concepts such as scientific phenomena.

The organizational system must be aware that instruction has to be flexible in order to meet the needs of the students. The school board, state department, legislators, administrators, instructors, students, and parents must understand the many aspects related to learning. By theorizing and researching educational theory, followed by application, the institution and the entire school community will understand and supply resources to create an educational system where individualized instruction can occur.

The theory of individual learning styles and the individual's ability to retain information is not a new concept (Watson, Skinner, & Piaget in Greeson & Zigarmi, 1985). The use of alternate learning styles is further supported by Piaget's theory on children's cognitive functioning (in Greeson and Zigarmi, 1985, p. 41), Dean and Gray's differences in cognitive strategies as they pertained to learning styles (Bayless & Livesey, 1985; Riding & Dyer, 1983; Gambrell & Bales, 1986; Greeson & Zigarmi, 1985; Weed & Ryan, 1983). However, due to its magnitude, not all of the influencing factors or theories have been researched.

This study suggested that more research needs to be done in the area of applied academics as a tool for learning. If the applied academics are to be used efficiently, then it must be integrated not only into the vocational technical curriculum but into the academic curriculum as well. It is believed that the applied academic curriculum should be the primary source of instruction in areas where abstract reasoning and thought are essential, e.g., biology, chemistry, and environmental concepts. Without a full understanding of these scientific concepts the earth will surely fall to over population, depletion of resources, and a polluted environment which will eventually destroy the earth as it exists today.

CHAPTER III

METHODOLOGY AND DESIGN

Introduction

Chapter III contains a description of the suburban setting where the research was conducted, a description of the population being studied, a summary of the procedures for gathering the data, and the process for determining the quantitative and qualitative data.

Setting

The Edmond Independent School District is located in a suburban community north of Oklahoma City, Oklahoma, an urban city. The school district is comprised of twelve elementary schools (K-5), four middle schools (6-8), and three high schools (9-12) located at different building sites within the city limits of Edmond. Roach (1993) identified that the student population of grades K-12 was approximately 15,000 students with a dropout rate of 2.40% with ITBS scores averaging at 73. The researcher also recognized that the community's residents, approximately 53,000 citizens, were primarily classified as white collar workers of medium to high socioeconomic status. Approximately 64.7% of the households are listed as being married couple families and 67.8% of the districts families own their own home.

Subjects

The population of students of this quasi-experimental pre-test/post-test control group design was drawn from this suburban school district within Central Oklahoma. The experimental group consisted of nine existing class sections of Applied Biology/Chemistry classes located at two homogenous high schools located at two separate sites. One school had four class sections of ABC whereas the other school had five class sections of ABC. The total number of subjects selected for the experimental group was 148. The control group consisted of eight class sections selected from two volunteer teachers who were currently teaching biology in a traditional teaching method. The traditional classes were located at two different high schools and totaled 128 students. One school had three class sections of traditional biology and one school had five class sections of traditional biology.

All eighth grade students attended a presentation by the districts career education specialist coordinated through their social studies class. At this presentation, the students learned of opportunities that would be offered to them at the high school level according to their occupational and academic interests. The presenter also offered information regarding learning styles, right/left brain learning and teaching styles, and differences between applied and traditional math and science classes. Students then pre-enrolled, guided by the high school counselors, into either the applied biology and chemistry class or physical science followed by the traditional biology class at their 10th grade year during the spring six-year-plan of study counseling session.

The criteria cited by counselors for enrollment into an applied academic class included: learning styles, reading level, grade point average, and career cluster interest. Counselors and teachers had opportunities throughout the year to participate in staff development, which provided guidance, to help them suggest student placement into the next year's academic classes. Hence, suggested student placement, into an applied biology and chemistry class, was provided if the students were interested in learning through a hands-on approach, wanted to know "WHY" they were learning the biological concept, were successful in cooperative learning groups, had a minimum of an eighth grade reading level, were above 70% GPA in a previous science class, were above 40 NCE on the ITBS/TAP science assessment, and/or had an interest in a technical, health, or business career cluster. The Applied Biology and Chemistry class was primarily offered at the ninth grade level; therefore, the majority of the experimental group consisted of ninth grade students who had been successful in their previous years science class.

The experimental group of students had previously been enrolled in a physical science class at the ninth grade. The students then primarily enrolled in a traditional biology class at the tenth grade level; therefore, the majority of the control group consisted of tenth grade students. The traditional biology classes were chosen from teachers who volunteered to participate in the research study and who had not been previously instructed in applied teaching techniques. The tenth grade students primarily had successfully completed ninth grade physical science and had enrolled into the traditional biology class during a regularly scheduled pre-enrollment session guided by the high school counselor. One control school totaled three sections and one control school totaled five sections for a total of eight class sections.

Instrumentation

The Iowa Test of Basic Skill/Test of Achievement and Proficiency (ITBS/TAP), science aptitude scores, normed from student scores throughout the United States, were collected from the students' 1993 and 1994 spring ITBS/TAP assessments. Internal consistencies and equivalent-form reliability coefficients are in the acceptable range of .80s-.90s (Linn, p. 393).

The National Association of Biology Teachers/National Science Teachers Association Instrument (NABT/NSTA) was used to measure the mean difference in scores in the students pre- and post-test scores regarding biology concepts. The biology concepts measured included: cell structure, bioenergetics, genetics, ecology, behavior, science/technology/society, systems, and taxonomy. The measurement regarding environmental knowledge was drawn from questions 4, 17, 25, 33, 41, 50, 58, and 73 on the NABT/NSTA. The 1990 version of the NABT/NSTA Biology Examination was used. The NABT/NSTA has a normed performance: mean score of 45.09, standard deviation of 13.77, standard error at .46, coefficient of variance 30.54 and a range of 67.

The Attitude Toward Science in School Assessment (ATSSA) developed by Germann (1988) was used to determine the students' attitudes toward science in the classroom. It is comprised of fourteen questions which measure the attitudes of the students towards science classes. The Likert scale responses and numerical values for each response are: strongly agree (5), agree (4), neither agree nor disagree (3), disagree (2), strongly disagree (1). The research by Germann indicates that the Cronbach alpha reliability was greater than 0.95, discrimination was demonstrated by norm-total correlations ranging between 0.61 and 0.89.

The Ecology Attitude Inventory (EAI) was used to determine the students' attitude toward environmental issues and awareness. The instrument was developed by Maloney, Ward, and Braucht (1975) and is divided into four subunits: verbal commitment (VC) which measured what a person states he/she is willing to do, actual commitment (AC) which measured what a person actually does, affect (A) which measured the emotion of the participants, and knowledge (K) which measured the actual knowledge a person has regarding environmental issues. The Pearson reliability coefficients were within the acceptable ranges VC, .91, AC, .93; A, .92; and K, .89 (Maloney & Ward (1973) in Mosley, 1993, p. 76).

The Learning Styles Inventory (LSI) was administered to both the ABC students and the traditional biology students during the second week of the first nine weeks of the school year. The LSI was developed by Kolb and revised in 1985. Type 1 learners are classified as "Divergers," have valuing skills, ask the question, “Why?”, and they like discussion, group work, and feedback. Type 2 learners are classified as “Assimilators,” have thinking skills, ask the question, “What?”, and they are sequential learners, are successful in traditional classrooms, and are conducive to the philosophy of the traditional science curriculum. Type 3 learners are classified as “Convergers,” ask the question, “How does this work?”, and they have a need to experiment, use hands on methods of learning, and need to see the relevance to real-life problems. Learning Style Number 4 classifies learners as "Accommodators," have acting skills, ask the question, "If?", and they like a variety of instruction, believe that the curriculum should follow the students interests, and enjoy experiential learning. The internal reliability as measured by Cronbach's alpha's is concrete experience (CE) .82, reflective observation (RO) .73, abstract conceptualization (AC) .83, active experimentation (AE) .78, abstract-concrete (AC-CE) .88, and active-reflective (AE-RO) .81 (Smith & Kolb,1986).

Design of the Study

The experimental group, students enrolled in Applied Biology and Chemistry (ABC) were instructed in the units established by the Center for Occupational Research and Development (CORD): Natural Resources, Disease and Wellness, Nutrition, Continuity of Life, Plants and Reproduction and Air and Other Gases. Prior to instruction, the students participated in the following pretests: NABT/NSTA, ATSSA, and EAI. The pre-tests were administered during the second and third weeks of the first nine weeks. The LSI was administered during the second week of the first nine weeks prior to the instruction of the ABC curriculum. The post-tests were administered during the eighth week of the fourth nine week school term.

The control group, students enrolled in a traditional biology class, were instructed in concepts from Heath-Biology with units specifically chosen by the individual instructors. Prior to instruction during the second week of the first nine weeks, the students participated in the following pre-tests: NABT/NSTA, ATSSA, and

EAI. The LSI was administered during the second week of the first nine weeks prior to the instruction of traditional biology. The post-tests were administered during the eighth week of the fourth nine week school term.

The Iowa Test of Basic Skills/Test of Achievement and Proficiency (ITBS/TAP) NCE science pre-scores and post-scores were obtained from the students' cumulative records. The pre-scores were pulled from the Spring of 1993 assessment scores and the post-scores were pulled from the Spring of 1994 assessment scores. Both the control group and the experimental group were administered post-tests and were conducted during the eighth week of the fourth nine weeks. The post-tests included the NABT/NSTA, ATSSA, and the EAI. Mean differences were calculated between the pre- and post-test scores:

1. Fall 1993 NABT/NSTA vs. Spring 1994 NABT/NSTA

2. Fall 1993 ATSSA vs. Spring 1994 ATSSA

3. Fall EAI 1993 vs. Spring 1994 EAI questions 1-30

4. Spring 1993 ITBS/TAP NCE science scores vs. Spring 1994 ITBS/TAP NCE science scores

5. Fall 1993 NABT/NSTA pre- test vs. Spring 1994 NABT/NSTA post-test questions: 4, 17, 25, 33, 41, 50, 58, and 73 (ecology concepts)

6. Suburban NABT/NSTA scores vs. Rural NABT/NSTA scores

The mean differences were calculated between the pre- and post-tests for the experimental group and for the control group. The mean difference between the pre-and post-tests were compared between the experimental group, Applied Biology Chemistry, and the control group, traditional Biology I.

Null Hypotheses

Ho_1. There is no significant difference in the pre- and post-test mean differences on the NABT/NSTA between the students enrolled in the ABC curriculum compared to the students enrolled in the traditional biology curriculum.

Ho_2. There is no significant difference in pre- and post-test mean differences on the ATSSA between the students enrolled in the ABC curriculum compared to the students enrolled in the traditional biology curriculum.

Ho_3. There is no significant difference in the pre- and post-test mean differences on the EAI between the students enrolled in the ABC curriculum compared to the students enrolled in the traditional biology curriculum.

Ho_4. There is no significant difference in the pre- and post-test mean differences on the ITBS/TAP science aptitude between the students enrolled in the ABC curriculum compared to the students enrolled in the traditional biology curriculum.

Ho_5. There is no significant difference in the pre- and post-test mean differences dealing with environmental concepts on the NABT/NSTA between the students enrolled in the ABC curriculum and the students enrolled in the traditional biology curriculum.

Ho_6. There is no significant difference in the pre- and post-test mean differences on the NABT/NSTA between the students with quadrant 1 learning style in ABC compared to the students with quadrant 1 learning style in the traditional biology curriculum.

Ho $_7$. There is no significant difference in the pre- and post-test mean differences on the NABT/NSTA between the students with quadrant 2 learning style in ABC compared to the students with quadrant 2 learning style in the traditional biology curriculum.

Ho $_8$. There is no significant difference in the pre- and post-test mean differences on the NABT/NSTA between the students with quadrant 3 learning style in ABC compared to the students with quadrant 3 learning style in the traditional biology curriculum.

Ho $_9$. There is no significant difference in the pre- and post-test mean differences on the NABT/NSTA between the students with quadrant 4 learning style in ABC compared to the students with quadrant 4 learning style in the traditional biology curriculum.

Ho $_{10}$. There is no significant difference in the pre- and post-test mean differences on the NABT/NSTA between suburban students enrolled in the ABC curriculum compared to rural students enrolled in the ABC curriculum.

Statistical Analysis

An analysis of variance was used to compare the mean differences of the experimental group to the control group. Pre- and post-assessment results were analyzed at the Oklahoma State University Computer Center using the Statistical were analyzed at the Oklahoma State University Computer Center using the Statistical Analysis System (SAS) computer program. T-tests for independent samples were used to determine if the treatment, Applied Biology Curriculum, had a significant difference in student gain, i.e., between pre- and post-test scores. T-tests measure the actual mean difference observed (X1 - X2) with the difference expected by chance (Gay, 1992, p. 436). The level of significance used to either accept or reject the stated null hypothesis was set at $\leq .05$.

An analysis of covariance was calculated in order to statistically control the effects of the multiple independent variables, i.e., ITBS and science grade, on the dependent variable, i.e., student gain, and provide evidence for a strong case of cause and effect (Sprinthall, 1983). The analysis of covariance was used to test "the significance of the differences between means of final experimental data by taking into account and adjusting initial differences in the data" (Kerlinger, 1964). Therefore, the f-value at the ≤ 0.05 level of significance was used to determine if the treatment, applied biology and chemistry curriculum, had a significant impact on student gain regarding: knowledge of biological concepts, attitude towards science, attitude towards the environment, and knowledge of environmental concepts.

A qualitative analysis was obtained through the administration of open ended questions asked via an interviewer. The parties interviewed included: an administrator (N=1), students (N=276), and teachers (N=2). Students were interviewed in the classroom setting and the teachers and administrators were interviewed one-on-one. The goal of the qualitative analysis was to note variables within the "natural setting" (Key, 1990, p. 173) and to observe "interactions between variables" (Key, 1990, p. 173) which influence statistical outcomes.

CHAPTER IV

ANALYSIS OF DATA

Introduction

The major purpose of this study was to compare the Applied Biology and Chemistry curriculum to the traditional biology curriculum through mean difference of students on standardized assessments: Iowa Test of Basic Skills/Tests of Achievement and Proficiency, ITBS/TAP; National Association of Biology Teachers/National Science Teachers Association Instrument, NABT/NSTA; Attitude Toward Science in School Assessment, ATSSA; Environmental Attitudes Inventory, EAI; and Learning Styles Inventory, LSI. The assessments attempted to note differences and/or similarities between groups in these areas: knowledge of biological concepts, knowledge of environmental concepts, attitude towards science, attitude towards environmental issues, biology aptitude, and learning styles.

T-tests were used to compare the mean differences in the pre- and post-tests of the NABT/NSTA; pre- and post-tests of the ATSSA; pre- and post-tests of the EAI; and pre- and post-spring NCE science ITBS/TAP scores for both the control and experimental groups. T-tests were then used to compare the mean difference in the NABT/NSTA: pre- and post-tests of the ATSSA; pre- and post-tests of the EAI; and pre- and post-spring NCE science ITBS/TAP scores of the control group to the experimental group.

The ATSSA was divided into three main components: affect, verbal commitment, and actual commitment. Mean differences and t-tests were calculated to determine the significant difference of each component. The overall attitude towards environmental issues was determined by using all three components of the ATSSA. The NABT/NSTA item numbers 4, 17, 25, 33, 41, 50, 58, and 73 were used to determine environmental knowledge.

Kolb's learning style instrument was used to categorize each student according to his/her learning style. Mean differences of the NABT/NSTA were calculated and t-tests were used to determine if there was a significant difference between the control group and the experimental group within each identified learning style.

An analysis of covariance was used to determine if the independent variables, science grade and ITBS/TAP, influenced the dependent variable, student gain on the NABT/NSTA, ATSSA, and EAI. The school and hours of the day were pooled together, used to calculate the sums of squares, and used as error. The pooled groups compared the various classes and variation between treatment and control. Note the teacher and school designations variables were ignored.

Presentation of Data

Quantitative Analysis

Tables I and II show the distribution of the mean differences between the pre- and post-scores of the experimental group and the control group respectively. The

TABLE I

DISTRIBUTION OF MEAN DIFFERENCE BETWEEN PRE- AND POST-SCORES FOR STUDENTS TAUGHT USING THE ABC CURRICULUM

Student	NABT	ATSSA	ATT	AFF	VCOM	ACOM	ECO	ITBS
1	-3	4	13	3	6	4	-1	0
2	7	-20	-3	-1	1	-3	0	-23
3	7	-12	-4	-2	-3	1	-1	-2
4	17	-11	13	5	4	4	1	16
5	9	- 6	-8	-4	-3	-1	1	14
6	15	-22	10	1	2	7	2	-23
7	17	- 4	6	1	3	2	3	3
8	-7	9	9	-1	5	5	0	15
9	12	1	2	-1	2	1	2	14
10			1	-5	0	6		-20
11	11	-12	19	3	6	10	1	
12							-4	10
13		3	11	3	4	4		
14	4	12	2	3	3	-4	-1	-24
15	6	-11	3	0	2	1	1	-9
16	11	4	4	1	-1	4	1	9
17	-3	-10	-9	-2	-4	-3	-1	
18	-6	-17	11	2	0	9	-1	48
19		1	7	-2	1	8		
20	8	30	5	-2	2	5	3	
21	-8	-4	12	1	5	6	-2	-10
22	-15	3	16	2	5	9	2	
23	1	-5	9	-1	1	9	-2	6
24			5	4	1			1
25	13	-2	4	-2	0	6	2	18
26	8	-17	8	1	0	7	0	27
27	5	-3	-2	-3	-1	2	2	-12
28	4	7	-1	-1	-1	1	-1	9
29	13	14	-5	-2	-3	0	0	0
30	8		11	2	0	9	3	-2
31	9	2	9	1	2	6	2	-9
32	11	6	13	0	4	9	2	26
33	-9	-3	9	2	3	4	-1	19
34	-3	3	11	2	3	6	1	-1
35	7	4	-4	-6	-1	3	-1	
36	13	9	-5	-2	-5	2	3	12
37	15	0	-17	-2	-6	-9	2	-13
38	7	-13	-5	-2	1	-4	3	-2
39	17						4	31
40	3	-15	-3	-5	-6	8	2	15
41	-2	-14	6	1	1	4	2	-10
42	17	13	10	2	2	6	2	11
43	6		9	1	2	6	2	27

TABLE I (Continued)

Student	NABT	ATSSA	ATT	AFF	VCOM	ACOM	ECO	ITBS
44		-2	-1	0	-5	4		15
45		-20	4	0	4	0		44
46	8	-3	15	7	1	7	0	22
47	-10	-7	8	3	0	5	-1	3
48	-1	-17	12	3	2	7	2	-20
49		1	8	-1	2	7	-1	7
50	2	0	-3	-3	-2	2	1	13
51	-7	-32	16	2	6	8	2	10
52		13	-2	-4	-4	6		9
53	1	8	-4	-1	-6	3	0.0	19
54	11	-11	2	-2	-1	5	1	
55	8	5	-5	-3	-4	2	0	
56	-1	-19	16	1	6	9	0	-8
57	-2	-7	18	2	7	9	1	2
59	-9	2	17	8	5	4	1	24
60		1	-4	-1	-5	2		16
61	-8	1	10	3	3	4	-3	
62	14	-17	-1	0	1	-2	1	-16
63	29	8	5	-5	3	7	1	10
64							1	2
65	-4	-4	14	1	6	7	-2	-5
66	-9	-2	1	3	-5	3	-1	3
67	6	1	6	0	-2	8	2	-3
68		14	1	1	-4	4		28
69	-11	-5	13	4	0	9	-5	21
70		11	-4	-1	-5	2		22
71	-1	-1	16	3	7	6	0.0	5
72	9	8	8	1	-1	8	3	16
73	13	-3	3	5	0	-2	1	-14
74	3	5	10	1	0	9	1	-5
75	23	4	-8	-2	-5	-1	1	8
76	2	-7	-3	3	-4	-2	-2	
77	-7	-12	10	3	-1	8	0	
78	-4	-1	17	5	3	9	0	-7
79	-7	-4	14	4	4	6	-1	17
80	-10	12	12	1	4	7	-3	
81	-19	22	1	-1	2	0	-4	21
82	19	-4	11	4	1	6		16
83	9						1	30
84	11	-36	8	5	2	1	2	19
85	6		2	2	0	0	-1	
86	8	25	5	5	2	-2	2	
87	28	7	5	2	1	2	4	-6
88	9	-9	1	2	-1	0	0	9
89	16	-15	5	-1	2	4	3	

TABLE I (Continued)

Student	NABT	ATSSA	ATT	AFF	VCOM	ACOM	ECO	ITBS
90	0	0	15	2	5	8	-2	9
91	-8	6	-6	-2	-4	0	0	14
92	8	-10	6	1	2	3	1	
93	-2	18	3	1	1	1	-1	19
94	-5	-17	3	0	3	0	0	-3
95	15	-3	14	-1	7	8	3	-23
96	2	15	1	1	0	0	1	
97	14						2	18
98	24	1	1	-3	-1	5	3	
99	2	-28	3	1	1	1	-2	5
100	21	5	5	-1	-1	7	1	16
101	-4						-1	11
102		-16	-1	-1	1	-1		-6
103	-2						-1	-15
104	-6	-21	-1	-1	1	-1	-1	31
105	-15	-2	6	4	1	1	-3	6
106	9	12	-3	3	-1	-5	0	
107	-11		-3	0	-2	-1	0	6
108	-1	-10	18	3	6	9	2	3
109		13	5	-2	2	5		25
110		22	16	4	5	7		
111	-3	-2	5	0	3	2	1	
112	6	1	4	0	8		0	6
113								
114	15	-7	-4	-1	1	-4	1	-4
115	-3	3	-4	-7	-2	5	-1	7
116	8	0	-2	1	-1	-2	-2	
117	11	-3	-1	-1	0	0	0	
118	14	-11	6	0	3	3	1	6
119	17	-1	10	2	3	5	1	
120		-16	0	1	1	-2		
121	5	-20	12	0	7	5	-1	5
122	10	-30	12	2	4	6	1	13
123	7	-11	-4	-3	0	-1	2	
124	18	-8	8	4	3	1	3	
125	11	20	13	2	4	7	0	1
126	11						2	-6
127		-26	3	-3	1	5		-7
128	-3	-15	-4	-2	0	-2	2	
129	3	-20	-3	-2	0	-1	0	18
130	3	-19	-7	-3	-2	-2	1	14
131	-1	9	-4	-1	-2	-1	0	-1
132	-3	-3	7	2	1	4	-1	19
133	-3	-21	14	1	5	8	3	-13
134	19	0	-1	0	-7	6	2	7
135	-1	3	3	1	1	1	0	11

TABLE I (Continued)

Student	NABT	ATSSA	ATT	AFF	VCOM	ACOM	ECO	ITBS
136		-6	14	3	6	5		5
137	-11	-7	2	2	-2	2	-2	4
138	10	-12	8	2	2	4	0	37
139	6	-1	-4	-2	-1	-1	4	15
140	13	6	14	2	7	5	2	-3
141		10	11	2	5	5		19
142		-6	11	2	2	7		59
143	2	-15	5	-1	1	5	0	41
144		-5	17	1	7	9		0
145	-6	2	8	-3	4	7	1	10
146	7	1	-4	-2	0	-2	2	
147	5	-7	14	0	5	9	-1	0
148		26	-7	-3	0	-4		63
149	5	-4	3	2	-1	2	0	15
Mean Differ-ences	4.5	-3.05	4.88	0.44	1.01	3.46	0.51	8.21
Maximum Score	29.0	30.0	19.0	8.0	7.0	10.0	4.0	63.0
Minimum Score	-19.0	-36.0	-17.0	-7.0	-7.0	-9.0	-5.0	-23.0

TABLE II

DISTRIBUTION OF MEAN DIFFERENCE BETWEEN PRE- AND POST-SCORES FOR STUDENTS TAUGHT USING THE TRADITIONAL CURRICULUM

Student	NABT	ATSSA	ATT	AFF	VCOM	ACOM	ECO	ITBS
1	1						2	24
2	0	-7	-1	-2	1	0	-1	
3	11	-12	4	-2	0	6	0	-22
4	-5						2	0
5	6	-7	-2	0	0	-2	-1	
6	-3	-13	-6	-1	-1	-4	0	
7	4	-1	1	-2	3	0	-1	-21
8	5		-8	-3	-2	-3	2	-14
9	-1	19	-2	-2	1	-1	-2	
10	1	-13	3	2	1	0	-1	0
11	0						-1	
12	5						-2	-20
13		-4	1	-1	0	2		-4
14	3	5	-1	1	0	-2	-4	15
15	-1						0	-9
16	13	9	0	0	1	-1	2	-17
17	-3	-4	-2	-1	-1	0	1	-10
18	-17	-24	-4	0	-1	-3	-4	-32
19	0	-4	1	-2	2	1	-2	
20	-1	9	2	3	0	-1	-2	19
21	2	-27	7	-1	4	4	1	-5
22	9	-6	-3	-2	1	-2	2	-8
23	-8	-8	4	2	3	-1	2	-5
24	3	12	-3	-2	0	-1	-1	5
25	-6	19	0	0	2	-2	2	-1
26	-3	-7	-8	-4	0	-4	0	
27	7						0	
28								0
29	4	-5	-1	0	0	-1	-1	-2
30	5						2	
31	-2	-28	2	1	0	1	-2	-12
32	2	6	-3	-1	-2	0	0	-9
33	4						0	-12
34	13	-7					0	-13
35	12		0	-1	-1	2	3	-7
36	-9						1	-9
37	-12						0	--12
38	1	6	-9	-4	-4	-2	1	-12
39	2						2	-3
40	-5						0	-5
41	3	-3	-2	-3	-3	1	-1	-26
42	0						1	-12
43	7	10	-1	-2	-2	1	1	

TABLE II (Continued)

Student	NABT	ATSSA	ATT	AFF	VCOM	ACOM	ECO	ITBS
44	9	2	1	1	0	0	0	-11
45	12	7	0	1	0	-1	2	-6
46	-12	-10	2	-2	3	1	1	
47	0						-1	-17
48	-3						-1	2
49	25		8	-1	2	-1	2	-3
50	-5		-5	-3	0	-2	1	
51	-2	15	1	2	2	-3	2	-11
52			5	1	0	4		-38
53	8	9	2	-1	1	2	0	-20
54	5	4	3	0	2	1	0	
55	-2						1	-25
56	-2			1			0	-4
57	1						1	-13
58	-10	0	3	1	1	1	-1	-18
59	-4		0	0	0	0	2	-37
60	0						0	
61	4	-6	-3	0	0	-3	3	-29
62	-2						-1	
63	2						-2	14
64	10	2	-1	1	-2	0	0	
65	4	37	-2	0	0	-2	-1	-23
66	15						2	
67	-4						-2	
68	2	6	0	0	1	-1	1	
69	9	1	4	2	0	2	2	11
70	-15	5	-4	-1	-2	-1	-2	-2
71			-7	-2	0	-5	0	-17
72	11	3	0	-1	1	0	-3	0
73	5	0	4	1	3	0	0	-22
74	13	-6	-1	-1	0	0	0	-8
75		6	-7	-2	-3	-2		20
76		5	-5	-1	2	-6		-10
77	11		4	2	1	1	-1	-17
78	-8	-7	-3	-2	0	-1	-2	
79	6	-3	0	0	14	-1	1	-8
80		9	-6	-1	-2	-3		-7
81	-11						-1	-27
82								
83	-1	12	-2	-1	-2	1	1	-11
84	7						1	-31
85	4	-8	-7	0	-5	-2	3	-6
86	1	3	-5	-3	-1	-1	0	-1
87	0	-17	7	0	2	5	-1	9
88	7	4	-3	-1	-3	1	1	
89	-3	5	3	2	0	1	0	11

TABLE II (Continued)

Student	NABT	ATSSA	ATT	AFF	VCOM	ACOM	ECO	ITBS
90	-4	8	-3	-3	-1	1	-1	4
91	9						1	8
92	-1	-7	1	2	-1	0	1	
93	0						2	-7
94	-1						-2	-7
95	-22	5	-1	-1	1	-1	-2	-9
96	7	13	-2	1	0	-3	0	-18
97	6	-6	-4	-2	0	-2	1	-15
98	-5	3	-2	-2	1	-1	-1	-30
99		-5	5	1	0	4		
100	3	-3	-6	-1	-2	-3	0	15
102	7	6	-5	0	-2	-3	0	-13
103								-8
104	7	20	-4	-3	-2	1	1	9
105		-1	5	3	1	1		
106	-20	-16	-4	-2	-2	0	-1	-21
107	4	2	2	2	-1	1	0	2
108	16	12	-1	0	-1	0	1	7
109	2		-2	0	-3	1	2	
110	1	-11	2	1	2	-1	0	1
111	-1	18	-3	-2	-1	0	1	14
112	7	6	-3	-3	0	0	1	
113	6	-16	-8	-4	0	-4	0	-41
114	5	-21	-4	-2	1	-3	0	
115	5	4	-1	-1	-1	1	0	-7
116	12	8	1	0	1	1	1	-9
117	6	-2	-4	0	0	-4	0	-13
118	-6	-5	-4	-1	1	-4	-2	-32
119								-16
120	-4						-3	-4
121	13	-3	0	1	0	-1	0	-22
122	-6	-6	-2	0	0	-2	-2	-6
123	6	-13	-5	-2	-1	-2	-1	
124		4	-5	1	-3	-3		-3
125	-7	3	-2	2	-3	-1	1	-25
126	4	-12	8	0	3	5	2	-32
127	9	5	2	1	-1	2	0	-6
128	0	-11	1	-1	3	-1	-2	

TABLE II (Continued)

Student	NABT	ATSSA	ATT	AFF	VCOM	ACOM	ECO	ITBS
129	1	33	-4	-3	0	-1	1	-17
Mean Differ- ences	1.76	-3.05	4.88	0.44	1.01	3.46	0.07	-9.13
Maximum Score	25.0	37.0	8.0	3.0	4.0	6.0	3.0	24.0
Minimum Score	-22.0	-28.0	-9.0	-4.0	-5.0	-6.0	-4.0	-41.0

codes are as follows: NABT=(biology concepts) NABT/NSTA; ATSSA=Attitude Towards Science in School Assessment: ATT=(attitudes towards environmental concepts) Ecology Attitude Inventory; AFF=(affect) Ecology Attitude Inventory; VCOM=(verbal commitment towards environmental issues) Ecology Attitude Inventory; ACOM=(actual commitment towards environmental issues) Ecological Attitude Inventory; ECO=(knowledge of ecological concepts) NABT/NSTA; and ITBS/TAP (aptitude). Tables III and IV show the comparison of the mean pre- and post-scores for the experimental and control groups t-values, P=T, the number of students involved with each assessment, and standard deviation.

Tables V and VI list individual pre- and post-test scores for each of the assessment areas and identifies each student by his/her preferred learning style. Table V provides a range of student assessment scores for students taught using the ABC curriculum and Table VI provides a range of student assessment scores for students taught using a traditional method of biology curriculum.

Table VII provides the mean differences for both the pre- and post-tests for the NABT/NSTA experimental group and the control group and the t-value regarding gain in the knowledge of biological concepts. The calculated t-value (2.55) was significant at the 0.05 level; therefore, the null hypothesis regarding the comparison of the mean differences for students taught using the ABC (mean difference of 4.55) to students taught using the traditional method of instruction (mean difference of 1.76) could be rejected (P=0.01). Therefore, these initial assessments suggest that students taught using the ABC curriculum had a greater gain in science knowledge than students taught with

TABLE III

A COMPARISON OF MEAN DIFFERENCES BETWEEN PRE- AND POST-ASSESSMENTS FOR STUDENTS TAUGHT USING ABC CURRICULUM

Total	Variable	T	Prob>|T|	N	Mean Difference	Std Dev
148	NABT	5.38	0.00*	126	4.55	9.49
	ATSSA	-2.90	0.00*	132	-3.05	12.09
	ATTITUDE	7.84	0.00*	138	4.88	4.32
	AFFECT	1.97	0.05*	138	0.44	2.59
	VCOM	3.67	0.00*	138	1.01	3.24
	ACOM	10.34	0.00*	137	3.46	3.92
	ITBS/TAP	5.03	0.00*	117	8.21	14.98
	ECONP	3.28	0.00*	125	6.40	21.80

*Statistically significant at the 0.05 level

TABLE IV

A COMPARISON OF MEAN DIFFERENCES BETWEEN PRE- AND POST-ASSESSMENTS FOR STUDENTS TAUGHT USING TRADITIONAL CURRICULUM

Total	Variable	T	Prob>|T|	N	Mean Difference	Std Dev
128	NABT	2.52	0.01*	115	1.76	7.43
	ATSSA	0.05	0.96	86	0.06	11.40
	ATTITUDE	-2.98	0.04*	94	-1.12	3.63
	AFFECT	-3.11	0.00*	94	-0.51	1.59
	VCOM	-0.42	0.67	94	-0.07	1.71
	ACOM	-2.36	0.02*	94	-0.53	2.18
	ITBS/TAP	-6.81	0.00*	98	-9.13	13.28
	ECONP	0.50	0.62	115	0.87	18.49

*Statistically significant at the 0.05 level

TABLE V

PRE- AND POST-ASSESSMENT SCORES FOR STUDENTS TAUGHT USING THE ABC CURRICULUM

Student	LS	NABT/NSTA Pre/Post N = 80		EAI Pre/Post N = 30		ATSSA Pre/Post N = 14		ECON Pre/Post N = 8	
1	1	19	16	6	19	46	50	1	0
2	1	13	20	16	13	62	42	2	2
3	4	16	23	25	21	57	45	2	1
4	1	22	39	6	19	60	49	2	3
5	3	14	23	24	16	39	33	1	2
6	1	2	17	9	19	46	24	0	3
7	4	13	30	10	16	48	44	0	3
8		27	20	12	21	57	66	2	2
9	2	11	23	22	24	17	18	0	2
10	3	18		15	16	41		1	
11	4	15	26	4	23	30	18	0	1
12	1	26	16	18		18		4	0
13	2		22	9	20	35	38		1
14	2	19	23	10	12	41	53	2	1
15	1	16	22	16	19	42	31	0	1
16	2	11	22	12	16	46	50	1	2
17	1	19	16	14	5	47	37	3	2
18	4	28	22	11	22	37	20	3	2
19	1		14	9	16	41	42		5
20	4	16	24	14	19	26	22	2	0
21		16	8	7	19	26	22	2	0
22	4	33	18	5	21	17	20	2	3
23	4	22	23	10	19	32	44	4	2
24	4	22		4	9	42		2	
25	1	11	24	16	20	41	39	0	2
26	4	14	22	7	15	22	5	2	2
27	1	17	22	13	11	52	49	0	2
28	3	26	30	16	15	26	33	4	3
29	3	17	30	11	6	28	42	3	3
30	4	27	35	12	23	57		1	4
31	4	13	22	10	19	16	18	0	2
32	3	39	50	7	20	40	46	2	4
33	1	33	24	12	21	42	39	3	2
34	2	23	20	10	21	61	64	1	2
35	4	25	32	17	13	62	66	4	3
36	4	18	31	19	14	48	57	1	4
37	2	7	22	27	10	69	69	2	4
38	2	25	32	21	16	55	42	1	4
39	4	17	34	14		42	1	5	
40	2	21	24	18	15	69	54	1	3

TABLE V (Continued)

Student	LS	NABT/NSTA Pre/Post N = 80		EAI Pre/Post N = 30		ATSSA Pre/Post N = 14		ECON Pre/Post N = 8	
41		17	15	16	22	65	51	1	3
42	1	23	40	4	14	41	28	2	4
43	1	11	17	14	23	43		0	2
44	1		14	16	15	48	46	0	2
45	4	14	12	16	35	15		2	
46	1	12	20	6	21	46	43	1	1
47	4	34	24	9	17	46	39	3	2
48	1	16	15	9	21	50	33	1	3
49	1			13	21	32	33		
50	2	19	21	20	17	56	56	1	2
51	3	22	15	6	22	46	14	1	3
52	4	35		19	17	35	48	2	
53	1	24	25	20	16	42	50	1	1
54	1	7	18	13	15	53	42	1	2
55	2	26	34	17	12	56	61	3	3
56	1	23	22	7	23	44	25	2	2
57	2	17	15	4	22	57	50	0	1
58	4	24	15	7	24	49	51	2	3
59	2		29	21	17	64	65		3
60	3	33	25	6	16	38	39	4	2
61	3	12	26	16	15	66	49	2	3
62	1	13	42	11	16	49	57	0	1
63	4	13	21	13	21	41		0	1
64	4	21	17	8	22	37	33	2	0
65	2	26	17	19	20	70	68	2	1
66	1	18	24	14	20	48	49	1	3
67	1	23		14	15	36	50	0	
68	3	34	23	5	18	41	36	5	0
69	3		31	19	15	51	62		3
70	3	26	25	9	25	34	33	1	1
71	3	30	39	11	19	29	37	1	4
72	1	16	29	13	16	47	44	1	2
73	3	22	25	10	20	56	61	1	2
74	1	11	34	24	16	41	45	1	2
75	4	14	16	22	19	46	39	3	1
76	4	24	17	12	22	35	23	1	1
77	4	37	33	5	22	22	21	3	3
78	3	14	7	6	20	43	39	2	1
79	1	25	15	10	22	20	32	3	0
80		42	23	21	22	48	70	6	2
81	1	0	19	4	15	18	14		1
82	2	8	17	10		29		0	1
83	1	10	21	17	25	53	17	1	3
84	1	14	20	19	21	30		1	0

TABLE V (Continued)

Student	LS	NABT/NSTA Pre/Post N = 80		EAI Pre/Post N = 30		ATSSA Pre/Post N = 14		ECON Pre/Post N = 8	
85	2	10	18	14	19	45	70	0	2
86	2	15	43	18	23	59	66	0	4
87	4	24	33	18	19	51	42	2	2
88	4	3	19	17	22	57	42	0	3
89	2	23	23	4	19	20	20	4	2
90	1	30	22	17	11	45	51	2	2
91	2	15	23	12	18	24	14	2	3
92		22	20	14	17	52	70	3	2
93	1	27	22	19	22	66	49	2	2
94	4	17	32	7	21	45	42	0	3
95	4	24	26	20	21	52	67	1	2
96	3	19	33	18		51		1	3
97	1	38	62	16	17	46	47	4	7
98	1	15	17	14	17	50	22	3	1
99	3	19	40	14	19	18	23	2	3
100	1	22	18	20		50		2	1
101	14		14	13	43	27	1		
102	4	20	18		23	61		2	1
103	1	22	16	17	16	35	14	4	3
104	2	39	24	20	26	43	41	5	2
105	2	12	21	16	13	25	37	2	2
106	4	18	7	15	12	40		1	1
107	3	21	20	4	22	50	40	1	2
108			14	7	12	14	27		2
109	3	3		1	17	14	36	0	
110	1	10	7	15	20	44	42	0	1
111	4	23	31		23		42	2	2
112	3	17		14		40		3	
113	1	11	26	14	10	55	48	1	2
114	1	30	27	17	13	49	52	2	1
115	4	13	21	20	18	22	22	2	0
116	1	16	27	20	19	38	35	0	0
117	4	13	27	15	21	47	36	0	1
118	1	19	36	5	15	43	42	0	1
119	1	11		15	15	42	26	2	
120	2	12	17	6	18	37	17	1	0
121	4	5	15	9	21	56	26	0	1
122	4	13	20	21	17	62	51	1	3
123	1	8	26	12	20	41	33	1	4
124	1	8	19	5	18	22	42	0	0
125	4	11	22	22		42		0	2
126	3		19	11	14	52	26		2
127	4	19	16	18	14	33	18	0	2

TABLE V (Continued)

Student	LS	NABT/NSTA Pre/Post N = 80		EAI Pre/Post N = 30		ATSSA Pre/Post N = 14		ECON Pre/Post N = 8	
128	2	19	22	16	13	69	49	3	3
129	3	19	22	21	14	63	44	1	2
130	1	24	23	25	21	51	60	1	1
131	2	26	23	13	20	47	44	3	2
132	2	25	22	7	21	49	28	0	3
133	3	20	39	19	18	45	45	1	3
134	1	30	29	19	22	42	45	3	3
135	1		34	5	19	45	39		4
136	1	36	25	14	16	53	46	3	1
137	2	20	30	11	19	37	25	0	0
138	3	17	23	25	21	43	42	9	4
139	2	16	29	2	16	51	57	0	2
140	3	21		5	16	32	42	1	
141	1	14		7	18	32	26	0	
142	3	14	26	11	16	40	25	3	3
143	4	9		3	20	37	32	0	
144	1	22	16	9	17	39	41	1	2
145	2	11	18	22	18	38	39	0	2
146	2	16	21	9	23	27	20	2	1
147	2		30	17	10	43	69		1
148	1	23	28	18	21	51	47	1	1
Average Scores ($\bar{X}$ Scores)		18.92	24.09	13.44	18.01	43.61	40.50	1.49	2.07

Note: The national norms based on post-secondary students: NABT/NSTA: 45.09; EAI: 47.90; ATSSA: 41.29. The national norms based on secondary students: NABT/NSTA: 45.09.

TABLE VI

PRE- AND POST-ASSESSMENT SCORES FOR STUDENTS TAUGHT USING THE TRADITIONAL BIOLOGY CURRICULUM

Student	LS	NABT/NSTA Pre/Post N = 80		EAI Pre/Post N = 30		ATSSA Pre/Post N = 14		ECON Pre/Post N = 8	
1	1	14	15	17		51		0	2
2	2	13	13	19	18	47	40	3	2
3	3	6	17	10	14	52	40	0	0
4	4	23	18	16		49		0	2
5	2	22	28	20	18	42	35	4	3
4	3	17	14	18	12	57	44	1	1
5	1	18	22	18	19	43	42	2	2
6		10	15	17	9		45	0	2
7	3	21	20	15	13	49	68	3	1
8	1	23	24	17	20	35	22	3	2
9	1	20	20	19		59		2	1
10	3	19	24	17		39		3	1
11	1		20	17	18	58	54		2
12	4	19	22	20	19	57	62	4	0
13	2	16	15	20		44		1	1
14	3	6	19	18	18	26	35	0	2
15	1	24	21	20	18	47	43	1	2
16	2	21	4	17	13	56	32	4	0
17	1	17	17	22	23	49	45	5	3
18	4	20	19	21	23	46	55	3	1
19	3	24	26	17	24	66	39	1	2
20	2	13	22	20	17	50	44	1	3
21	2	26	18	19	23	52	44	0	2
22	3	21	24	21	18	55	67	2	1
23	2	28	22	16	16	47	66	2	4
24	4	16	13	15	7	46	39	3	5
25	4	16	23	20		41		3	3
26	4		25	18		44			2
27	2	20	24	20	19	51	46	2	1
28	2	15	20	16		43		0	2
29	1	22	20	18	20	58	30	3	1
30	4	18	20	24	21	45	51	1	1
31	4	20	24	14		53		1	1
32	2	15	28	22		40	33	2	2
33	1	21	33	21	21	41		0	3
34	2	27	18	21		43		0	1
35	3	22	10	19		33		1	1
36	1	21	22	21	12	60	66	2	3
37	2	23	25	24		36		2	4
38		20	15		11		41	1	1

TABLE VI (Continued)

Student	LS	NABT/NSTA Pre/Post N = 80		EAI Pre/Post N = 30		ATSSA Pre/Post N = 14		ECON Pre/Post N = 8	
39	3	12	15	23	21	30	27	1	0
40	1	26	26	19		65		1	2
41	2	19	26	21	20	34	44	1	2
42	1	7	16	23	24	16	18	0	0
43	1	13	25	21	21	52	59	1	3
44	1	36	24	21	23	54	44	1	2
45	4	23	23	18		55		4	3
46	3	20	17	21		30		2	1
47	2	5	30	24	24	58		0	2
48	1	20	15	22	17		38	0	1
49	3	23	21	22	23	50	65	2	4
50	2	12		14	19		26	2	
51	4	8	16	18	20	48	57	0	0
52	2	19	24	19	22	53	57	1	1
53	1	20	18	20		29		1	2
54	1	16	14	21		41		2	2
55	2	20	21	17		45		1	2
56	3	28	18	13	16	69	69	2	1
57	1	21	17	22	22		31	1	3
58	2	13	22	21		37		1	3
59	3	10	14	21	18	38	32	0	3
60	2	15	13	24		48		2	1
61	2	24	26	14		67		2	0
62	1	18	28	18	17	48	50	1	1
63	4	18	22	17	15	27	64	2	1
64		5	20		9		55	0	2
65	2	15	11	13		52		3	1
66	1	16	18	23	23	33	39	1	2
67	1	22	31	16	20	60	61	0	2
68	4	32	17	21	17	45	50	4	2
69	3	20		20	13		50	3	
70	2	13	24	21	21	44	47	3	0
71	2	9	14	19	23	44	44	1	1
72	2	14	27	24	23	54	48	1	1
73	2		20	22	15	24	30		3
74	2		19	20	15	52	57		2
75	2	13	24	18	22	41		2	1
76		28	20	23	20	46	39	4	2
77	2	16	22	21	21	57	54	1	2
78	2	13		21	15	46	55	1	
79	4	28	17	22		48		2	1
80	1				21		18		
81	2	26	25	18	16	34	46	1	2
82	4	21	28	23		24		3	4

TABLE VI (Continued)

Student	LS	NABT/NSTA Pre/Post N = 80		EAI Pre/Post N = 30		ATSSA Pre/Post N = 14		ECON Pre/Post N = 8	
83		20	24	21	14	57	49	2	5
84	3	19	20	24	19	43	46	1	1
85	1	24	24	14	21	62	45	1	0
86	2	26	33	20	17	47	51	2	3
87	2	27	24	20	23	61	66	2	2
88	4	25	21	23	20	50	58	2	1
89	2	18	27	18		59		1	2
90	1	23	22	18	19	49	42	2	3
91	2	17	17	17		59		1	3
92	2	14	13	16		42		2	0
93	4	37	15	15	14	59	64	3	1
94	1	14	21	21	19	45	58	1	1
95	1	9	15	15	11	43	37	0	1
96	4	26	21	21	19	58	61	2	1
97	4		27	12	17	70	65		3
98	2	15	18	21	15	69	66	2	2
99	1	16	23	22	17	56	62	2	2
100	3		15	18		52			0
101	3	18	25	23	19	30	50	1	2
102	4		14	17	22	36	35		4
103	3	20	0	26	22	69	53	1	0
104	3	34	38	18	20	66	68	2	2
105	2	13	29	21	20	35	47	1	2
106	2	16	18	16	14	38		2	4
107	4	11	12	16	18	48	37	1	1
108		24	23	24	21	38	56	1	2
109	2	17	24	22	19	40	46	1	2
110	1	5	11	22	14	42	26	1	1
111		11	16	20	16	34	13	1	1
112	3	19	24	22	21	53	57	0	0
113	2	27	39	19	20	51	59	2	3
114	3	21	27	16	12	66	64	1	1
115	2	20	14	22	18	42	37	3	1
116	4		21	22		46			3
117	2	27	23	20		52		3	0
118	2	16	29	22	22	42	39	1	1
119	1	21	15	22	20	43	37	3	1
120	1	13	19	20	15	57	44	2	1
121	2	25		21	16	14	18	4	
122	1	24	17	21	19	46	49	2	3
123	3	14	18	13	21	60	48	2	4
124	1	20	29	17	19	45	50	2	2

TABLE VI (Continued)

Student	LS	NABT/NSTA Pre/Post N = 80		EAI Pre/Post N = 30		ATSSA Pre/Post N = 14		ECON Pre/Post N = 8	
125	3	21	21	14	15	41	30	3	1
126	1	21	22	23	19	17	50	2	3
Average Scores ($\bar{X}$ Score)		19.04	21.13	19.22	18.57	46.83	48.52	1.69	1.78

Note: The national norms based on postsecondary students: EAI 47.90; ATSSA 41.29. The national norm based on secondary students: 45.09.

TABLE VII

MEAN DIFFERENCES FOR STUDENTS USING THE ABC CURRICULUM COMPARED TO STUDENTS USING TRADITIONAL CURRICULUM REGARDING BIOLOGY CONCEPTS

Curriculum	N	Mean Gain	T Value	Prob>|t|
ABC	126	4.55	2.55	0.01*
Traditional	115	1.76		

*Significant at the 0.05 level

traditional biology curriculum.

Table VIII provides the mean differences of the pre- and post-tests for the ATSSA assessment for the experimental group and the control group and the t-value regarding the change in attitude towards science. The experimental group of students taught using the ABC curriculum had a mean difference of -3.05 and the control group of students taught using a traditional method of instruction had a mean difference of 0.06. The calculated t-value (2.55) was not significant at the 0.05 level; therefore, the null hypothesis could not be rejected.

Table IX provides the mean differences for the pre-and post-tests for the EAI assessment questions 101-130 of the experimental and control groups and the t-value regarding the change in attitude towards environmental issues. The calculated t-value (8.26) was significant at the 0.05 level with a P-value of 0.00 between the students taught using the ABC curriculum (mean difference of 4.88) and the students taught using the traditional biology curriculum (mean difference of -1.12.) Therefore, students taught using the ABC curriculum had a significantly greater positive change on the EAI assessment than students taught using the traditional biology curriculum.

Table X provides the mean difference for the pre- and post-tests for the EAI assessment questions 101-110 of the experimental and control groups and the t-value regarding the change effect in attitude towards environmental issues. The calculated t-value (3.44) was significant at the 0.05 level (P=0.00) between the students taught using the ABC curriculum (mean difference of 0.44) and the students taught using traditional curriculum (mean difference of -0.51.) Therefore, the initial assessments indicate that

TABLE VIII

ATTITUDE TOWARDS SCIENCE MEAN DIFFERENCES USING THE ABC CURRICULUM COMPARED TO STUDENTS USING TRADITIONAL CURRICULUM

Curriculum	N	Mean Gain	T Value	Prob>|t|
ABC	132	-3.05	-1.90	0.06
Traditional	86	0.06		

TABLE IX

ATTITUDE TOWARDS ENVIRONMENTAL ISSUES MEAN DIFFERENCES FOR STUDENTS USING THE ABC CURRICULUM COMPARED TO STUDENTS USING TRADITIONAL CURRICULUM

Group	N	Mean Gain	T Value	Prob>|t|
ABC	138	4.88	8.256	.00*
Traditional	94	-1.12		

*Significant at the 0.05 level

TABLE X

AFFECTIVE MEASUREMENT TOWARDS ENVIRONMENTAL ISSUES MEAN DIFFERENCES FOR STUDENTS USING THE ABC CURRICULUM COMPARED TO STUDENTS USING TRADITIONAL CURRICULUM

Curriculum	N	Mean Gain	T Value	Prob>|t|
ABC	138	0.44	3.44	0.00*
Traditional	94	-0.51		

*Significant at the 0.05 level

students taught using the ABC curriculum had a greater positive gain on the EAI regarding affect towards environmental issues than students taught using the traditional curriculum.

Table XI provides the mean difference for the pre- and post-tests for the EAI assessment questions 111-120 of the experimental and control groups and the t-value regarding the change in verbal commitment toward environmental issues. The calculated t-value (3.33) was significant at the 0.05 level (P=0.00) between the students taught using the ABC curriculum (mean difference of 1.01) and the students taught using traditional curriculum (mean difference of -0.07.) Therefore, the students taught with the ABC curriculum had a greater positive gain on the EAI regarding verbal commitment towards environmental issues than students taught using traditional curriculum.

Table XII provides the mean difference for the pre- and post-tests for the EAI assessment questions 121-130 of the experimental and control groups and the t-value regarding the change in actual commitment toward environmental issues. The t-value (9.90) was significant at the 0.05 level (P=0.00) between the students taught using the ABC curriculum (mean difference of 3.46) and the students taught using traditional curriculum (mean difference of -0.53.) Therefore, the initial assessments indicate that students taught using the ABC curriculum had a greater positive gain toward actual commitment regarding environmental issues than students taught using traditional curriculum.

Table XIII provides the mean differences for the pre- (spring 1993) and post- (spring 1994) ITBS/TAP assessments of the experimental and control groups and the

TABLE XI

VERBAL COMMITMENT TOWARDS ENVIRONMENTAL ISSUES MEAN DIFFERENCE FOR STUDENTS USING THE ABC CURRICULUM COMPARED TO STUDENTS USING TRADITIONAL CURRICULUM

Curriculum	N	Mean Gain	T Value	Prob>|t|
ABC	138	1.01	3.33	0.00*
Traditional	94	-0.07		

*Significant at the 0.05 level

TABLE XII

ACTUAL COMMITMENT TOWARDS ENVIRONMENTAL ISSUES MEAN DIFFERENCES FOR STUDENTS USING THE ABC CURRICULUM COMPARED TO STUDENTS USING TRADITIONAL CURRICULUM

Curriculum	N	Mean Gain	T Value	Prob>|t|
ABC	137	3.46	9.90	0.00*
Traditional	94	-0.53		

*Significant at the 0.05 level

TABLE XIII

ITBS/TAP MEAN DIFFERENCES FOR STUDENTS USING THE ABC CURRICULUM COMPARED TO STUDENTS USING TRADITIONAL CURRICULUM

Curriculum	N	Mean Gain	T Value	Prob>|t|
ABC	117	8.21	8.90	0.00*
Traditional	98	-9.13		

*Significant at the 0.05 level

t-value regarding the gain in aptitude towards science concepts. The t-value (8.90) was significant at the 0.05 level (P=0.00) between the students taught using the ABC curriculum (mean difference of 8.205) and the students taught using traditional curriculum (mean difference of -9.133.) Therefore, the initial assessments indicate students taught using the ABC curriculum had a higher gain on the ITBS/TAP NCE score in science than students taught with the traditional biology curriculum.

Table XIV provides the mean difference for the pre- and post-tests for the NABT/NSTA assessment questions 4, 17, 25, 33, 41, 50, 58, and 73 of the experimental and control groups and the t-value regarding the gain in knowledge of environmental concepts. The calculated t-value (2.13) was significant at the 0.05 level (P=0.04) between the students taught using the ABC curriculum (mean gain of 6.40) and the students taught using a traditional method of instruction (mean gain of 0.87.) Therefore, the initial assessments indicate that students taught using the ABC curriculum had a larger mean gain in the knowledge of environmental concepts than the students taught using the traditional biology curriculum.

Table XV provides the mean difference for the pre- and post-tests for the NABT/NSTA assessment for the experimental and control groups and t-value for students with the preferred learning style 1. The calculated t-value (1.74) was not significant at the 0.05 level (P=0.06).

Table XVI provides the mean differences for the pre- and post-tests for the NABT/NSTA assessment of the experimental and control groups and the t-value for students with the preferred learning style 2. The calculated t-value (0.66) was not

TABLE XIV

ENVIRONMENTAL CONCEPTS MEAN DIFFERENCE FOR STUDENTS USING THE ABC CURRICULUM COMPARED TO STUDENTS USING TRADITIONAL CURRICULUM

Curriculum	N	Mean Gain	T Value	Prob>|t|
ABC	125	6.40	2.13	0.04*
Traditional	115	0.87		

*Significant at the 0.05 level

TABLE XV

LEARNING STYLE 1 MEAN DIFFERENCES FOR STUDENTS USING THE ABC CURRICULUM COMPARED TO STUDENTS USING TRADITIONAL CURRICULUM

Curriculum	N	Mean Gain	T Value	Prob>|t|
ABC	43	5.37	1.740	0.064
Traditional	32	1.84		

TABLE XVI

LEARNING STYLE 2 MEAN DIFFERENCE FOR STUDENTS USING THE ABC CURRICULUM AS COMPARED TO STUDENTS USING TRADITIONAL CURRICULUM

Curriculum	N	Mean Gain	T Value	Prob>|t|
ABC	26	5.08	0.66	0.51
Traditional	38	3.71		

significant at the 0.05 level (P=0.51).

Table XVII provides the mean difference for the pre- and post-tests for the NABT/NSTA assessment of the experimental and control groups and the t-value regarding students with the preferred learning style 3. The calculated t-value (1.72) was not significant at the 0.05 level (P=0.09).

Table XVIII provides the mean difference for the pre- and post-tests for the NABT/NSTA assessment of the experimental and control groups and the t-value for students with a preferred learning style 4. The calculated t-value (2.40) was significant at the 0.05 level (0.02) between the experimental group (mean difference of 4.39) and the control group (mean gain of -1.77). Therefore, the initial assessments indicate that students with a preferred learning style of Kolb's #4 and taught using the ABC curriculum had a higher mean gain regarding biological concepts than students with a preferred learning style of Kolb's #4 taught using traditional curriculum.

Table XIX provides the mean difference for the pre- and post-tests for the NABT/NSTA assessment of students taught using the ABC curriculum in suburban communities and rural communities. The calculated t-value was not significant at the 0.05 level (0.902).

In Tables XX-XXIII the school and hour of each class are pooled together, used to calculate the sums of the squares, and used as error. No significant difference was found between the treatments for biological concepts as shown in Table XXI with F=1.47 (P=.24). A significant difference was evident in the variables for attitude towards the environmental concepts F=5.22 (P=.04) and towards the environment F=17.10 (P=.00), as

TABLE XVII

LEARNING STYLE 3 MEAN DIFFERENCE FOR STUDENTS USING THE ABC CURRICULUM AS COMPARED TO STUDENTS USING TRADITIONAL CURRICULUM

Curriculum	N	Mean Gain	T Value	Prob>|t|
ABC	19	5.42	1.72	0.09
Traditional	38	0.81		

TABLE XVIII

LEARNING STYLE 4 MEAN DIFFERENCES FOR STUDENTS USING THE ABC CURRICULUM AS COMPARED TO STUDENTS USING TRADITIONAL CURRICULUM

Curriculum	N	Mean Gain	T Value	Prob>|t|
ABC	33	4.39	2.40	0.02*
Traditional	17	-1.77		

*Significant at the 0.05 level

TABLE XIX

MEAN DIFFERENCES FOR STUDENTS USING THE ABC CURRICULUM IN SUBURBAN SCHOOLS AS COMPARED TO STUDENTS USING THE ABC CURRICULUM IN RURAL SCHOOLS

Curriculum	N	Mean Gain	T Value	Prob>|t|
ABC Suburban	126	4.55	-0.12	0.90
ABC Rural	20	4.70		

TABLE XX

ANALYSIS OF COVARIANCE BETWEEN NABT MEAN DIFFERENCE AND SCIENCE GRADE AND ITBS/TAP

Sources of Variation		Sums of Squares	F Value	Pr>F
Grade	1	3.36	1.47	.24
ITBS/TAP	1	18.46		
Group	1	151.87		
Class	15	1449.97		
Students	164	12287.30		

TABLE XXI

ANALYSIS OF COVARIANCE BETWEEN ATSSA AND SCIENCE GRADE AND ITBS/TAP

Sources of Variation		Sum of Square	F Value	Pr>F
Grade	1	1193.03	6.30	0.026*
ITBS/TAP	1	856.47		
Group	1	1003.81		
Class	13	2070.76		
Students	148	18900.26		

*Significant at the 0.05 level

TABLE XXII

ANALYSIS OF COVARIANCE BETWEEN ECOLOGICAL CONCEPTS AND SCIENCE GRADE AND ITBS/TAP

Sources of Variation		Sum of Square	F Value	Pr>F
Grade	1	6.32	5.22	0.037*
ITBS/TAP	1	1.37		
Group	1	7.20		
Class	15	20.70		
Students	163	434.23		

*Significant at the 0.05 level

TABLE XXIII

ANALYSIS OF COVARIANCE BETWEEN EAI AND SCIENCE GRADE AND ITBS/TAP

Source of Variation		Sum of Square	F Value	Pr>F
Grade	1	2.83	17.10	0.012*
ITBS/TAP	1	46.81		
Group	1	1406.36		
Class	13	1069.13		
Students	158	5433.67		

*Significant at the 0.05 level

shown in Tables XXII, XXIII, and XXIV, respectively. The significant difference in attitude towards science favored the control group which was taught using the traditional method. The significant difference in attitude towards the environment and knowledge of environmental concepts was positive towards the experimental group which was taught using the ABC curriculum. The analysis of covariance showed evidence that the two independent variables, GPA and ITBS, did have an affect on the dependent variable.

Qualitative Data Regarding the ABC Curriculum

Table XXIV reported the student responses obtained via class interviews. Responses, if duplicated, were only reported once.

TABLE XXIV

STUDENTS' PERCEPTIONS OF THE ABC COURSE

Questions	Responses
1. How did you like this course overall?	Liked; indifferent; boring; fun; easier; working in groups was fun; books are repetitive; interesting; not as hands-on as I thought that it would be;
2. What specific things did you like about the ABC course?	Fun learning; fieldtrips; labs; zoo; group work; discussions; short videos; group reports; easy to understand;
3. What specific things did you dislike about the ABC course?	group reports; homework; reading; notebooks, and objectives; notes; books need an index; short videos; videos were too short; not enough labs; wanted to dissect; lab conclusions and questions were too difficult;
4. How does this class compare with any other science classes you have had?	Had more videos; a lot better; harder; better; worse; more interesting and fun; some material students have already had;
5. What changes do you think should be made in this course for next year?	Need dissection; more labs; more hands-on; better topics like more physiology; change class description; more human anatomy; smaller classes; more fieldtrips; only one book;

TABLE XXV

ADMINISTRATORS' PERCEPTIONS OF THE ABC CURRICULUM

Questions	Responses
1. Should students receive credit for graduation for this course?	Yes, this course meets the science minimum curriculum requirements of the SDE Priority Academic Skills, therefore, should be as viable as other science curriculum.
2. Should this course be given credit for college entrance requirements as a lab science course?	Definitely, it's structured as a lab course. IF it's also maintaining the rigor of other college entrance courses, then students will have earned the credit.
3. In you opinion, what are the students' perceptions of this course?	Students seem to value this course as a science course requirement and part of the total high school preparation for post-secondary plans.
4. How has the course enhanced education in your school?	The curriculum is at least if not more than, developmentally appropriate for ninth grade students. It is important to offer variety in core curriculum so as to meet the various needs of students.
5. In your opinion, how should the ABC course be offered next year?	ABC should be offered as one ninth or tenth grade curriculum option. Students who indicate a preference for health careers might benefit from enrollment in this course.

TABLE XXVI

INSTRUCTORS' PERCEPTIONS OF THE ABC CURRICULUM

Questions	Responses	
1. How well did you feel this curriculum met the learner outcomes for Bio I?	Instructor 1.	I feel that the outcomes would be met if all the units were completed.
	Instructor 2.	Very well.
2. Do you believe that this course changed students' attitudes toward science?	Instructor 1.	I did not observe this.
	Instructor 2.	Yes. I believe that the students realized why they were learning the subject matter (for career consideration) and thus it became more important.
3. What do you think your students perceptions of this course were?	Instructor 1.	They came in thinking this to be a low-level course. Many would not do the required work, but I do not think they would have done the work in any class.
	Instructor 2.	Most thought the course was challenging-for some I believe it was harder than expected. I think that most thought that it was a worthwhile course.
4. What do you think parents perceptions of this course were?	Instructor 1.	I think many of them also interpreted "hands-on" to mean low level.
	Instructor 2.	I think most parents were pleased and satisfied with it.

TABLE XXVI (Continued)

Questions		Responses
5. How do you think your principal perceived this course?	Instructor 1.	He did not indicate any opinion about it. This was an exceptionally busy year with many new courses being added due to the conversion from a high school with three grade levels to a high school with four grade levels.
	Instructor 2.	A very important course-a new, innovative way of teaching-another step forward in bettering our students' education.
6. How do you think your superintendent perceived this course?	Instructor 1.	Do not know.
	Instructor 2.	I felt the superintendent was very supportive.
7. Should students be given science credit for this course?	Instructor 1.	Yes.
	Instructor 2.	Yes! Without a doubt.
8. What is your overall perception of the course?	Instructor 1.	It is a good course. It is a practical course for the average student when it is used as a dumping ground for low level students. It then is not possible to do many of the labs which the labs which are rather sophisticated.
	Instructor 2.	Very good curriculum-fun to teach-brings biology to a more personal level with the students.
9. Do you see the need for a graduate level course aimed at teaching ABC? If so, briefly describe this course.	Instructor 1.	Training needs to include content of course (units available) and cooperative learning. Also, how to put students into groups and manage them.

TABLE XXVI (Continued)

Questions		Responses
	Instructor 2.	Use teachers who have already taught the course. It would probably be best offered in the summer. At least an extensive workshop- perhaps a graduate level course of 1-2 hours, covering the basic premise of applied curriculum.
10. What advice would you offer to someone who is planning to teach this course next year?	Instructor 1.	Get training!!! Do not spend much time reading in class. Give homework.
	Instructor 2.	Talk to people who have taught the course. Attend some training. Become familiar with how the text books tie together. Become familiar with the premise of applied education.

CHAPTER V

SUMMARY, CONCLUSIONS, AND RECOMMENDATIONS

Introduction

Science facts are compounding daily adding to an already vast list of scientific concepts; and educators are forced to rely upon memorization of these facts and terms by students to meet state and national mandated standards. With traditional educational teaching methods, students are not developing the skills needed to apply memorized scientific knowledge to real life situations; furthermore, students normally forget the memorized facts and concepts within a short period of time. It has been noted that today's citizens must be scientifically literate in order to be aware of societal and global needs. This awareness will affect legislation and life styles and promote an understanding of the importance of becoming lifelong learners.

The new national standards for teaching, to be published in the fall of 1994, are expected to change the philosophy of teaching science to some students to teaching science to all students (Hoffman & Stage, 1993). The new text being developed will address the necessity of recognizing the needs of all special populations including women, ethnic groups, and physically and educably challenged youths and it will also stress the need to satisfy all learning styles. The document will illustrate the "interweaving of curriculum, teaching, and assessment" and characterize "the inclusion not only of the subject matter (ecology, energy, space, and so on) but also inquiry, decision making, and content (social, ethical, and historical)" (Hoffman & Stage, p. 31).

The applied science biology/chemistry curriculum is a possible solution to meeting the requirements established by the new national standards for teaching. The applied sciences provide a rigorous curriculum which is applied to real world experiences (CORD, 1993). Curriculum, in the past, has often been developed according to Bloom's Taxonomy: awareness, understanding/comprehension, application, analysis, synthesis, and evaluation. The applied biology/chemistry curriculum uses Bloom's highest levels of learning, analysis and synthesis, and incorporates "real-world applications" (Daggett, 1994, p. 27). Therefore, students learn to solve societal and life problems instead of learning just for the sake of getting a grade.

Palmer (1993) cited research conducted in 1980 by Tanner which supported for the development of new standards designed for teaching. The findings stated that participation in activities which include life experiences, while learning scientific concepts, helps to "produce adults who are informed about and actively promote environmentally positive behavior" (p. 26). Tanner's hypotheses included the fact that children must understand and internalize everyday experiences before they can solve problems related to societal problems. Teachers must become versed in teaching methods that will "produce active and informed minds" (p. 27).

Problem Statement

"There has been a growing realization that the meanings for words and views of the world that even high school and college students bring with them to science lessons may have an inordinate effect on learning science" (Osborne & Cosgrove, 1983, p. 825). Mills (1990) stated that it is possible for students to pass high school and college science classes and still not have basic concepts that are transferable to the understanding and application of science-related phenomena. If these concepts are not fully understood, then the basic understanding of science-related concepts and the application of those concepts will not be passed to future generations and will affect the existence of the world as is known today.

Summary of Study

The purpose of this study was to compare the Applied Biology and Chemistry (ABC) curriculum instructional method with the traditional biology curriculum. This study tried to determine if students learn biology concepts and/or environmental concepts and develop a more positive attitude towards science and/or the environment better using the ABC curriculum compared to students who were taught with a traditional biology curriculum.

This study was developed using a quasi-nonequivalent pre-test post-test control group design. The experimental and control populations were drawn from a suburban school district within Central Oklahoma. Two hundred and seventy six students were selected from two high schools within the Edmond Public School District. The experimental group was drawn from students enrolled in an applied science class called Applied Biology and Chemistry which consisted of nine existing classes with 148 students (primarily ninth grade). The control group was drawn from students enrolled in a traditional science class, whose teachers volunteered to participate in the research study which consisted of eight existing classes with 128 students (primarily tenth grade). Both the experimental group and the control group had opportunities to participate in similar types of presentations regarding differences between applied academics and traditional curriculum, learning styles, and academic requirements for specific careers.

All students were administered three pre-tests, three post-tests, one learning style assessment, and an aptitude assessment. The three pre-/post-tests included: NABT/NSTA (National Association of Biology Teachers/National Science Teachers Association), ATSSA (Attitude Toward Science in School Assessment), and EAI (Ecology Attitude Inventory). The pre-tests were administered during the second and third weeks of school and the post-tests were administered during the eighth week of the fourth nine weeks. Kolb's learning style assessment was administered during the second or third week of school.

All students are administered the ITBS/TAP (Iowa Test of Basic Skills/Test of Achievement and Proficiency) assessment every spring; therefore, the ITBS/TAP science NCE scores were retrieved from the students' cumulative records.

Mean gain scores were calculated between the pre- and post-test scores as follows:

1. Fall 1993 NABT/NSTA vs. spring 1994 NABT/NSTA

2. Fall 1993 ATSSA vs. Spring 1994 ATSSA

3. Fall 1993 EAI vs. Spring 1994 EAI questions 1-30

4. Spring 1993 ITBS/TAP NCE science scores vs. Spring 1994 ITB/TAP NCE science scores

5. Fall 1993 NABT/NSTA pre-test vs. Spring 1994 NABT/NSTA post-test questions: 4, 17, 25, 33, 41, 50, 58, and 73 (ecology concepts)

6. Suburban NABT/NSTA scores vs. Rural NABT/NSTA scores

The mean gain scores were compared between the experimental group, ABC, and the control group, traditional Biology I. The rural mean gain scores were taken from data collected in 1993-94 from a report which is currently being finalized (Key, J., & Hamby, J., 1995). T-tests and analysis of covariance computer analyses were conducted to determine if a significant difference existed between the mean gain of the students enrolled in an applied biology class as compared to students enrolled in a traditional biology class.

Summary Table

Table XXVII summarizes the data from Chapter IV. It lists the assessments which were used, maximum/minimum assessment scores, mean differences, standard deviation, p>|T|, comparison between students enrolled in ABC to students enrolled in the traditional biology curriculum p>|T|, PR>F, and the instructional method statistically favored.

TABLE XXVII

SUMMARY OF DATA

Assessment	Curriculum	Pre/Post Max/Min Test Means	Mean Difference	S.D.	t-Value P>|T|	Comp t-Value p>|T|	f-Value PR>F	Favored Curr
NABT/NSTA	ABC	18.92/24.09	4.55	9.49	5.38	0.01*	.24	ABC
	TRAD	19.04/21.13	1.76	7.47	0.01			
ATSSA	ABC	43.61/40.50	-3.5	12.09	0.00	0.06*	.03*	TRAD
	TRAD	46.83/48.52	-0.06	11.34	0.96			
EAI	ABC	13.44/18.01	4.88	7.32	0.00	0.00*	.00*	ABC
	TRAD	19.22/18.57	-1.12	3.63	0.00			
ECOLOGY	ABC	1.49/ 2.07	0.51	1.74	0.00*	0.04*	0.04*	ABC
KNOWLEDGE	TRAD	1.69/ 1.78	0.07	1.48				
ITBS	ABC		8.21	14.98	0.00	0.00*		ABC
	TRAD		-9.13	13.28	0.00			
LS 1	ABC		5.37	10.30		0.06		N/A
	TRAD		1.84	5.80				
LS 2	ABC		5.08	8.37		0.51		N/A
	TRAD		3.71	8.02				
LS 3	ABC		5.42	9.39		0.10		N/A
	TRAD		0.81	7.58				
LS 4	ABC		4.39	8.82		0.02*		ABC
	TRAD		-1.76	8.14				
Suburban	ABC	18.92/24.09	4.70			0.90		N/A
Rural	ABC	24.95/29.65	4.55					

*Significant at the 0.05 level

Note: N/A identifies that there was no favored curriculum

Null Hypotheses

The following null hypotheses were either accepted or rejected using the t-value to determine statistical significance. The level of significance was established at < 0.05.

Ho $_1$. There is no significant difference in the pre- and post-test mean differences on the NABT/NSTA between the students enrolled in the ABC curriculum compared to the students enrolled in the traditional biology curriculum.

This null hypothesis was rejected with a significant difference P=0.01. Students taught using the applied biology and chemistry curriculum had a mean difference of 4.55 while students taught using traditional biology curriculum had a mean difference of 1.76. These findings suggest that students taught using the ABC curriculum had a larger positive mean gain on the NABT/NSTA which measured biological concept knowledge. However, when a comparison was made using an analysis of covariance controlling for ITBS and science grade, the significant difference was P=.24. Therefore, no signficant difference was found between students using the ABC method of instruction as compared to students using the traditional method of instruction. This suggests that the statistical difference derived from the t-test regarding the mean gain scores of the NABT/NSTA may be a function of the covariants ITBS score and science grade.

Ho $_2$. There is no significant difference in pre- and post-test mean differences on the ATSSA between the students enrolled in the ABC curriculum compared to the students enrolled in the traditional biology curriculum.

Students taught using the ABC curriculum had a mean difference of -3.05 and the students taught using the traditional curriculum had a mean difference of 0.06. The t-value was not significant at the .05 level of confidence (P=0.59), however, after controlling for ITBS and science grade via an analysis of covariance there was a significant difference (P=.03) showing that students taught using traditional biology curriculum had a larger positive mean gain on the ATSSA, attitude towards science, as compared to students using the ABC curriculum.

Ho $_3$. There is no significant difference in the pre- and post-test mean difference on the EAI between the students enrolled in the ABC curriculum compared to the students enrolled in the traditional biology curriculum.

The t-test (P=0.00) rejected the null hypothesis. The analysis of covariance (P=0.00) maintained the significance of difference at the 0.05 level. Students taught using the ABC curriculum had a mean gain of 4.88 and students taught using the traditional biology curriculum had a mean difference of -1.12. Therefore, students taught with the ABC curriculum had a larger positive mean gain on the EAI, attitude towards the environment, than students who were taught with traditional biology curriculum.

Ho $_4$. There is no significant difference in the pre- and post-test mean difference on the ITBS/TAP, science aptitude, between the students enrolled in the ABC curriculum compared to the students enrolled in the traditional biology curriculum.

The null hypothesis was rejected with a significant difference of P=0.00. Students taught using the ABC had a mean gain of 8.21 and the students taught with traditional biology curriculum had a mean difference of -9.13. Therefore, students using the ABC curriculum had a larger positive mean gain in aptitude in science as measured by the ITBS/TAP assessments as compared to students taught using traditional biology.

Ho $_5$. There is no significant difference in the pre- and post-test mean differences dealing with environmental concepts on the NABT/NSTA between the students enrolled in the ABC curriculum and the students enrolled in the traditional biology curriculum.

The null hypothesis was rejected with a significant difference; t-test (P=0.04) and maintained with the analysis of covariance (P=0.04). Students taught using the ABC curriculum had a mean gain score of 6.40 and students taught using the traditional biology curriculum had a mean gain of 0.87. Therefore, students taught using the ABC curriculum had a larger positive mean gain regarding environmental concepts than students who were taught using the traditional biology curriculum.

Ho $_6$. There is no significant difference in the pre- and post-test mean differences on the NABT/NSTA between the students with quadrant 1 learning style taught using the ABC compared to the students with quadrant 1 learning style taught with the traditional biology curriculum.

The null hypothesis could not be rejected. The t-test showed that there was not a significant difference (P=0.06). Therefore, there was no significant difference in students who preferred learning style 1 between students taught using the ABC curriculum as compared to students taught using the traditional biology curriculum.

Ho $_7$. There is no significant difference in the pre- and post-test mean differences on the NABT/NSTA between the students with quadrant 2 learning style taught using the ABC compared to the students with quadrant 2 learning style taught using the traditional biology curriculum.

The null hypothesis could not be rejected. Therefore, there was no significant difference (P=0.51) in students who preferred learning style 2 between the students taught using the ABC curriculum and students taught using the traditional biology curriculum.

Ho $_8$. There is no significant difference in the pre- and post-test mean differences on the NABT/NSTA between the students with quadrant 3 learning style taught using the ABC compared to the students with quadrant 3 learning style taught using the traditional biology curriculum.

The null hypothesis could not be rejected. The significant difference using the t-test was P=0.09. Therefore, there was no significant difference in students with learning style 3 between students taught using the ABC curriculum and students taught using the traditional biology curriculum.

Ho $_9$. There is no significant difference in the pre- and post-test mean differences on the NABT/NSTA between the students with quadrant 4 learning style in ABC compared to the students with quadrant 4 learning style in the traditional biology curriculum.

The null hypothesis was rejected with the level of significance being P=0.02. Students taught using the ABC curriculum had a mean gain of 4.39 and students taught using traditional biology curriculum had a mean difference of -1.77. Therefore, students with learning style 4 taught using the ABC curriculum had a significant difference with a mean positive gain in the knowledge of biological concepts as measured by the NABT/NSTA as compared to students taught using traditional biology curriculum.

Ho $_{10}$. There is no significant difference in the pre- and post-test mean difference on the NABT/NSTA between suburban students enrolled in the ABC curriculum compared to rural students enrolled in the ABC curriculum.

The null hypothesis could not be rejected. The t-test showed that there was not a significant difference (P=0.90). Therefore, students taught using the ABC curriculum in a suburban school district did not score significantly different as compared to students taught using the ABC curriculum in a rural school district.

The qualitative data identified students', administrators', and instructors' perceptions of the Applied Biology and Chemistry curriculum. Overall, the students liked the change in format, e.g., the inclusion of unit videos, activities related to hands-on learning, working in cooperative learning groups, an opportunity to participate on fieldtrips, more experience in formal and informal labs, and a feeling that the subject matter was presented in easier to understand method of instruction. The students' dislikes included the opinions that the videos were too short, there were no animal dissections, the lab reports, i.e., conclusions and questions were too difficult, there was too much homework, too much reading, too many notes and that they did not want to have to compile a notebook. The major consensus was that the students believed that they would be as successful in their next years' science class as compared to the other students in the traditional class. However, they did feel that it was not as "hands-on" as had been presented.

The administrators' responses showed great support for the Applied Biology and Chemistry curriculum. The support was exhibited through statements, such as, "it was developmentally appropriate for ninth grade students;" "the ABC curriculum met the PASS, Priority Academic Student Skills, skill requirements as mandated by the State Department of Education of Oklahoma;" and "the students seemed to value the course as a science course requirement and part of the total high school preparation for post secondary plans." Also, the administrators believed that the curriculum was better structured as a laboratory class as compared to the traditional biology classes, i.e., the students spent more time in formal and informal lab as did the traditional biology classes.

The applied academic instructors believed that if the students were properly placed, not all below level students, the curricular outcomes could be met and that they could become more personable to their students. One teacher believed that the students' attitudes toward science were positively changed as they realized why they were learning the subject matter. Both instructors believed that the students felt that the curriculum was harder than they had expected, their first impression of ABC was that it was a below level class because applied meant easier. Overwhelmingly, the teachers stated that the two-week training course required to teach the ABC curriculum was a must. The instructors believed that the teacher training should include: ways to control groups, cooperative learning techniques, the premise of applied education, and how the units tie together.

Conclusions

The major conclusion of this research study indicated that there was some evidence to support the hypothesis that the achievement of students enrolled in Applied Biology and Chemistry showed a statistically significant difference compared to students enrolled in a traditional biology class, e.g., environmental attitude and knowledge. The researcher noted that when analyzing the students pre- and post-test assessments, within their own group, the data provides information which strengthens the statistical data. Educational significance can be established through the following qualitative data. First, the students taught with the ABC curriculum had a positive mean gain on four out of the five assessments. The attitude in science was the only assessment with a negative difference. Furthermore, the ABC students had lower initial scores on three of the pre-test assessments, EAI, ATSSA, and ECON. The qualitative data gives evidence that the student placement did not align with the requested student profile. It was noted that the ABC classes were actually used to place students who were not educationally involved, had incongruent attitudes with the schools' goals, and who had disciplinary problems.

In response to the inference that students were not appropriately placed, the researcher implemented a t-test. The t-test was designed to compare the students entering into the ABC and traditional classes by comparing their pre-test scores. The five assessments compared were NABT/NSTA, ATSSA, EAI, ECON, and ITBS. T-tests showed that three out of the five assessments, ATSSA, EAI, and ITBS, pre-test means were significantly different, $P=0.026$, $P=0.00$, and $P=0.00$, respectively. The difference in the pre-test scores for biology concepts NATB/NSTA was not significant (P=0.89)

The students taught using the traditional biology curriculum had a positive mean gain on three out of the five assessments. The two mean differences which were negative were the attitude towards the environment and the ITBS. All three subdivisions of the attitude towards science had a negative mean difference.

The quantitative data regarding the comparison of biological concepts as measured by the NABT/NSTA showed that the students enrolled in ABC had a more positive mean gain than the students enrolled in a traditional biology class (P=0.01). However, the analysis of covariance could not maintain the significance (P=0.42), which is evidence that the treatment was not the only factor influencing the students mean differences. It should be noted that the ITBS mean difference scores as reported in Table XIII show that there is an observable difference between the students that were taught using the ABC curriculum compared to students who were taught using the traditional biology curriculum. This notable difference would give a possible clue to the reason why the analyses of covariance came out nonsignificant. Therefore, the researcher believed that the ABC curriculum should be considered a viable curriculum and an option in teaching biology concepts. This is supported by research conducted by Beadles (1992), Key and Lee-Cooper (1994), and Key and Hamby (1995) which showed that students taught using the ABC curriculum have either done as well or better than the students taught using traditional biology curriculum.

The comparison of the students attitude towards science as measured by the ATSSA showed that the students enrolled in the ABC curriculum exhibited a negative change in attitude as compared to students in the traditional biology curriculum who exhibited a positive change in attitude. It was noted that the t-test was not significant at the .05 level, P=0.06; however, the analysis of covariance, which controlled for ITBS and science grade, positively influenced the level of significance establishing a significant level (P=0.03). The qualitative research explained that many of the students who were placed into the ABC curriculum were misplaced. Many of the students going into the program were identified as having negative attitudes towards school, teachers, and science and many had serious behavioral problems; therefore, many of the ABC students were already functioning in the classroom with a negative attitude.

The comparison of the environmental concepts measured by the NABT/NSTA questions 4, 17, 25, 33, 41, 50, 58, and 73 showed that students enrolled in the ABC curriculum had a larger positive mean gain compared to the students enrolled in the traditional curriculum. The calculated t-value (2.13) was significant at the 0.015 level (P=0.04). The students who were taught using ABC had a mean gain of 6.40 and the students who were taught using the traditional curriculum had a mean gain of 0.87. The researcher believed that the ABC curriculum should be used as an instructional option in the implementation of a K-12 environmental education programs.

The comparison of the attitude towards environmental issues as measured by the EAI assessment showed that the students enrolled in the ABC curriculum had a larger positive change in attitude towards ecology as the students enrolled in the traditional biology curriculum. The statistical data included P=0.00 and PR=0.00. It was noted that the "Natural Sciences" unit was a major unit taught within the ABC curriculum, whereas chapters regarding ecology are found at the end of traditional texts and often times are not taught. The researcher believed that the ABC curriculum should be used as a resource in order to integrate environmental concepts into already existing science curriculum. The ultimate goal would be to positively change students, hence, societal attitudes, affect, verbal commitment, and actual commitment towards the environment.

The comparison of aptitude regarding science concepts as measured by the ITBS/TAP showed that students enrolled in the ABC curriculum had mean gain scores significantly more positive than students enrolled in a traditional biology class. The significant difference was calculated to be P=0.00. The researcher noted that the ITBS/ TAP assessment primarily identifies the ability to understand the nature of science, i.e., science process skills and inquiry skills, and secondarily to specific concepts relating to earth science, life science, and physical science (Riverside, 1993). The traditional science curriculum primarily deals with the memorization of scientific concepts. Therefore, the researcher believed that the ABC curriculum teaches skills identified and mandated through state and national standards, e.g., PASS skills and Goals 2000 respectively, as measured by ITBS/TAP.

The comparison of the students mean gain on the NABT/NSTA as related to the students learning style showed that there was a significant difference in the mean gain between the students enrolled in ABC as compared to students enrolled in the traditional biology curriculum for students with learning style 4, P=0.02. Learning styles 1, 2, and 3 ABC students had a more positive mean gain on the NABT/NSTA than the traditional biology students; however, it was not significantly different at the 0.05 levels, P=0.06, 0.51, and 0.09, respectively.

The researcher noted that the characteristics of the different learning styles as identified by Kolb (McCarthy, 1992).

Type 1 learners:

1) perceive information concretely
2) process information reflectively
3) integrate information with real life situations
4) have personal involvement with their learning
5) value insight thinking
6) learn by listening and sharing ideas
7) favorite question is, WHY?

The researcher believed that the characteristics of style 1 learners is consistent with the philosophy of the applied science curriculum. Type 1 learners like discussion, group work, and feedback. Therefore, style 1 learners could academically benefit from the use of the ABC curriculum.

Type 2 learners:

1) perceive information abstractly
2) process information reflectively
3) integrate information into what is known
4) influenced by what the "experts think"
5) are sequential learners
6) are successful in traditional classrooms
7) favorite question is, WHAT?

The researcher believed that the characteristics of type 2 learners is conducive to the philosophy of traditional science curriculum. Some type 2 learners find it very uncomfortable and frustrating to participate in an applied academic curriculum.

Type 3 learners:

1) perceive information abstractly
2) process information actively
3) integrate theory and practice
4) experiment and tinker with things and ideas
5) learn by testing theories
6) apply common sense
7) need to know, HOW DOES THIS WORK?

The researcher believed that type 3 learners could be successful in either an applied academic curriculum or a traditional academic curriculum. The philosophy of the applied curriculum is consistent with the type 3 learners' need to experiment and use hands on methods of learning. Also, they have a need to understand the people skills needed for life, i.e., see relevance to real-life problems. However, the characteristics include an inability to be flexible and work in teams.

Type 4 learners:

1) perceive information concretely
2) process information actively
3) integrate experience and application
4) believe in self discovery

5) are risk takers

6) take what is and add to it

7) favorite question is, IF?

The researcher's data supported the belief that type 4 learners are more successful in non-traditional classes, such as, one using the Applied Biology and Chemistry curriculum. The type 4 learner likes a variety of instruction, believes that the curriculum should follow the students' interests, and enjoys experiential learning. Oftentimes the type 4 learner is bored and frustrated in a traditional classroom and will fail due to their lack of enthusiasm.

The comparison of the students from a rural setting and the students from a suburban setting regarding the knowledge of biological concepts showed that there was no significant difference between the mean scores of the NABT/NSTA assessment. The mean difference was 4.70 and 4.5 respectively with a level of significance at P=0.90. The researcher believed that the ABC curriculum is designed to meet the needs of a large portion of students and should be used at the ninth and tenth grade level as curricular options in a variety of academic settings.

Recommendations

The conclusions of this research support the following recommendations regarding educational philosophy:

1) The statistically significant differences exhibited between the mean differences of the students taught using the ABC curriculum as compared to students taught using the traditional biology curriculum supports the hypothesis that ABC is a viable

curriculum regarding environmental issues: affect, verbal and actual commitment and knowledge. The researcher recommends that the ABC curriculum be considered as an instructional option for implementing environmental education into the existing K-12 educational curriculum. It was believed that the ABC curriculum could have a positive impact regarding the commitment of the future citizens toward eliminating current global environmental concerns, thereby, insuring a world suited for life as is known today.

2) The researcher believes that the statistically significant differences between the mean scores of students taught using the ABC curriculum as compared to students taught using the traditional biology curriculum regarding biological knowledge, ecological knowledge and commitment, and aptitude supports the belief that the use of application in teaching abstract concepts should extend into other areas of the academic curriculum. Therefore, the researcher recommends that other areas of study develop or integrate the use of application into their already established criteria. The development of such curriculum would help to meet the educational needs of all learners.

3) The statistically significant difference exhibited between the scores of the students taught using the ABC curriculum as compared to students taught using the traditional biology curriculum supports the belief that textbook companies should restructure the presentation of science data in order to address misconceptions. The restructuring of information should include techniques used in the ABC, e.g., the presentation of biological concepts using real world application.

4) The review of literature supported the theory that the differences in the learning styles of students influence the success of students in their academic careers.

The researcher recommends that educators consider learning styles before counseling students into designated plans-of-study. The findings of this research study support the theory that style 4 learners learn biological concepts better using the ABC curriculum than learning style 4 learners taught using the traditional curriculum. Therefore, it is suggested that learning styles are influences by traditional or ABC curricula and should be part of the criteria used for student placement into core and elective classes.

5) The qualitative statements obtained from teachers who are currently using the ABC curriculum suggest that instructors should receive training before teaching the applied academic curriculum. The teachers believed that proper instruction would eliminate confusion and frustration in the preparation and administration of the Applied Biological and Chemistry concepts. Therefore, the researcher recommends that proper in-service training occur before teachers are allowed to teach an applied academic class.

6) The analysis of covariance used in this research study supports the theory that further research should control for multiple variables, e.g., science grades and ITBS/TAP scores. Through the control of multiple variants, the research can better determine if the significant differences were factors related to the treatment of the experimental group or a factor regarding multiple variants.

7) The comparison of rural and suburban schools suggested that the applied biology and chemistry curriculum is a viable science curriculum which meets the needs of a certain ethnic, social, and economic population. The researcher recommends that research should be conducted using other populations, such as inner city youth.

8) The quantitative and qualitative data provided evidence that student placement into the applied academic classes is inappropriate. The researcher suggests

that in order to equalize the differences between the control and experimental group, future researchers could develop the ABC and traditional populations by using only the top 25% and the bottom 25% of respective groups.

9) It is believed that the ABC curriculum should be implemented into the existing academic and vocational curriculum as an option supported by the Oklahoma Regents for Higher Education, higher education institutes, common schools, and vocational institutes and be valued as a laboratory science unit to be counted towards college entrance.

Summary

The major conclusion of this research study is that students who were taught using the Applied Biology Curriculum scored significantly higher on the assessment, measuring the knowledge of biology concepts, than students taught using the traditional biology curriculum. This conclusion is indicated by an analysis of the t-test. However, the analysis of covariance suggested that this difference might be attributed to multiple variants (ITBS and science grade). The researcher would like to note that the observable difference in ITBS mean differences and ITBS means scores, as established in Table XIII, could give a clue to the reason why the analysis of covariance was nonsignificant.

The conclusions also suggest that the students taught using the traditional biology curriculum had a larger positive mean gain regarding the attitudes toward science. The qualitative data obtained from the instructors suggests that this could be influenced by the large numbers of students who were enrolled by their counselors into the ABC classes who were identified as at-risk students (high absenteeism and disciplinary records). However, the students taught using the ABC curriculum were identified as having larger positive mean gains on their attitude towards the environment and environmental knowledge assessments, and in the ability to understand the nature of science (science process and inquiry skills).

The researcher further noted that students taught using the ABC curriculum which were identified as having the ability to perceive information concretely, process information actively, integrate experience and application, and had a belief in self discovery, i.e., learning style 1, had a higher mean gain regarding biology concepts than students taught using the traditional biology curriculum. Qualitative data supports the belief that all learning styles, especially 1, 3, and 4, would benefit from the philosophy of the ABC curriculum. This data was identified through the characteristics of the specific learning style and through the numerical data which indicated that the ABC students of every learning style had a higher mean gain when assessing for biology concepts.

When ABC students from a suburban school setting were compared to the ABC students from a rural school setting, no statistical differences were calculated. This factor leads to the assumption that the ABC curriculum meets the needs of a variety of diverse populations.

The statistical analysis of this research supports the opinion that the ABC curriculum should be seen as a viable method for meeting the needs of all students. It was found that the use of application, a nontraditional teaching method, allows students to understand science concepts in a “real world” context, making the tasks purposeful to their lives. Also, the curriculum meets the needs of specific learning styles which enables students to attain higher achievement and positively changes the student's attitude toward science and the environment. It is believed that the ABC curriculum enhances student awareness regarding the significance of their own place in maintaining the order of all communities within the world, thereby creating a sense of responsibility toward the environment. The researcher believes that the applied academic curriculum should be seen as a viable educational tool, one that creates an awareness of global environmental issues and teaches students how to become problem solvers and lifelong learners.

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APPENDIXES

APPENDIX A

OKLAHOMA STATE UNIVERSITY

IRB FORM FOR HUMAN

SUBJECTS RESEARCH

OKLAHOMA STATE UNIVERSITY
INSTITUTIONAL REVIEW BOARD
FOR HUMAN SUBJECTS RESEARCH

Date: 12-10-93 **IRB#:** ED-94-027

Proposal Title: THE COMPARISON OF APPLIED BIOLOGY/CHEMISTRY CURRICULUM TO TRADITIONAL BIOLOGY

Principal Investigator(s): [redacted], Kimberly Wilson

Reviewed and Processed as: Exempt

Approval Status Recommended by Reviewer(s): [redacted]

APPROVAL STATUS SUBJECT TO REVIEW BY FULL INSTITUTIONAL REVIEW BOARD AT NEXT MEETING.
APPROVAL STATUS PERIOD VALID FOR ONE CALENDAR YEAR AFTER WHICH A CONTINUATION OR RENEWAL REQUEST IS REQUIRED TO BE SUBMITTED FOR BOARD APPROVAL. ANY MODIFICATIONS TO APPROVED PROJECT MUST ALSO BE SUBMITTED FOR APPROVAL.

Comments, Modifications/Conditions for Approval or Reasons for Deferral or Disapproval are as follows:

[redacted]

Please reference the fact that you will also be accessing ITBS scores for participating students in the parental permission form.

Signature: ______________________ **Date: December 15, 1993**
Chair of Institutional Review Board

APPENDIX B

STUDENT PROFILE APPLIED ACADEMIC

PROGRAM 1993-1994

STUDENT PROFILE
APPLIED ACADEMIC PROGRAM
1993-94

_The applied academic program was designed to help prepare students for the work force of the 90's. Students today need skills in order to survive in today's world of technology: learning to learn, listening, oral communication, problem solving, creative thinking, self-esteem, goal setting/motivation, personal and career development, interpersonal skills, teamwork, negotiation, organizational effectiveness, leadership, competence in writing, competence in computation, and competence in reading.

An initial step in program success depends on proper student placement. Placement begins with student interest in the TECHNOLOGY, BUSINESS, AND HEALTH career clusters. Listed are points which are to be considered as students a re placed into the Applied Academic Program.

Algebra I (A)

___1. The students have successfully completed pre-algebra. (C average or better.)
___2. The students read on a minimum of an eighth grade reading level. 40th percentile on NCE-reading level.
___3. The students may have exhibit a desire, i. e., been successful, in a non-traditional mode of learning.
___4. The students do not score below the 40th percentile on the ITBS in math.
___5. Recommendation of mathematics teacher.
___6. Should be enrolled in Biology I (A) or Biology I concurrently as a 9th grader.
___7. May be used as vocational and/or college preparatory.

Geometry (A)

___1. The students have successfully completed Algebra I (A) or Algebra I. (C average or better.)
___2. The students read on a minimum of an eighth grade reading level. 40th percentile on NCE-reading level.
___3. The students may have exhibited a desire, i. e., been successful, in a non-traditional mode of learning.
___4. The students do not score below the 40th percentile on the ITBS in math.
___5. Recommendation of mathematics teacher.
___6. May be used as vocational and/or college preparatory.

Biology I (A)

___1. The students have successfully completed 8th grade science. (C average or better.)
___2. The students read on a minimum of an eighth grade reading level. 40th percentile on NCE-reading level.

___3. The students have successfully completed or are concurrently enrolled in Algebra I (A) or Algebra I.
___4. The students do not score below the 40th percentile on the ITBS in science.
___5. Teacher recommendation.
___6. The students may have an interest in a career within the health career cluster.

Intro to Physics
___1. The students have successfully completed Algebra I (A) or Algebra I and Biology I (A) or Biology I. (C average or better.)
___2. The students are concurrently enrolled in Geometry (A) or Geometry .
___3. The students read on a minimum of an eighth grade reading level. 40th percentile on NCE-reading level.
___4. The students do not score below the 40th percentile on the ITBS in science.
___5. Teacher recommendation.
___6. The students may have an interest in a career within the business or technology career clusters.

APPENDIX C

APPLIED BIOLOGY/CHEMISTRY--EDMOND

PUBLIC SCHOOLS 1993-1994

COURSE OBJECTIVES

Biology/Chemistry
Edmond Public Schools
1993-94 Lesson Plans
9th Grade

Note: IL=informal lab; FL=formal lab; D=day or 55 minutes; M=minutes

First Nine Weeks
Unit: Natural Resources-All units
State Learner Outcomes (rational): BI.1a, BI.1b, BI.1c, BI.1d, BI.1e, BI.1f BI .1g, BI.2, BI.4, BI.10, BI.11, BI.21, CHI.1a, CHI.1b, CHI.1c, CHI.1d, CHI.1e, C HI.3c, CHI.3d
Priority academic student skills; 8th grade level (Oklahoma State Competencies): I-A, I-B, I-C, I-D, II-A, II-B, II-C, II-D, II-E, IV-A, IV-B, IV-D, IV-H, V-D, V-E, VII-A, VII-B

Subunit 1: Introduction to Natural Resources
Objectives: Identify and give examples of natural resources.
_Classify natural resources by the following categories:
____Limited resources
____Unlimited resource
____Renewable resource
____Nonrenewable resource
_Explain what depletion and degradation mean in terms of natural resources.
_Analyze jobs to see how natural resources are involved in every job.

Activities	Method
Kicker pg. 2	teacher directed
1-1	cooperative group
1-2	cooperative group
Supplemental p. 19	cooperative group
Organ Transplantation	small group research/report
Identification of Natural Resources p. 20	small group research/report
Scenario p. 5	teacher directed
Job Profile	read/discuss
1-3	cooperative groups
1-4	cooperative groups
Lab 1	cooperative groups1
1-6	individual
1-7	small group research/ report
1-8	cooperative groups
Occupations	cooperative group report

Subunit: Fossil Fuels

Objectives: Identify uses of fossil fuels.
_Describe the chemical composition of fossil fuels.
_Explain the combustion of fossil fuels as a chemical reaction.
_Analyze major problems of using fossil fuels.
_Evaluate possibilities for replacing fossil fuels with alternative sources of energy.
_Identify jobs related to fossil fuels.

Activities	Method
Kicker p. 27	teacher directed
Scenario p. 29	teacher directed
2-1	cooperative groups
2-2	cooperative groups
2-3	teacher directed
2-4	teacher directed
Job profile	read, discussion
Lab: Safety teacher directed	
2-5	cooperative groups
2-6	small group research/report
2-8	small group research/report
Job profile p. 41	read, discuss
2-9	small group research/report
2-10	cooperative groups
Lab 2	cooperative groups
Occupations	cooperative group report

Subunit: Air and Our Atmosphere

Objectives: Describe the composition of air.
Explain the two main reasons that air is an essential natural resource.
Analyze the causes and effects of problems related to air as a natural resource.
Suggest ways to reduce problems related to air.
Identify jobs that are concerned with air and air quality.

Activities	Methods
Kicker	teacher directed
Job Profile	read/discuss
3-1	cooperative groups
Scenario p. 61	read/discuss
3-2	small group research/report
Scenario p. 63	read/discuss
3-4	cooperative group
Lab 3	cooperative group
Scenario	read/discuss
3-5	cooperative groups
3-6	cooperative groups

pH p. 68	teacher directed
Job Profile	read/discuss
3-7	cooperative groups
3-8	small group research report
Occupations	cooperative group report

Subunit: Water as a Natural Resource

Objectives: Explain how water cycle works.
Describe what an aquifer is and how it is maintained.
Relate three physical and chemical properties of water to its importance as a natural resource.
Explain ways that physical and chemical changes in water may affect its quality.
Explain factors that influence the amount of water available for use.
Propose steps that industries and communities may take to preserve water quality and reduce water shortages.
Assess ways that jobs are affected by the quality and quantity of water.

Activities	Methods
Kicker p. 85	teacher directed
Lab 4	cooperative groups
4-1	cooperative groups
4-2	cooperative groups
4-3	cooperative groups
Job profile	read/discuss
Scenario 4-6	read/discuss
4-7	cooperative group
4-8	cooperative group
Occupations	cooperative group report

Subunit: Soil as a Natural Resource

Objectives: Describe how soil is formed from organic and inorganic materials.
Evaluate how soil layers and soil composition affect soil's ability to support life.
Describe how plants are affected by soils lacking in nitrogen, phosphorus or potassium.
Explain how minerals are cycled through the environment.
Identify three major soil-related problems and their causes.
Propose ways to respond to problems related to soil.
Identfy jobs that are related to soil.

Activity	Method
Kicker p. 125	teacher directed
Job profile p. 127	read/discuss
Scenario	read/discuss
5-1	cooperative groups

Lab 7	cooperative groups
5-2	cooperative groups
5-3	teacher directed
Scenario	cooperative groups
5-4	cooperative groups
Lab 8	cooperative groups
5-5	small group/report
5-6	small group/report
Video	
5-7	cooperative group
5-8	small group/report
5-9	cooperative group
5-10	class discussion
Occupations	cooperative group reports

Subunit: Living Resources: Plants and Animals

Objectives: Identify the ways that people use plants and animals as natural resources

Identify uses of plants and animals as being consumptive or nonconsumptive.

Explain how plants and animals are related through the food web and through the carbon dioxide-oxygen cycle.

Explain the major problems that affect plants and animals as natural resources.

Propose ways to respond to problems related to plants and animals.

Discuss jobs that are directly involved with plants and animals.

Activity	Method
Kicker	teacher directed
Scenario p. 161	read/cooperative group
6-1	cooperative groups
6-2	small group research/report
Food web	cooperative groups
Job profile	teacher directed
Scenario p. 169	cooperative group
6-3	cooperative group
6-4	small group research/report
Video	
Job profile	teacher directed
Scenario p. 179	cooperative groups
6-6	cooperative groups
Lab 10	cooperative groups
Occupations	cooperative groups reports

Second Nine Weeks
Unit: Continuity of Life-All units
State Learner Outcomes (rational): BI.1a, BI.1b, BI.1c, BI.1d, BI.1e, BI.1d, BI.1f, BI.1g, BI.2, BI.4, BI.12, BI.13, BI.14, BI.18, BI.21, BI. 22, CHI.1a, CH I.1b, CHI.1c, CHI.1d, CHI.1e, CHI.3c, CHI.3d,
Priority academic student skills; 8th grade level (Oklahoma State Competencies): I-A, I-B, I-C, I-D, II-A, II-B, II-C, II-D, II-E, IV-A, IV-D, IV-H, V-D, V-E , VII-A, VII-B

Subunit: How Cells Grow and Reproduce

Objectives: Using a model, demonstrate how cells are organized and how they relate to their environment via a membrane.
Construct a model of DNA.
Explain how we can distinguish between two individual by analyzing tissue samples.
Explain how DNA is able to control the activities of the cell.
Explain how a cell is able to make a copy of itself (reproduce).
Relate errors in cell activities to diseases in humans.

Activities	Method
Kicker p.2	teacher directed
Scenario p. 7	read/discuss
Job profile p. 9	read/ discuss
1-3	cooperative groups
1-4	cooperative groups
Lab 1	cooperative groups
Occupations	cooperative group reports

Subunit: How Organisms Reproduce

Objectives: Explain the role of meiosis in organisms that reproduce sexually.
Relate sexual changes occurring in adolescents to the development and function of their reproductive systems.
Explain the events of the menstrual cycle in terms of hormones and their effects.
Weigh the advantages and disadvantages of internal and external fertilization for animals.
Compare the methods of artificial insemination used in humans and in other animals.
Evaluate various methods of birth control for their ease of use and effectiveness.

Activities	Methods
Kicker p. 43	teacher directed
2-1	small group research/report
2-4	teacher directed
Label drawings	cooperative groups
2-6	cooperative groups
2-7	small group research report
2-8	teacher directed
Lab 4	cooperative groups
2-9	small group research report
Scenario p. 58	read/discuss
2-10	cooperative groups
2-11	cooperative groups
Occupations	cooperative group reports

Subunit: Pregnancy and Birth

Objectives: Illustrate the connections between mother and fetus during pregnancy. Relate these connections to the exchange of nutrients and wastes between mother and fetus.

Relate physiological changes in a expectant mother to fetal development and birth.

Link birth defects in humans and other animals to the factors thought to be responsible for them.

Describe techniques used to detect the condition of the fetus inside the uterus.

Recommend changes a pregnant woman should make in her lifestyle, diet, and behavior to ensure a normal birth.

Activities	Method
Kicker p. 88	teacher directed
Scenario	read/discuss
3-1	cooperative groups
3-2	small group research/report
Guest Speaker	
3-3	
3-4	cooperative groups
Scenario p. 96	read/discuss
3-5	cooperative groups
3-7	small group research/report
Occupations	cooperative group reports

Subunit: Genetic Inheritance in a Family

Objectives: Interpret a karyotype, using a knowledge of chromosomes and how they are inherited.
Explain how the sex of a child is determined.
Analyze the genetic relationship among members of the same family.
Contrast the inheritance pattern of a dominant trait with that of recessive trait.
Predict the characteristics of offspring based on a knowledge of genotypes.
Predict the characteristics of an offspring using a family pedigree.
Explain what a mutation is and how it may affect inherited biological traits.

Activities	Methods
Kicker p. 112	teacher directed
4-1	
cooperative groups	
Karyotype	
cooperative groups	
Scenario p. 115	read/discuss
4-2	cooperative groups
4-3	teacher directed
4-4	cooperative groups
4-5	cooperative groups
4-7	cooperative groups
Lab 6	cooperative groups
4-8	cooperative groups
Occupations	cooperative group reports

Subunit: Genetic Inheritance in a Population

Objectives: Evaluate contributions each of the following has made to the diversity of life on Earth:
a. mutations in DNA
b. natural selection
c. artificial selection
Rate the effectiveness of various methods used by animal breeders to produce desirable traits in animals.
Compare and contrast the effects of natural and artificial selection in animal populations.
Predict how an environmental change will encourage or discourage:
a. formation of new animal species,
b. extinction of existing animal species.

Activities	Method
Kicker p. 141	teacher directed
5-1	cooperative groups
Scenario p. 144	read/discuss
5-2	cooperative groups

Scenario p. 146	read/discuss
5-3	cooperative groups
Lab 7	cooperative groups
5-4	cooperative groups
Scenario p. 149	read/discuss
5-5	teacher directed
5-6	cooperative groups
Occupations	cooperative group reports

Subunit: Genetic Engineering and Other Biotechnologies

Objectives: Explain how new technologies can be used to detect defects in genes.
Decribe the basic processes used in genetic engineering.
Identify the ways genetic engineering can benefit mankind
Evaluate the ethical issues surrounding the use of genetic engineering.

Activities	Methods
Kicker p. 164	teacher directed
Scenario p. 166	read/class discussion
6-1	cooperative groups
Recombinant DNA	cooperative groups
6-2	cooperative groups
6-3	small group/report
6-4	cooperative groups
Occupations	cooperative group reports

Third Nine Weeks
Units: Nutrition -#1, #2, #3, #5; Disease and Wellness -#2
State Learner Outcomes (rational): BI.1a, BI.1b, BI.1c, BI.1d, BI.1e, BI.1f, B I.1g, BI.2, BI.4, BI.6, BI-15, BI-20, BI.21, BI.22, CHI.1a, CHI.1b, CHI.1c, CHI .1c, CHI.1d, CHI.1e, CHI.3c, CHI.3d
Priority academic student skills; 8th grade level (Oklahoma State Competencies): I-A, I-B, I-C, I-D, II-B, II-C, II-D, II-E, IV-A, IV-D, IV-H, V-D, V-E, VII-A, VII-B

Subunit: Different Diets for Different Needs

Objectives: Link the different types of nutrients to their functions into the body.

Identify different food/feed-selection criteria used in various health conditions including age, pregnancy and disease states.

Distinguish the differences among various diets/ration regimens (high protein, low carbohydrate, antibiotic-supplemented feeds, etc.

Evaluate diets to determine the balance of your caloric intake and average caloric usage, and predict the effect that such a diet might have on your body weight.

Identify factors-other than nutritional needs-that affect people's diets and eating patterns.

Activities	Methods
Kicker p. 2	teacher directed
Scenario p. 3	cooperative groups
1-1	cooperative groups
1-2	cooperative groups
1-3	cooperative groups
1-4	cooperative groups
Occupations	cooperative group reports

Subunit: You Really Are What You Eat

Objectives: Analyze the basic building blocks of the following nutrients: proteins, carbohydrates, and fats.
Relate the chemical structure of each nutrient to its nutritional role.
Determine the presence of selected nutrients in sample meals developed by dietitians, based on laboratory tests of the meals' nutrient content.
Evaluate the nutrient content of sample diets and menus based on how adequately the four major food groups are distributed in the diet.
Judge whether a given diet-over a period of several days-would meet the Recommended Daily Allowances for nutrients in the following categories: protein, carbohydrates, fats, vitamins, and minerals.
Select animal feeds, based on feed-label information, that satisfy the Nutrient Requirement Tables for animals.

Activities	Methods
Kicker p. 39	teacher directed
2-1	small group research/report
Scenario p. 42	teacher directed
2-2	individual
2-3	cooperative groups
2-4	individual
Job profile pg. 50	read, discuss
2-5	cooperative groups
2-6	cooperative groups
2-7	cooperative groups
2-8	small group research/report
Lab 3	cooperative groups
Scenario p. 63	read, discuss
2-9	Individual
2-10	cooperative group reports
Occupations	cooperative group reports
Lab 4 revised	groups

Subunit: How is Food Digested and Absorbed?

Objectives: Draw a diagram of the human digestive tract, identifying nutritional roles of each part.
Describe the mechanical processes by which food is broken down in the body.
Relate the chemical nature of acids, bases, and salts to their roles in digestion.
Relate the "lock and key" action of enzymes to the way enzymes help digest food.
Explain how nutrients in food are absorbed into the bloodstream and made available to cells throughout the body.

Identify the role of gut microorganisms in digestion.
Compare and contrast the functioning of human, ruminant, and nonruminant digestive systems.

Activities	Methods
Kicker p. 90	teacher directed
3-1	cooperative groups
3-2	small group research/reports
Scenario p. 95	read, discuss
Lab 5	cooperative groups
Scenario p. 101	read, discuss
3-3	cooperative groups
Job profile p. 104	read, discuss
3-4	cooperative groups
Lab 6	cooperative group reports
Occupations	cooperative group reports
Guest Speaker	

Subunit: Dietary Problems

Objectives: Match physical symptoms of vitamin and mineral deficiencies to specific nutrients that may be lacking.
Investigate the effects on the body of protein shortages.
Describe the effects of starvation on an animal, citing physical, symptoms and behavioral changes.
Predict the type of health problems a person may develop from consuming the following diets: low fiber, high fat, low protein.
Relate animal-production practices to low-fat animal products.

Activities	Methods
Kicker p. 181	teacher directed
Scenario p. 182	read, discuss
5-1	cooperative groups
Scenario p. 192	read, discuss
Job profile p. 198	read, discuss
Scenario p. 198	read, discuss
Job profile p. 201	read, discuss
5-5	cooperative group
Scenario p. 202	read, discuss
5-6	cooperative group
5-7	cooperative group
Occupations	cooperative group reports

Subunit: How Do Our Bodies Defend Against Invaders:

Objectives: Describe the major pathogens that invade the human body.
Evaluate personal habits and environmental conditions according to their potential for allowing microorganisms (pathogens) to invade the human body.
Contrast the ability of a person with a healthy immune system to fight disease to that of a person with a weakened immune system.
Explain ways that an immune system can be weakened or even destroyed (AIDS, chemotherapy, genetic disease, etc.)
Describe how some people's immune systems actually work against their own bodies (autoimmune disease).

Activities	Methods
Kicker p. 45	teacher directed
Scenario p. 47	read, discuss
2-1	cooperative groups
2-2	small group/ research report
2-3	cooperative group research report
Scenario p. 50	read, discuss
Scenario p. 52	read, discuss
2-5	small group research report
Job profile p. 54	read, discuss
2-6	cooperative groups
Scenario p. 57	read, discuss
Lab 3	cooperative groups
2-7	cooperative groups
Scenario p. 60	read, discuss
2-8	cooperative groups
Scenario p. 63	read, discuss
Job profile p. 64	read, discuss
Lab 4	individual participation
2-9	small group research/ report
2-11	cooperative group research report
2-12	small group research report
Scenario p. 70	read, discuss
2-14	cooperative groups
Occupations	cooperative group reports

Fourth Nine Weeks
Units: Plant Growth and Reproduction-#1, #2, #3; Air and Other Gases-#2
State Learner Outcomes (rational): BI.1a, BI.1b, BI.1c, BI.1d, BI.1e, BI.1f, BI.1g, BI.2, BI.3, BI.4, BI.5, BI.6, BI.7, BI.8, BI.12, BI.14, BI.17, BI.18, B I.21, BI.22, CHI.1a, CHI.1b, CHI.1c, CHI.1d, CHI.1e, CHI.3b, CHI.3c, CHI.4a
Priority academic student skills; 8th grade level (Oklahoma State Competencies): I-A, I-B, I-C, I-D, II-A, II-B, II-C, II-D, II-E, II-A, IV-A, IV-D, IV-H, V-D, V-E, VII-A, VII-B

Subunit: Introduction to Plants
Objectives: Locate the main vegetative and reproductive parts of plants.
Observe with a microscope how plant cells are organized into tissues.
Compare the results of germination in different types of seeds you collect.
Match the abnormal appearance of plant leaves, stems, or roots to the disease, pest, or nutritional condition that is causing the change in appearance.
Identify the many ways that plants are useful to us.

Activities	Methods
Kicker p. 2	teacher directed
Scenario p. 3	read, discuss
1-1	cooperative groups
1-2	cooperative groups
Job profile p. 10	read, discuss
1-3	cooperative groups
Scenario p.14	read, discuss
Lab 1	cooperative groups
1-4	small group research/report
1-6	small group research/report
Scenario p. 28	read, discuss
1-7	cooperative groups
1-8	cooperative groups
Occupational	small group research/reports

Subunit: Growing and Caring For Ornamental Plants
Objectives: Describe how different types of plants are used in and around homes and offices.
Evaluate those factors that make a soil suitable for growth of plants.
Compare the primary, secondary, and trace nutrients required by plants in terms of why they are required

and how available they may be in soil.
Trace the movement of forms of nitrogen and phosphorus through the environment as they become available to plants.
Analyze the decisions involved in planting seeds as they relate to seed variety, moisture, temperature, spacing and care of seedlings.
Select a method of transplanting according to the type of plan to be moved.

Activities	Methods
Kicker p. 53	teacher directed
Job profile p. 55	read, discuss
2-1	individual discussion
2-2	cooperative groups
2-3	cooperative groups
2-4	small group research/reports
Nutrient cycles	teacher directed
2-5	cooperative groups
Job profile p. 69	read, discuss
Lab 3	cooperative groups
Job profile p. 72	read, discuss
Lab 4 revised	cooperative groups
2-6	cooperative groups
2-7	cooperative groups
Job profile	read, discuss
2-8	small group research/report
2-9	small group research/report
2-10	small group research/report
Occupations	small group research/report
Lab 7 (Nat. Resources)	groups

Subunit: How Do Plants Reproduce?

Objectives: Relate the processes of DNA replication and mitosis to different methods of vegetative propagation.
Use tissue culture techniques to produce plants that are genetically identical to a given plant.
Predict which genotypes the offspring of two plant varieties will exhibit, by using Punnet squares.
Describe the importance of flower structure to the practice of artificial pollination.
Relate the importance of meiosis to the process by which a plant breeder develops hybrid varieties.

Activities	Methods
Kicker p. 100	teacher directed
Scenario p. 101	read, discuss
Lab 5	cooperative groups
Job profile, p. 107	read, discuss
3-2	small group research/report

Job profile p. 111	read, discuss
Meiosis	teacher directed
3-3	teacher directed
3-4	cooperative groups
3-5	cooperative groups
Lab 7	cooperative groups
Occupational	small group research/reports

Subunit: How Does Air Support Life?

Objectives: Describe the cycles of the three atmospheric gases most _essential to life: carbon dioxide, oxygen, and nitrogen.

Provide the rational for planting legumes as a rotation crop in a specific agricultural environment.

Design a floricultural environment to maximize plant growth, considering the factors of transpiration, photosynthesis, respiration, and nitrogen fixation.

Analyze the mechanics of breathing, using the pressure/volume relationship of gases.

Analyze animal respiration in terms of three aspects of the behavior of gases: gas diffusion, partial pressure, and the solubility of gases.

Predict the effect of a rapid change of atmospheric pressure on the dissolved gas in a solution.

Explain how photosynthesis replenishes cellular energy.

Explain what happens during cellular respiration at the molecular level.

Activities	Methods
Kicker p. 41	teacher directed
Carbon cycle	teacher directed
Job profile	read, discuss
Oxygen cycle	teacher directed
Nitrogen cycle	teacher directed
2-1	small group research/report
2-2	cooperative groups
Scenario p. 48	read, discuss
2-3	teacher directed
Scenario p. 50	read, discuss
Lab 4	cooperative group
2-4	teacher directed/guest speaker
2-5	cooperative groups
Scenario p. 54	read, discuss
2-6	cooperative groups
2-7	cooperative groups
Occupations	small group research/reports

Additional Activities:

Students will have an opportunity to participate in a field trip once a semester.

Students will have an opportunity to discuss experiences with a speaker once every quarter.

Students will have an opportunity to participate in a health career fair.

Students will have an opportunity to view each subunit video at a specific time designated by the teacher.

Evaluation:

Unit pre-tests: help the student identify the objectives of the unit being studied

Subunit tests: will be given for a student grade

Unit post-tests (open notebook): will be given as a 9 week test

NABT/NSTA pre and post-test: will measure student gain regarding biology concepts

ITBS pre and post-test: will measure student gain regarding science aptitudes

Science Attitude pre and post-test: will measure the students attitude toward science as a class subject

Environment Attitude pre and post-test: will measure the students attitude towards the environment and issues confronting society

Science grade point average pre and post: will measure the students gain regarding their science 8th grade to their 9th grade ABC class

<u>Rationale</u>:

Cooperative group: The purpose is to teach young people

_a. how to relate to others in a cooperative way rather than a competitive way

_b. the concept that a group working cooperatively together can accomplish more than one person alone

c. the importance of pooling individual ideas to come-up with well-rounded-solutions to questions and problems

_d. to value and depend upon the ideas and abilities of others

___*Small group reports*: the purpose is to teach students, within the cooperative learning setting, to use library and other community resources, to find out information. Students need to practice finding information, organizing it into a group presentation, and then the presenting the information in a coherent and interesting way to others.

___*Read/discuss*: This method is a way to insure that written material, presented in the text, is actually read by the student. Reading textual material seems to be neglected by most students; therefore, if it was read aloud in class and discussed, most students would "tune-in" and be exposed to the information.

___*Teacher directed class discussion*: After reading, laboratory, activities, etc., an additional opportunity to apply learned concepts to "real-life" problems/situations will serve to "drive home" the meaning of what was just learned. This is an effort to turn classroom learnin g ___into life application. Discussion serves to bring many different view - points to light, expanding the learning experience. Also, it gives the teacher an opportunity to validate each student as they participate.

___*Labs*: Participation in laboratory activities helps to reinforce the biology concepts being studied, exhibits the application of the concepts showing "real-life" situations, and increases the ability to retain to information longer.

___*Field trips*: This is a valuable tool, provided to the students, in order for them to understand professionals in the workplace. It gives the students an opportunity to ask questions, understand the environment of the workplace, explains the application of the concepts being learned and see professionals on task within the job setting.

___*Speakers*: Provides expertise and application to the concepts being learned, role models, and career information.

___*Video*: Provides the students with a visual tool to further understand the concepts being taught.

APPENDIX D

TRADITIONAL BIOLOGY I--EDMOND

PUBLIC SCHOOLS 1993-1994

COURSE OBJECTIVES

Course:	Biology I Traditional	Grade: 10	Year '89-90
Semester:	First & Second	Textbook: Heath Biology	

Please note: Requirements listed below are minimal expectations for optimum student achievement. If adopted textbooks are followed in the order specified both concept skills and process skills will be maximized. Lab content may be cove red using teacher made labs. Only department or media center videotapes may be shown.

Chapters	Sections Covered	Lab Topics	Approximate Time
Chapter 1	all (1 week)	1-A Lab safety 1-B Using the microscope	1 day
Chapter 2	all (1 week)	Lab activity-distinguish living from non-living	1 week
Chapter 5	all (2 weeks)	5-A Plant & animal cells 5-B Homeostasis Osmosis	1 day 1 day
Chapter 7	1-7 (<1 week)	DNA transcription and translation	short week
Chapter 8	all (< 1 week)	8-A Mitosis	short week
Chapter 9	all (> 1 week)	Lab activity-probability 9-A Genetics of Corn Genotypes & Phenotypes	long week
Chapters 10 & 11	1-4 (1 week) 5&6	Lab activity-pedigree 11-A Human Traits	1 week
Chapter 17	all (< week)	17-A Phylogenetic Tree Classification	short week
Chapters 18 19 20	1,2,7,9,10, 11, 12 1-5 1.2.3.7,8	Lab activity-growing bacteria 19A Protists 19B green algae Fungi lab	2 weeks
Chapter 21	all (1 week)	21-A Flower structure	1 week
Chapter 22	all (1 week)	Lab activity-germination 22-A Seed structure 22-C Vascular tissues	1 week
Chapter 23	1,2,6,7,8,9, 10, 11	23-A Root/Cross sections	short

Chapter 24	all (> 1 week)	24-A Leaf structure Lab activity-guard cells Chromatography lab	long week
Chapter 26	all (1 week)	Lab activity-characteristics of different plants	1 week
Chapter 27	all	Lab activity-Sponges & Cnidarians	1 week
28	Intro. 1,5,7	Lab activity-vinegar eel planaria eathworms (live)	
29	all	Starfish lab Lab activity-squid	
Chapter 30	all	Arthropod lab	1 week
Chapter 31	all	Lab 31-A Vertebrate skeletons	1 week
Chapter 37	all	Lab activity-tissue survey 37-A Bones and muscles	1 week
Chapter 38	1-8 (> 1 week)	Frog digestive system	1 short week
Chapter 39	all (1 week)	Respiratory system	1 week
Chapter 42	all (2 weeks)	Lab activity-touch 42-A Reflex responses and receptors Eye dissection	2 weeks
Chapter 45	all (1 week)	Chick development lab	1 week
Chapter 46	all (1 week)	Animal behavior lab	1 week
Chapter 47	all (1 week)	47-A Plant adaptations	1 week
Chapter 48	all (1 week)	Lab activity-nitrogen fixing bacteria Ecosystem lab	1 week
Chapter 49	all (1 week)	Lab activity-Reproductive patterns; population crowding	1 week
Chapter 50	all (1 week)	Lab activity-acid rain Pollution lab	1 week

Note: No distinction is made between the amount of time spent in formal labs and informal labs.

APPENDIX E

PERMISSION TO USE GERMANN ATTITUDE

TOWARD SCIENCE IN SCHOOLS

ASSESSMENT

PERMISSION GRANTED.
CREDIT MUST BE GIVEN TO
OUR WORK AND ITS COPYRIGHT
OCT 01 1993
JUDY SPREITZER, MANAGER
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JOHN WILEY & SONS, INC.

* See attached addendum.

August 26, 1993

John Wiley
Journal Permission
605 3rd Avenue
New York City, NY 10158

If material appears in our book with credit given to another source, authorization from that source is required.

Dear Mr. Wiley,

I am conducting research at Oklahoma State University which involves data gathering from a small number of Oklahoma's secondary schools. My research specifically is related to the Applied Biology/Chemistry curriculum, developed by CORD, and how it influences today's students enrolled in science.

I would like to use the Attitude Toward Science in Schools Assessment, developed by Germann, printed in the Journal of Research in Science Teaching, Vol. 25, No. 8, 1988. A maximum number of ten schools would be involved. All research would be conducted under the supervision of Dr. James Key, Oklahoma State University, Stillwater, OK.

For more information, please call me at 405-340-2838 or Dr. James Key at 405-744-8139.

Thank you for your consideration.

Sincerely,

Kimberly Wilson
Tech Prep Counselor
Special Services
215 N. Boulevard
Edmond, Oklahoma

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APPENDIX F

PERMISSION OF EDMOND PUBLIC SCHOOL

DISTRICT TO CONDUCT RESEARCH

IN APPLIED BIOLOGY

AND CHEMISTRY

Edmond Public Schools

1216 South Rankin
Edmond, Oklahoma 73034

Office of
School Superintendent

Telephone
405/340-2800

November 22, 1993

IRB
Oklahoma State University
005 Life Sciences East
Stillwater, OK 74078

Edmond Public Schools has approved Kim Wilson's research in Applied Biology.

Brenda R. Lyons, Ed.D
Assistant Superintendent/Instruction

BRL/bt

APPENDIX G

PARENT PERMISSION LETTER REGARDING CHILD'S PARTICIPATION IN STUDY OF COMPARISON OF ABC CURRICULUM TO TRADITIONAL BIOLOGY CURRICULUM

June 25, 1994

Dear Biology I Parents/Guardians,

My goal as an educator is to provide appropriate curriculum and to help create an environment where ALL students can learn. To help me accomplish my goals, I am continuing my education and am working towards a Ph.D. in environmental science with an education emphasis. My doctoral thesis is on "The Comparison of the Applied Biology/Chemistry Curriculum to Traditional Biology." During the 93-94 school year, your child had an opportunity to participate in the following assessments: NABT/NSTA (National Association of Biology Teachers/National Science Teachers Association), SAA (Science Attitude Assessment), EAA (Environmental Attitude Assessment), LSI (Learning Styles Inventory), and TAP (Tests of Achievement and Proficiency.) I am asking for your permission to use your child's data. **Your child's name will not be used in any way. ALL data will be recorded anonymously.**

Please understand that participation is voluntary, there is no penalty for refusal to participate. I have enclosed a consent form printed on a self addressed stamped postage card. If you would like to withdraw your child's name from this research project, return the postcard marked "NO." If you are giving your consent, return the postcard marked "YES."

YOUR RESPONSE IS ESSENTIAL!!!!!!! PLEASE, RETURN THE PRE-PAID POSTCARD, ASAP.

Thank you for your assistance. If you have questions, you may contact me at work, 340-2292, or at home, 359-3697, or you may contact the Oklahoma State University Research Services, 001 Life Sciences East, Oklahoma State University, Stillwater at 744-5700 .

Sincerely,

Kimberly Wilson

Kimberly Wilson
Career Education Counselor
Edmond Public Schools

I have read and fully understand the purpose of this consent form. I sign it freely and voluntarily.

____YES, I give my permission for ____________________________
child's name
data to be used for the doctoral research project.

____NO, I do not give my permission for ______________________
child's name
data to be used for the doctoral research project.

Signed: Student____
Parent/Guardian______________________________________
Date____

"I certify that I have personally explained all elements of this form to his/her parent or guardian before requesting consent."

____
researcher

APPENDIX H

INTERVIEW QUESTIONS REGARDING THE

STUDENTS' PERCEPTION OF THE

ABC COURSE

STUDENTS' PERCEPTIONS OF APPLIED BIOLOGY/CHEMISTRY COURSE

1. How did you like this course overall?

2. What specific things did you like about the Applied Biology/Chemistry course?

3. What specific things did you dislike about the Applied Biology/Chemistry course?

4. How does this class compare with any other science classes you have had?

5. What changes do you think should be made in this course for next year?

APPENDIX I

INTERVIEW QUESTIONS REGARDING THE

ADMINISTRATOR'S PERCEPTIONS OF

THE ABC COURSE

APPLIED BIOLOGY/CHEMISTRY ADMINISTRATORS QUESTIONNAIRE

1. Should students receive science credit for graduation for this course?

2. Should this course be given credit for college entrance requirements as a lab science course?

3. In your opinion, what are the students' perceptions of this course?

4. How has the course enhanced education in your school?

5. In your opinion, how should the Applied Biology/Chemistry course be offered next year?

APPENDIX J

INTERVIEW QUESTIONS REGARDING THE

INSTRUCTOR'S PERCEPTION OF THE

ABC COURSE

APPLIED BIOLOGY/CHEMISTRY TEACHER QUESTIONNAIRE

Please answer the following questions about each of the AB/C units.

UNIT # _____: ____

1. Date you began this unit: ____________________________________

2. Date you ended this unit: ____________________________________
   % of unit completed: __________

3. Which, if any, of the activities listed in the unit did you utilize in class?

4. Did you use any additional/supplemental resources in teaching this unit? If so, please list them.

5. Approximately what percentage of this unit was spent in lab and lab related activities?

   ____

6. Which of the labs did you use? *(Titles from curriculum or other sources.)

7. What is your overall perception of this unit?

Please answer the following questions concerning the entire course.

1. How well did you feel this curriculum met the learner outcomes for Biology I?

2. Do you believe that this course changed students' attitudes toward science? If so, how?

3. What do you think your students' perceptions of this course were?

4. What do you think parents' perceptions of this course were?

5. How do you think your principal perceived this course?

6. How do you think your superintendent perceived this course?

7. Should students be given science credit for this course?

8. What is your overall perception of the course?

9. Do you see the need for a graduate level course aimed at teaching AB/C? If so briefly describe this course (no. of hours, when taught, what covered, etc.)

10. What advice would you offer to someone who is planning to teach this course next year?

VITA

Kimberly Kay Miles Wilson

Candidate for the Degree of

Doctor of Philosophy

Thesis: A COMPARISON OF THE APPLIED BIOLOGY/CHEMISTRY CURRICULUM TO THE TRADITIONAL BIOLOGY CURRICULUM

Major Field: Environmental Science

Biographical: Attended Forgan Public Schools, Forgan, Oklahoma, 1961-1963; graduated from C. E. Donart High School, Stillwater, Oklahoma in May, 1974; received the Bachelor of Science degree in Science Education from the University of Central Oklahoma, 1982; received the Master of Science degree in Educational Administration from the University of Central Oklahoma, 1989; completed requirements for the Doctor of Philosophy degree at Oklahoma State University in December, 1994.

Professional Experience: Seventh Grade Science Instructor, Mayfield Junior High, Oklahoma City, January, 1983 to August, 1984; Biology and Physiology/Anatomy Instructor, Putnam City High School, Oklahoma City, August, 1984 to August 1985; Biology and Environmental Science Instructor, Putnam City North High School, Oklahoma City, August, 1985 to August, 1991; Gifted and Talented Supervisor, Putnam City North High School, Oklahoma City, August, 1991 to August ,1992; Supervisor of Career Education, Edmond Public Schools, Edmond, Oklahoma, August, 1992 to October, 1994; Coordinator of School-to-Work Programs, Moore-Norman Vo-Tech Center, Norman, Oklahoma, October, 1994 to present.