# AN ASSESSMENT OF A PILOT PROGRAM OF THE APPLIED BIOLOGY/CHEMISTRY CURRICULUM

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# AN ASSESSMENT OF A PILOT PROGRAM OF THE APPLIED BIOLOGY/CHEMISTRY CURRICULUM

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# CHAPTER I

## INTRODUCTION

By the year 2000 the United States will have developed many more job areas in a wide variety of technological fields. It is important to note that much of the technology required for these jobs has yet to be fully developed. Almost one-half of the new jobs that will be pursued will involve some working knowledge of biology and/or chemistry (U.S. Department of Commerce, 1987).

Today's students will be the workers in the new labor market that will require new and more wide ranging knowledge. This is rather alarming when one considers that many of our students are low achievers in the science areas. It is thought by some that many students might well develop a more in-depth interest in science if they were given an opportunity to see and take part in a more practical approach to the teaching of such subjects as biology and chemistry. One approach might be to help students explore the common ways in which science might be applied and how it affects their daily lives. Harvey (1991) pointed out that the Blueprint for Career Preparation (Florida Department of Education, 1989) covers all levels of education from Kindergarten through post-secondary programs but specifically addresses the need for a new applied curriculum which will make academic concepts relevant to the workplace, especially in the areas of communications, math, and science. If students did truly develop a stronger interest in science through a more practical or applied approach, then quite likely their grades as well as confidence level would improve.

While most jobs in the future will require a higher degree of knowledge, not every job will require a college degree. Many jobs may be more effectively performed by a person with applied knowledge in some of the academic areas rather than an in-depth theoretical knowledge. In today's society many technical jobs are available that are more suited to people who may not have technical degrees but have a solid base of applicable knowledge in the various fields of science.

For many years science classes in our public schools have been taught under the philosophy that as long as a student memorizes facts and information that student is well educated in science. Information has often been presented in such a way as to try to ensure that the student remembers as many facts as possible with little or no emphasis being placed on the application of such knowledge. Even in laboratory settings, the emphasis has been on the rote memorization of scientific information. It is furthermore evident that very little attention has been paid to improving the attitudes of students toward the study of science.

## Problem

Traditional science teaching methods may be ineffective in preparing students to enter the labor market and assume roles as productive members of a very technologically advanced workforce. It must be understood that most science oriented jobs require the ability to apply the knowledge taught in public school science courses. While most people believe this, there is still an argument that teaching students using an applied curriculum which allows them to practice using the knowledge gained in the science classroom is not as effective in providing a broad base of scientific knowledge as the traditional, rote memorization teaching method and curriculum so prevalent in schools today. It is for this reason that it was deemed necessary to investigate the effectiveness of an applied biology curriculum taught using the cooperative learning method versus the traditional biology curriculum taught using traditional teaching methods.

## Purpose

The purpose of this study was to assess a pilot program of the Applied Biology/Chemistry curriculum taught using the cooperative learning method as compared to the traditional biology curriculum taught using more traditional teaching methods by means of scores of students on a standardized biology test and an attitude toward science survey.

## Objectives

In order to achieve the purpose of this study, the following objectives were formulated. The objectives of this study were:

1. To determine gain scores on the National Association of Biology Teachers/National Science Teachers Association (NABT/NSTA) Biology Test of those students taught the Applied Biology/Chemistry curriculum using the cooperative learning method and those taught the traditional biology curriculum using traditional teaching methods.
2. To compare the scores on the NABT/NSTA Biology Test of the students taught the Applied Biology/Chemistry curriculum using the cooperative learning method and those taught the traditional biology curriculum using traditional teaching methods.
3. To compare students' attitudes toward science as measured by the Scientific Attitude Inventory between the students taught the Applied Biology/Chemistry curriculum using the cooperative learning method and those taught the traditional biology curriculum using traditional teaching methods.

## Hypotheses

In order to achieve the objectives of the study the following hypotheses needed to be tested:

Hypothesis 1—There is no significant difference between the pre- and post-test scores of students enrolled in ABC Biology I.

Hypothesis 2—There is no significant difference between the pre- and post-test scores of students enrolled in ABC Biology II.

Hypothesis 3—There is no significant difference between the pre- and post-test scores of students enrolled in traditional Biology I.

Hypothesis 4—There is no significant difference between the pre- and post-test scores of students enrolled in traditional Biology II.

Hypothesis 5—There is no significant difference between pre- and post-test difference scores for students in ABC Biology I versus students in traditional Biology I.

Hypothesis 6—There is no significant difference between pre-test/post-test difference scores for students in ABC Biology II and traditional Biology II.

Hypothesis 7—There is no significant difference between the two year pre-test/post-test scores for students enrolled in both ABC Biology I and II.

Hypothesis 8—There is no significant difference between the two year pre-test/post-test difference scores for students enrolled in both traditional Biology I and II.

Hypothesis 9—There is no significant difference between two year pre-test/post-test difference scores for students enrolled in both ABC Biology I and II versus students enrolled in both traditional Biology I and II.

Hypothesis 10—There is no significant difference between pre- and post-test attitude scores for students enrolled in ABC Biology II.

Hypothesis 11—There is no significant difference between pre- and post-test attitude scores for students enrolled in traditional Biology II.

Hypothesis 12—There is no significant difference between pre-test/post-test difference attitude scores for students enrolled in ABC Biology II versus students in traditional Biology II.

## Definitions

### Biology I Students

Students enrolled in the first level biology course offered at Thomas High School. This course is a laboratory science class and meets the requirements for high school science credit in the State of Oklahoma. The students in this course were primarily 9th grade students with one exception (a 10th grade girl).

Biology II Students

Students enrolled in the second level biology course offered at Thomas High School. This course is a laboratory science class and meets the requirements for high school science credit in the State of Oklahoma. The students in this course were primarily 10th grade students with one exception (an 11th grade girl).

Traditional Curriculum

The traditional curriculum approach involved the use of state adopted textbooks, lab manuals, and study guides that were heavily based in the theoretical concepts of biology. The teaching method utilized was most usually a modified lecture and demonstration followed by students completing activities in lab manuals and study guides. The units taught included:

Biology I 1990-91

Life: Common Characteristics
Biology As A Science
Materials of Life
Cell Structure and Function
The Cellular Basis of Heredity
Change With Time
Classification
Monerans, Protists, Fungi and Viruses
Plants
Animals: Sponges through Mollusks
Animals: Arthropods through Vertebrates
Plant Reproduction and Development
Animal Reproduction
Animal Development (Oram, 1989)

Biology II 1991-92

Cell Structure and Function
Energy for Life
Principles of Heredity

Genes and Chromosomes
The Genetic Code
Simple Organisms: Reproduction
Simple Organisms: Other Life Functions
Simple Organisms and Disease
Plant Nutrition
Plants: Other Life Functions
Food Getting and Digestion
Transport
Support and Locomotion (Oram, 1989)

Applied Biology/Chemistry Curriculum (ABC)

Teaching materials for the ABC curriculum consisted of those developed by the Center for Occupational Research and Development (CORD) in Waco, Texas. These materials were comprised of printed text, true story scenarios, job profiles, activities involving real-life situations, practical laboratory exercises, and lists of vocabulary terms. Each unit included a subdivided video illustrating real-life situations to which scientific concepts might be applied. Students were encouraged to interact and work in cooperative learning groups while the teacher acted as a guide through the exploration of various topics in the biology curriculum. Units taught included:

ABC Biology I 1990-91

Life: Common Characteristics
Biology As A Science
Materials of Life
Cell Structure and Function
The Cellular Basis of Heredity
Change With Time (Oram, 1989)

(Dec. 3, 1990, Began teaching ABC curriculum.)
Introduction to Natural Resources
Fossil Fuels
Air and Our Atmosphere

Water as a Natural Resource
Soil as a Natural Resource
Living Resources: Plants and Animals (Kousen and Roper, 1990)
Do Health Care Providers Help Us Deal With Disease? (Marshall, 1990)

<u>ABC Biology II 1991-92</u>

How Cells Grow and Reproduce
How Organisms Reproduce
Pregnancy and Birth
Genetic Inheritance in a Family
Genetic Inheritance in a Population
Genetic Engineering and Other Biotechnologies (Harless, 1991)
Different Diets for Different Needs
You Really Are What You Eat
How is Food Digested and Absorbed
Food Technology
Dietary Problems (Taylor, 1991)

## Cooperative Learning Method

The definition of cooperative learning as forwarded by Johnson and Johnson (1987) was stated as:

> Students working cooperatively toward a shared goal, with all group members succeeding or failing as a unit. A cooperative learning group is one that has positive interdependence, where shared goals link group members; individual accountability, where each group member needs to know the material; and cooperative skills, where students support one another rather than put one another down (p. 46).

## Suggested Learner Outcomes for Science Students in Oklahoma

The Oklahoma Learner Outcomes for science describe what Oklahoma students should demonstrate after twelve years of science instruction. These outcomes are designed as minimum competencies for average students. School districts and schools should use these minimum competencies as a core for developing a complete science curriculum appropriate to the needs of their students (Oklahoma Department of Education, 1991). See Appendix C for Oklahoma Department of Education Learner Outcomes—State Competencies for Biology I and II.

## Limitations

1. The Applied Biology/Chemistry curriculum materials were not available until December 3, 1990. Therefore, the use of the ABC curriculum as an independent variable for this study was limited to the Spring semester of the 1990-91 school year.
2. Only the Natural Resources unit of the ABC curriculum was available when the project began, so it was the only ABC unit taught in its entirety during the Spring in the ABC Biology I. The Disease and Wellness unit became available in April and one sub-unit was taught from it in May. The Oklahoma Student Learner Outcomes for Biology I were used as the guide to be sure the curriculum met Biology I requirements. The state-adopted Biology I text, Biology—Living Systems (1989) was used to supplement the Natural Resources unit, as indicated in the definitions section, to meet all objectives.
3. During the 1991-92 school year, the ABC Continuity of Life and Nutrition units were available and taught in the ABC Biology II section.

4. Intact classes were assigned to be taught the traditional and ABC curriculum on a random basis. Students were assigned to these classes for scheduling convenience with their other classes.

## Scope

This study was conducted in the secondary science program of the Thomas, Oklahoma, Independent School District. The Thomas Independent School District is comprised of Kindergarten through 12th grade, located on one central campus facility. Different buildings are used to house different programs and age groups.

Thomas, Oklahoma, is a rural town of approximately 1500 residents in the western half of Oklahoma. The surrounding area is primarily agricultural land, with wheat and beef cattle being the predominant enterprises.

During the first phase of the study three sections of Biology I were used. Two of the three sections were taught using the ABC curriculum and one using the traditional curriculum. One section of ABC Biology I was comprised of twelve 9th grade girls and one 9th grade boy when the pre-test was administered. The second section of ABC Biology I was made up of eight 9th grade boys and one 10th grade girl. The traditional biology section was comprised of twelve 9th grade boys and two 9th grade girls.

Most of the students continued in the same sections for their Biology II classes with the following exceptions: Two students who took Biology I did not take Biology II. Five students moved out of the community. One student switched from ABC biology to traditional biology, moved away, and finally moved back and enrolled in ABC Biology II. Four students in the ABC Biology I course enrolled in traditional Biology II for scheduling reasons. Likewise, two students who had been in traditional biology during the spring 1991 semester enrolled in ABC Biology II for the fall 1991 semester.

## CHAPTER II

## REVIEW OF LITERATURE

The purpose of this chapter is to provide an overview of the literature in the area of science education as it applies to the objectives of this study. A comprehensive search was made of books, professional journals, government documents, and magazines to compile a representative review of the literature in this area. In order to make for a more understandable review, this chapter has been divided into the following sections: 1) Introduction, 2) Applied Basic Courses, 3) Cooperative Learning, 4) Teachers' Perceptions of Applied Curriculum, 5) Measuring Attitudes Toward Science, 6) Related Research, and 7) Summary.

### Introduction

Since 1975 manufacturing in the United States has declined. Some observers have indicated that our country has entered a post-industrial era, while others believe that we have entered a new time in history that they call a service economy (Harvey, 1991). Naisbitt (1989) contended that society has now entered the information age. The decline in the number of manufacturing jobs and the resulting increase in the number of information-based jobs has alarmed many segments of our society. The concern is that we are not adequately training our youth for entry into today's workforce. Employers are stressing a need for emphasis on workplace basics. These basics are generally referred to as reading, writing, and computing skills.

The need for more emphasis on basic skills has been addressed by nearly every author and researcher in the field of education and especially those in the area of educational reform. A Nation at Risk (1983) was one of the first educational reform reports to suggest that our nation's high school graduates need a more solid foundation in the academic basics. The National Secondary Vocational Education Commission (1984) also contended that students must be more proficient in the basic academic subjects and believed that one way to make this possible was to place more emphasis on showing students the relevance of the subject matter for which they are responsible. This philosophy has been followed for many years by programs in vocational education and recently the idea that allowing students the opportunity to apply learning as the most effective way to teach has been adopted by many in the academic education areas.

Applied academics are a very necessary part of education reform in the 1990s. Business and industry recognize the need for people who are firmly founded in the academic basics. As Kolde (1991) noted, though, it is not enough that a person has a cognitive knowledge of science and technology; the person must have affective and psychomotor domain skills related to the area of study inherent to the job being performed. Although vocational education has served to meet the specific occupational needs of students, it has become clear that academic basics must also be an integral part of preparing students for the world of work. The fact that the average employee changes occupations several times during his or her working life makes it necessary to produce more flexible and adaptable technologically literate citizens.

## Applied Basic Courses

Preparing students for the information age workforce means re-evaluating our educational strategies (St. Armand, 1992, p. 23). The old methods of lecture and step-by-step procedures may not be the best choices in today's classroom. In order to prepare students to apply scientific knowledge, the teacher must emphasize communication and critical thinking skills. The recent shift in curriculum philosophy from essentialist to experimentalist is the first step in the process of making the academic basics more relevant and useful to the student who will assume a productive role in today's society (Dobson, Dobson, and Koetting, 1985).

The goal of applied academic curriculum has been to serve that particular student population that has come to be known as the "forgotten half" (CORD, 1991). These are the students often referred to as general education students who may not initially be planning to pursue four year college degree programs. They may go to work immediately after high school, or they may continue their education in two-year post-secondary programs. While these students may not particularly have a need for an in-depth study of the theoretical foundations of scientific knowledge, they probably have a greater need for specific understanding of the application of science and technology to real-life situations than those students who will be pursuing college degrees. Teachers and curriculum developers must bear in mind the fact that while many jobs will require advanced college preparation, students with a good working knowledge of science and technology will be in demand as well. (Parnell, 1992) inquired:

> When will we learn in this country that we must meet the educational needs of the neglected majority of high school students—75% in most places—who are not likely to earn a college degree? If the sole purpose of education is to prepare students for college and graduate studies, our educational system is a failure by design, leaving the majority of students unprepared for the jobs of the future or even for the next step in education (p. 24).

Educators have discovered that the needs of students in the "forgotten half" cannot be met by requiring them to earn more credits in traditional courses (Pedrotti, 1992). They need courses designed specifically for the way they learn. The learning needs of these students are best met by courses that emphasize the application of abstract concepts to real-world situations and that involve them in hands-on learning.

Application relevant to life and work and hands-on learning are the fundamental principles that guided the design and development of the Applied Biology/Chemistry curriculum (CORD, 1991). It is expected that by being exposed to science in this manner, students will gain a greater appreciation for science and technology and be better able to place the traditional science curriculum into a context that makes it relevant and useful to them.

Not only does the aim of applied curriculum seek to enhance the learning and retention of scientific and technological information, it also attempts to serve as a way for students to develop an appreciation for the workings of science and the natural world. Dewey (1913) used experiential learning to give students a sense of admiration for the environment and the forces that shape it. In much the same way the applied academic curriculum developers have tried to emphasize the use of real-life examples and activities that are related to the various fields of science to help the teacher instill a more positive attitude about science in his or her students. In the eyes of the educators involved in the development of this curriculum, a positive attitude toward science is paramount to the efficacy of any teaching and learning activity. Rubin (1985) pointed out that an appreciation of the subject matter allows for more creativity on the part of the students as well as the teacher.

Another aspect of the aim of applied curriculum is the hope that it may be instrumental in keeping students in school. Musko (1992) noted that students have more opportunities to develop greater self-esteem when they are allowed to apply the learning in which they are involved. This, in turn, makes the students want to work harder and stay in school. Franz (1979) stated:

> If unmotivated students come to feel they are learning something useful, I believe, then those students will stop fighting the system. They may then surprise their teachers with the energy and enthusiasm they bring to science; they may even surprise themselves by succeeding at an academic course (p. 36).

Vocational education has used the applied learning concept since its inception and has shown very favorable results. In one of the more recent developments in vocational education students may take "Tech Prep." Under this model, academic and vocational subjects are intertwined and the applied learning concept is used for both. Parnell (1992) stated: "Students find that the tech prep approach can make learning more focused and give them more options after high school graduation (p. 26)." Many educators believe that the move toward a more applied approach to the teaching of basic academic subjects is a direct result of the implementation of the tech prep model by vocational education. Coorough (1992) stated:

> Tech prep is designed to overcome the rivalry and suspicion that often exists between academic, vocational, and grade-level educators. For this reason alone we should applaud its originators. The ultimate goal of tech prep is nothing less than the creation of a pragmatically educated citizenry—people who possess both theoretical knowledge and the capacity to translate that knowledge into tangible accomplishments (p. 34).

As the aim of the applied academic curriculum is also to create an educated citizenry with the capacity to use the knowledge they learn, the tech prep model is one that may well be both effective and efficient for academic programs. The key to success is getting academic and vocational faculties to cooperate (Coorough, 1992).

## Cooperative Learning

Many teachers who have initiated applied components in academic courses have found that the cooperative learning method is very complementary to the various aspects of the curriculum. This research utilized the cooperative learning method for the Applied Biology/Chemistry curriculum taught at Thomas High School. The ABC curriculum lends itself more openly to the use of creative learning environments such as cooperative learning than the traditional curriculum model.

Lapp, Flood, and Thrope (1989) liken cooperative learning to a group of people playing a trivia game at a party. Their analogy in this respect was stated:

> Do you remember the last time you were at a party and played Trivial Pursuit? All the members of the team pooled their knowledge to answer the questions. As a team member, you were less threatened when you didn't know an answer than you would have been if you were alone. It was fun and you learned a lot (p. 112).

Many researchers have shown that cooperative learning works in the classroom in much the same way as team play works in a game. It has been demonstrated that groups consisting of high and low achievers; males and females; and students of different ages, races, social, economic, and ethnic backgrounds can work together effectively and experience significant increases in reading and learning (Flood, 1980; Graves & Graves, 1983; Slavin, 1985).

The definition of a cooperative learning group as forwarded by Johnson and Johnson (1987) was stated as:

> Students working cooperatively toward a shared goal, with all group members succeeding or failing as a unit. A cooperative learning group is one that has positive interdependence, where shared goals link group members; individual accountability, where each group member needs to know the material; and cooperative skills, where students support one another rather than put one another down (p. 46).

This approach is particularly suited for the applied biology curriculum since one of the most prevalent aspects of the applied curriculum is group projects. As an example, students in the Applied Biology/Chemistry classes at Thomas High School were given various group research assignments which were to be presented to the class. Since the entire class was accustomed to working in groups, the presenters were given very constructive critiques from other class members for the purpose of improving the research, not for the usual purpose of belittling other students. The learning from these activities continued for long periods after the class was over. Roy, Laurie, and Browne (1983) noted that while cooperative learning creates many opportunities for peers to interact with each other during class, continued interaction occurs later in hallways, parking lots, and school cafeterias.

Not only does cooperative learning enhance the retention and understanding of basic concepts in the academic classroom, it also increases students' cognitive skills. Sherman (1988) noted that competitive instruction has been observed to stress the acquisition of low level information, rather than high level ideas and critical thinking skills as cooperative learning has been seen to foster. With school reform proposals all being heavily geared toward increasing the cognitive skills of students, the use of cooperative learning to accomplish this goal is a logical step in improving our education system.

In much the same way that the applied curriculum has been seen to increase student appreciation for science, the cooperative learning method also has been observed to foster a more positive attitude toward science and school as a whole. Salend and Sonnenschein (1989) noted that cooperative learning can lead to positive attitudes toward school and instructional tasks. They further stated that:

> In the affective domain, cooperative learning has promoted group socialization and group cohesiveness, decreased prejudicial and stereotypic attitudes, encouraged students to take risks, allowed students to learn about the unique talents of their peers, and fostered self esteem (p. 48).

By utilizing the cooperative learning method in conjunction with applied curriculum components, many educators have realized greater success in teaching their students what they really need to know.

## Teachers' Perceptions of Applied Curriculum

A number of educators who have implemented applied curriculum models in their programs have voiced their opinions on the effects of the new concept. Letters have been written to administrators and curriculum developers applauding the outcomes of the applied curriculum. A sample of these communications is presented here.

Applied curriculum has been used for the past few years in mathematics programs. A math teacher from Indiana wrote:

> For a few days many students tend to resist "story problems" but soon learn to really dig in and take pleasure in being able to solve interesting problems. They feel so much better about solving the applied mathematics problems than they ever felt about working 30 arithmetic problems that all look almost identical (Mayes, 1990, p. 1).

Another applied mathematics teacher, in a letter to the Center for Occupational Research and Development, wrote about a survey she had given to her students. She wrote:

> Comments such as "more trig" are coming from seniors whose tenth grade teachers thought may not even graduate! The increase in student confidence is incredible!! (DiGioia, 1990, p. 1).

In the survey written about in the above letter, applied mathematics students overwhelmingly answered yes to the following questions:

-Do you believe this course will help you in the world of work?

-Did the group activities increase your understanding?

-Did you feel the topics covered were appropriate to the world of work?

-Do you feel that the use of calculators was an important part of the course?

-Has the material in this course helped you in other courses?

-Would you recommend this course to another person?

Many teachers have written letters telling of phenomenal boosts in enrollment due to the applied academic courses. In a letter to school administrators, the former school superintendent for the State of Oklahoma wrote about the Principles of Technology course (an applied version of high school physics) saying:

> As you know, all students need to develop a higher level of math and

> science to be successful on the job or in college; yet most students in Oklahoma seem to fear the traditional physics course, which can often result in low enrollment. The Principles of Technology course provides a unique opportunity to introduce more high school students to physics concepts (Hoeltzel, 1990, p. 1).

A physics teacher from Wyoming who implemented the Principles of Technology course wrote about increased enrollments in a letter to CORD. He stated:

> Please accept my thanks for enabling us to acquaint many more of our students with physics. I can recall enrollments of only 2 students in my traditional physics course, with the usual class consisting of 3 or 4 students. During the 3 years in which we have offered Principles of Technology, we have touched 29 lives. That's 21 more than we would have seen in physics (Weller, 1990, p. 1).

To summarize the feelings of teachers on the subject of applied academic curriculum, the following letter of general praise is presented. A Principles of Technology teacher from New Mexico wrote to CORD stating:

> I am happy to report that Principles of Technology is the best curriculum package I have ever seen as teacher or student. Lest you think I make this statement lightly, let me explain my reasons.
>
> 1) About half of the students taking the class are students that not only would not normally take physics...they would probably not even take science.

2) The non-traditional physics students are competing with the rest of the class.

3) The material actually does what we in education usually only claim to do. It builds on itself and demonstrates the need for what is taught soon after it is taught.

4) The format for presenting material maintains student interest, reinforces the concepts, and is presented in a non-sexist manner.

5) The material is such that the students can see a need for the math in the course as well as math presented in their regular course.

6) The material is presented in small enough chunks that the students and the teacher are not overwhelmed before they have the opportunity to practice what they've learned in the lab experiment.

7) The lab experiments are real and they work! Please understand that everything does not always come out "by the book," but that seems to conform to the real world pretty well.

8) My students are learning.

9) My students enjoy the class.

10) I enjoy the class. (Barton, 1990, p. 2).

It can be seen from these communications that many teachers and administrators are duly impressed with the effects of applied curriculum on the achievement and attitudes of students.

## Measuring Attitudes Toward Science

Ward (1976) pointed out the need for students to develop a positive attitude toward science. Klopfer (1971) noted that the objectives of science education programs explicitly include an affective component addressing the desirability for students to emerge with positive attitudes toward the scientific enterprise and its practitioners. While many people think that the negative attitude toward science is a new phenomena brought about by shifts in cultural values, Heath, et.al. (1957) found that even in the innocent 1950s, students had negative attitudes toward science and scientists. Something had to be done to change this trend.

Moore and Sutman (1970) define a scientific attitude as:

> An opinion or position taken with respect to a psychological object in the field of science. A scientific attitude inventory is a test instrument which assesses some of the elements in each subdivision of the universe of content-scientific attitudes (p. 86).

The scientific attitude survey used in this study was designed and validated under this definition by these two authors. Their survey instrument has four characteristics. These characteristics are: 1) preparation based upon specification of the particular attitude to be assessed; 2) use of several items to assess each attitude; 3) provision for the respondent to indicate the extent of acceptance or rejection of an attitude statement; and 4) concern with intellectual and emotional attitudes.

In addressing the attitudes of high school biology students Hounshell and Hill (1989) noted the need for change. They stated:

> The problems associated with high school biology courses are gigantic. Failure rates are often high, especially in situations where the course is required, classes are too large, and lab space and equipment are inadequate. These factors and many more tend to affect motivation and ultimately general attitudes about science. The course needs to change to keep up with a truly technological society, perhaps more than any other course in the curriculum (p. 543).

For these reasons the development and implementation of an instrument that would assess the attitudes of high school students concerning science was deemed necessary. While no assessment instrument can be 100 percent valid or reliable, Moore and Sutman's (1970) instrument was validated and reliability tested using the pre-test/post-test method.

## Related Research

This section of the review of literature is to provide an overview of some of the research studies that have been conducted in the area of applied academic curriculum. Two major studies will be described, one from Iowa and one from Alabama.

The Iowa State University study (Dugger, 1989) showed that students using the Principles of Technology (PT) curriculum out-performed higher achieving physics students on knowledge of basic physics concepts covered by the PT curriculum. Principles of Technology, developed by CORD and funded by the Agency for Instructional Technology, consists of fourteen units, each focusing on basic concepts such as force, work, rate, resistance, energy, and power. Each unit addresses mechanical, fluid, electrical, and thermal applications of each basic concept.

This was a two year study designed to compare student performance in traditional physics classes with that of students taking PT. The scope of the study included 675 students in fifteen Iowa school districts.

All students took a pre-test to determine their physics knowledge before starting the physics or PT courses. As expected, the traditional physics students outscored the PT students on the pre-test by an average of five points. A post-test was administered after one year of physics and PT instruction, and the results were considerably different. PT students not only made up the initial five point difference, but they outscored the physics students by an average of 11 points. The physics students gained an average 12 points while the PT students gained 29 points.

A similar study completed at Auburn University (Baker, Wilmoth, & Lewis, 1990) compared the performance of students enrolled in PT with that of students enrolled in traditional physics. The evaluative criterion was a set of scores from test items extracted from a nationally recognized standardized physics exam relating to the areas of mechanics, heat, and electricity.

The Auburn study involved 226 students enrolled in eight first year PT courses and 306 students enrolled in eighteen randomly selected traditional physics classes in Alabama. Twenty-three teachers were involved in the study, of which fifteen were physics teachers and eight were PT teachers. Among the fifteen physics teachers, five were certified in physics while ten were certified in general science education. Of the eight PT teachers, seven held trade and industrial education certifications in areas related to electronics or computer science. Additionally, four of the PT teachers were also certified in math or physics.

Based on the data gleaned from this study, given the many student and teacher variables, it was concluded that the Principles of Technology was a sound academic course, equivalent to physics in terms of student performance on the standardized test.

As for student attitudes toward science being improved by the use of the applied academic curriculum, many informal and some formal research has been done. Ward (1976) conducted a study of the association of class size to student attitudes toward science. He found no significant relationship between class size and attitude, but he did find that a positive attitude toward science was strongly correlated to student achievement in science.

In another study of student attitudes toward science, Hounshell and Hill (1989) found that students who studied biology via a computer-based curriculum method not only maintained or improved academic achievement but showed significant improvements in their attitudes toward science as a whole. This study is particularly relevant because the use of computer-based curriculum methods have a great deal in common with the applied curriculum methods in use today.

## Summary

A review of the literature relating to applied academics and cooperative learning illustrated an overwhelmingly positive view of these two relatively new concepts in education. While most authors and researchers in the field of education see a need for some kind of change in the basic academic curriculum, there is still widespread disagreement as to exactly what that change should involve. Much of the literature cited in this chapter would indicate that applied academics and cooperative learning may very well be the change for which we have all been searching.

In summary, the applied academic curriculum allows students to see the relevance and put into practice the knowledge they receive in the classroom. As Franz (1979) noted, if students stay interested in a subject they will remain on task and in turn learn more. Not only will students learn more—but, using the proven argument of vocational education—they will remain in school and probably even continue their education after high school graduation if they can be given the option of taking courses that make basic academics interesting and useful to them (Musko, 1992).

Cooperative learning also plays a role in keeping students motivated and on the right track throughout their education. James (1989) stated:

> Cooperative learning places the responsibility for learning where it belongs—on the students. Cooperative learning increases achievement and improves students' attitude toward school, learning, and classmates. Cooperative learning makes teaching and learning more fun (p. 99).

Goodlad (1984) proposed more involvement in learning by students, not students learning on their own, but students teaching each other while being guided by a teacher or facilitator. As the applied academic curriculum lends itself so neatly to the implementation of the cooperative learning method, there is no reason that educators using this curriculum should not heed Goodlad's advice.

While learning and retention are of paramount concern to educators, the fact that student attitudes toward school have a great impact on achievement is also important. Many researchers have found that a positive attitude about school is directly related to student achievement. Measuring attitudes is a tricky business, but with the Scientific Attitude Inventory (Moore and Sutman, 1970) the task is made much more manageable. Students must have a positive outlook about the subjects in which they are enrolled if they are to succeed.

Finally, formal research studies have shown a significant increase in the achievement of students enrolled in applied academic courses when compared to those in traditional courses. With the picture painted in test scores, we, as educators, cannot dispute the fact that applied academic courses are a viable alternative to the traditional academic curriculum so prevalent in today's schools.

# CHAPTER III

## DESIGN AND METHODOLOGY

The purpose of this study was to assess a pilot program of the Applied Biology/Chemistry curriculum taught using the cooperative learning method as compared to the traditional biology curriculum taught using more traditional teaching methods by means of scores of students on a standardized biology test and an attitude toward science survey. In order to achieve the purpose of this study, the following objectives were formulated. The objectives of the study were:

1. To determine gain scores on the National Association of Biology Teachers/National Science Teachers Association (NABT/NSTA) Biology Test of those students taught the Applied Biology/Chemistry curriculum using the cooperative learning method and those taught the traditional biology curriculum using traditional teaching methods.
2. To compare the scores on the NABT/NSTA Biology Test of the students taught the ABC curriculum using the cooperative learning method and those taught the traditional biology curriculum using traditional teaching methods.

3. To compare students' attitudes toward science as measured by the Scientific Attitude Inventory between the students taught the ABC curriculum using the cooperative learning method and those taught the traditional biology curriculum using traditional teaching methods.

## Hypotheses

In order to achieve the objectives of the study the following hypotheses needed to be tested:

Hypothesis 1—There is no significant difference between the pre- and post-test scores of students enrolled in ABC Biology I.

Hypothesis 2—There is no significant difference between the pre- and post-test scores of students enrolled in ABC Biology II.

Hypothesis 3—There is no significant difference between the pre- and post-test scores of students enrolled in traditional Biology I.

Hypothesis 4—There is no significant difference between the pre- and post-test scores of students enrolled in traditional Biology II.

Hypothesis 5—There is no significant difference between pre- and post-test difference scores for students in ABC Biology I versus students in traditional Biology I.

Hypothesis 6—There is no significant difference between pre-test/post-test difference scores for students in ABC Biology II and traditional Biology II.

Hypothesis 7—There is no significant difference between the two year pre-test/post-test scores for students enrolled in both ABC Biology I and II.

Hypothesis 8—There is no significant difference between the two year pre-test/post-test difference scores for students enrolled in both traditional Biology I and II.

Hypothesis 9—There is no significant difference between two year pre-test/post-test difference scores for students enrolled in both ABC Biology I and II versus students enrolled in both traditional Biology I and II.

Hypothesis 10—There is no significant difference between pre- and post-test attitude scores for students enrolled in ABC Biology II.

Hypothesis 11—There is no significant difference between pre- and post-test attitude scores for students enrolled in traditional Biology II.

Hypothesis 12—There is no significant difference between pre-test/post-test difference attitude scores for students enrolled in ABC Biology II versus students in traditional Biology II.

## Hypothesis Testing

Since the study population was made up of two groups, the t-test was used to test for significant differences between means.

The use of t-tests to determine significant differences in the analysis of data was explained as follows (Popham 1973):

> The t-test is used to determine just how great the difference between two means must be for it to be judged significant, that is, a significant departure from differences, which might be expected by chance alone. Another way of stating the function of the t-test is to assert that, through its use, we test the null hypothesis that two group means are not significantly different, that is, the means are so similar that the same groups can be considered to have been drawn from the same population (pp. 124-125).

## Institutional Review Board (IRB)

Federal regulations and Oklahoma State University policy require review and approval of all research studies that involve human subjects before investigators can begin their research. The Oklahoma State University Office of University Research Services and the IRB conduct this review to protect the rights and welfare of human subjects involved in biomedical and behavioral research. In compliance with the aforementioned policy, this study received the proper surveillance and was granted permission to continue, approval number AG-92-023. (See Appendix A)

## Scope of the Study

The population of the study included students in the secondary science program of the Thomas, Oklahoma, Independent School District. The Thomas Independent School District is comprised of Kindergarten through the 12th grade and is located on one central campus facility. Different buildings are used to house different programs and age groups.

Thomas, Oklahoma, is a rural town of approximately 1500 residents in the western half of Oklahoma. The surrounding area is primarily agricultural land with wheat and beef cattle being the predominant enterprises.

During the first phase of the study three sections of Biology I were used. Two of the three sections were taught using the ABC curriculum and one using the traditional curriculum. One section of ABC Biology I was comprised of twelve 9th grade girls and one 9th grade boy when the pre-test was administered. One additional 9th grade girl moved in after the pre-test was given. Therefore, when the post-test was given this section was made up of thirteen 9th grade girls and one 9th grade boy. The second section of ABC Biology I was made up of eight 9th grade boys and one 10th grade girl. The traditional Biology I section was comprised of twelve 9th grade boys and two 9th grade girls.

During the second phase of this study two sections of Biology II were used. One section was taught using the ABC curriculum by the cooperative learning method, and one section was taught using the traditional curriculum with traditional methods. The ABC section of Biology II was made up of eight 10th grade girls, one 11th grade girl, and seven 10th grade boys. The traditional Biology II section was comprised of four 10th grade girls and ten 10th grade boys.

## Measuring Instruments

The 1990 version of the NABT/NSTA Biology Examination was used as a pre-test and post-test for all of the biology students. This test was assimilated by the members of the High School Biology Examination Development Committee of the National Association of Biology Teachers and the National Science Teachers Association. This committee was made up of eight individuals (four male and four female) from throughout the United States.

The examination was developed to measure skills and understanding in nine science areas. These concept areas include cell structure, bioenergetics, genetics, ecology, behavior, STS (Science, Technology, and Society), systems, and taxonomy.

The Scientific Attitude Inventory was used as a pre- and post-test to measure the attitudes of students in the biology classes.

This instrument is made up of sixty statements relating to science. Students could agree strongly, agree mildly, disagree mildly, or disagree strongly with each of the statements.

## Measurement Procedures

In the fall semester of 1990 part of the researcher's teaching schedule included three sections of Biology I. These sections were intact groups that had been developed primarily due to convenience of scheduling for students. These sections had not been grouped based upon test scores, gender, race, color, creed, or national origin.

All of these Biology I students had been taught traditional biology until December 3, 1990. That period of time covered most of the first semester. Both the ABC and traditional Biology I students were pre-tested with NABT/NSTA Biology Test on January 3, 1991.

As the fall semester 1991-92 school year began the Biology I students had become Biology II students. The post-test that had been given to the Biology I students was also utilized as a pre-test for the second year of this research. None of the biology students attended summer school or any form of formal science oriented educational experience between the spring and fall semesters. The NABT/NSTA Biology post-test was given to the Biology II students on May 6, 1992.

The scientific attitude inventory was given as a pre-test to both groups of biology students during the early part of the fall semester of 1991.

Scientific attitude inventories were given as a post-test to all of the biology students during early May of 1992 as scheduling permitted for each class section.

## Analysis Procedures

This study compared two groups of Biology I students during the first year and two groups of Biology II students the second year. One group was instructed by the traditional method using traditional materials. The other group was instructed by the cooperative learning method through the use of Applied Biology/Chemistry materials.

The quantitative comparison of the students was done from their pre- and post-test difference scores.

Since this study population was made up of two groups in each situation, the t-test was used to test for significant differences between the group means. The significance level of .05 was used as the level for acceptance or rejection of each of the formulated null hypotheses. The t-test was calculated using the 1990 SYSTAT statistical program for microcomputers (Wilkinson, 1990).

# CHAPTER IV

## PRESENTATION AND ANALYSIS OF DATA

The purpose of this study was to assess a pilot program of the Applied Biology/Chemistry curriculum taught using the cooperative learning method as compared to the traditional biology curriculum taught using more traditional teaching methods by means of scores of students on a standardized biology test and an attitude toward science survey.

### Findings of the Study

The following section was included to present analysis of the data collected relative to the objectives of this study.

The distribution of pre- and post- NABT/NSTA test scores recorded for students in ABC Biology I and II are presented in Table I. Each student is identified by a number in the left margin of the table. It should be noted that the scores across each row of the table are all for the same student. Pre-test scores ranged from 23.00 to 50.00 for the ABC Biology I course. Post-test scores observed at the end of ABC Biology I ranged from 22.00 to 60.00. There was a mean increase of 3.41 points between the pre-test and post-test for ABC Biology I. There were twenty-two students that began the semester; one girl moved into the community after the pre-test was given. Therefore, her post-test scores were not included. Thus n=22 for both the pre-test and the post-test. It should be noted that this group of students was taught traditional biology by traditional means for most of the first semester. They were then introduced to the ABC form of Biology I and taught by the cooperative learning method.

Table I also contains the distribution of NABT/NSTA pre- and post-test scores for students in ABC Biology II. Pre-test scores were comprised of the post-test scores students had recorded at the end of ABC Biology I. These scores ranged from 24.00 to 60.00. Post-test scores recorded at the end of ABC Biology II ranged from 23.00 to 58.00. There was a mean increase between ABC Biology II pre- and post-test scores of 3.15. Each student with a grade recorded under the Biology II side of Table I had taken ABC Biology I during the previous year.

The t-test showed a significant difference between the pre- test and post-test mean scores for ABC Biology I. Table II illustrates the t-test results on the comparison of pre- and post-test scores recorded for students in ABC Biology I. The group of 22 students had a mean pre-test score of 30.68 and a mean post-test score of 34.09. A t-value of 2.92 was computed and the difference was found to be significant at the .05 level ($\alpha$=.008).

TABLE I

DISTRIBUTION OF PRE- AND POST-TEST SCORES
FOR STUDENTS ENROLLED IN ABC
BIOLOGY I AND II

| Std. No. | Biology I Pre-Test (n=22) | Biology I Post-Test (n=22) | Biology I Difference | Biology II Pre-Test (n=13) | Biology II Post-Test (n=13) | Biology II Difference |
|---|---|---|---|---|---|---|
| 1 | 25.00 | 24.00 | -1 | 24.00 | 23.00 | -1 |
| 2 | 29.00 | 37.00 | 8 | 37.00 | 51.00 | 14 |
| 3 | 35.00 | 46.00 | 11 | 46.00 | 47.00 | 1 |
| 4 | 36.00 | 40.00 | 4 | 40.00 | 45.00 | 5 |
| 5 | 50.00 | 60.00 | 10 | 60.00 | 58.00 | -2 |
| 6 | 23.00 | 29.00 | 6 | 29.00 | 37.00 | 8 |
| 7 | 25.00 | 35.00 | 10 | 35.00 | 38.00 | 3 |
| 8 | 25.00 | 25.00 | 0 | 25.00 | 26.00 | 1 |
| 9 | 30.00 | 34.00 | 4 | 34.00 | 28.00 | -6 |
| 10 | 31.00 | 38.00 | 7 | 38.00 | 37.00 | -1 |
| 11 | 32.00 | 33.00 | 1 | 33.00 | 28.00 | -5 |
| 12 | 32.00 | 27.00 | -5 | 27.00 | 45.00 | 18 |
| 13 | 36.00 | 42.00 | 6 | 42.00 | 48.00 | 6 |
| 14 | 29.00 | 33.00 | 4 | | | |
| 15 | 47.00 | 45.00 | -2 | | | |
| 16 | 29.00 | 23.00 | -6 | | | |
| 17 | 28.00 | 32.00 | 4 | | | |
| 18 | 28.00 | 31.00 | 3 | | | |
| 19 | 24.00 | 24.00 | 0 | | | |
| 20 | 27.00 | 37.00 | 10 | | | |
| 21 | 26.00 | 22.00 | -4 | | | |
| 22 | 28.00 | 33.00 | 5 | | | |
| Mean Difference—Biology I | | | 3.41 | Mean Difference—Biology II | | 3.15 |

Note: The number of students tested in Biology I differs from the number tested in Biology II due to scheduling, transfers, out-of-district moves, and other circumstances beyond the control of the researcher.

TABLE II

COMPARISON OF PRE- AND POST-TEST SCORES RECORDED FOR STUDENTS IN ABC BIOLOGY I

| Pre-Test (n=22) mean / s.d. | Post-Test (n=22) mean / s.d. | t-value | p |
|---|---|---|---|
| 30.68 / 6.85 | 34.09 / 9.03 | 2.92 | **.008 |

**Significant beyond .01 level

Table III allows for a comparison of pre- and post-NABT/NSTA test scores for students in ABC Biology II. While there is a noticeable difference in the scores, the t-test revealed that this difference between the pre-test mean of 36.15 and the post-test mean of 39.31 was not significant ($\alpha$=.13).

TABLE III

COMPARISON OF PRE- AND POST-TEST SCORES RECORDED FOR STUDENTS IN ABC BIOLOGY II

| Pre-Test (n=13) mean / s.d. | Post-Test (n=13) mean / s.d. | t-value | p |
|---|---|---|---|
| 36.15 / 9.6 | 39.31 / 10.7 | 1.65 | .13 |

Table IV was developed to provide a summary of the distribution of pre- and post-test scores recorded for students in traditional Biology I and II. Pre-test scores in traditional Biology I ranged from 18.00 to 39.00 while post-test scores for the same group ranged from 23.00 to 50.00. The mean scores on the post-test were 5.93 points higher than on the pre-test taken by traditional Biology I students. Traditional Biology II students who had been enrolled in traditional Biology I had pre-test scores ranging from 26.00 to 50.00. The pre-test scores used for traditional Biology II students were comprised of the post-test scores recorded for these students at the end of traditional Biology I. Post-test scores for traditional Biology II students ranged from 26.00 to 50.00 with a mean difference between pre- and post-test scores of 0.22.

The comparison of pre- and post-test scores recorded for students in traditional Biology I are presented in Table V. There were fourteen students that began the semester and finished the semester, therefore, n=14 for this group. The t-test for this group (t=3.11) did show a significant difference ($\alpha$=.008) between the pre-test and post-test scores. These students began the year in the traditional Biology I class taught by the traditional method and remained in the same class for the year. However, they were pre-tested in January and post-tested in May just as the ABC Biology students were. The mean pre- and post-test scores were each less than the mean pre-test and post-test score of the ABC Biology group.

TABLE IV

DISTRIBUTION OF PRE- AND POST-TEST SCORES FOR STUDENTS ENROLLED IN TRADITIONAL BIOLOGY I AND II

| Std. No. | Biology I Pre-Test (n=14) | Biology I Post-Test (n=14) | Biology I Difference | Biology II Pre-Test (n=9) | Biology II Post-Test (n=9) | Biology II Difference |
|---|---|---|---|---|---|---|
| 1 | 18.00 | 30.00 | 12 | 30.00 | 26.00 | -4 |
| 2 | 24.00 | 26.00 | 2 | 26.00 | 31.00 | 5 |
| 3 | 26.00 | 37.00 | 11 | 37.00 | 32.00 | -5 |
| 4 | 27.00 | 27.00 | 0 | 27.00 | 29.00 | 2 |
| 5 | 27.00 | 31.00 | 4 | 31.00 | 29.00 | -2 |
| 6 | 28.00 | 33.00 | 5 | 33.00 | 37.00 | 4 |
| 7 | 30.00 | 26.00 | -4 | 26.00 | 30.00 | 4 |
| 8 | 32.00 | 50.00 | 18 | 50.00 | 44.00 | -6 |
| 9 | 34.00 | 46.00 | 12 | 46.00 | 50.00 | 4 |
| 10 | 20.00 | 23.00 | 3 | | | |
| 11 | 30.00 | 27.00 | -3 | | | |
| 12 | 19.00 | 37.00 | 18 | | | |
| 13 | 39.00 | 43.00 | 4 | | | |
| 14 | 24.00 | 25.00 | 1 | | | |
| Mean Difference—Biology I | | | 5.93 | Mean Difference—Biology II | | 0.22 |

Note: The number of students tested in Biology I differs from the number tested in Biology II due to scheduling, transfers, out-of-district moves, and other circumstances beyond the control of the researcher.

TABLE V

COMPARISON OF PRE- AND POST-TEST
SCORES RECORDED FOR STUDENTS
IN TRADITIONAL BIOLOGY I

| Pre-Test (n=14) mean / s.d. | Post-Test (n=14) mean / s.d. | t-value | p |
|---|---|---|---|
| 27.00 / 5.88 | 33.00 / 8.49 | 3.11 | **.008 |

**Significant beyond .01 level

A comparison of mean pre- and post-test scores for students in Traditional Biology II is presented in Table VI. A minute difference can be seen between the mean pre-test score (M=34.00) and the mean post-test score (M=34.22), but, of course, it was not significant ($\alpha$=.884).

Table VII was constructed to permit a comparison of mean differences between pre- and post-tests for students in traditional Biology I versus ABC Biology I. The t-test showed no significant difference ($\alpha$=.884) between the scores observed between pre- and post-tests for either traditional or ABC Biology I students.

TABLE VI

COMPARISON OF PRE- AND POST-TEST
SCORES RECORDED FOR STUDENTS
IN TRADITIONAL BIOLOGY II

| Pre-Test (n=9) mean / s.d. | Post-Test (n=9) mean / s.d. | t-value | p |
|---|---|---|---|
| 34.00 / 8.75 | 34.22 / 7.97 | .150 | .884 |

TABLE VII

COMPARISON OF PRE-TEST/POST-TEST DIFFERENCE
SCORES BETWEEN STUDENTS IN
ABC VERSUS TRADITIONAL
BIOLOGY I

| ABC (n=22) mean / s.d. | Traditional (n=14) mean / s.d. | t-value | p |
|---|---|---|---|
| 3.41 / 4.92 | 5.93 / 7.13 | -2.01 | .884 |

A comparison of mean differences between pre- and post-test scores for students in ABC or traditional Biology II is presented in Table VIII. The difference between the mean difference in ABC pre- and post-tests (M=3.00) and the mean difference in traditional pre- and post-tests (M=.22) was not significant ($\alpha$=.248).

TABLE VIII

COMPARISON OF PRE-TEST/POST-TEST DIFFERENCE SCORES BETWEEN STUDENTS IN ABC VERSUS TRADITIONAL BIOLOGY II

| ABC (n=13) mean / s.d. | Traditional (n=9) mean / s.d. | t-value | p |
|---|---|---|---|
| 3.15 / 6.15 | 0.22 / 4.44 | 1.23 | .248 |

A comparison of the difference between first pre-test and final post-test scores for students completing two years of ABC Biology is contained in Table IX. A t-test yielded a significant difference ($\alpha$=.001) between the mean pre-test score (M=30.68) and the mean post-test score (M=38.5) for the students enrolled in two full years of ABC biology.

The difference between first pre-test and final post-test scores for students completing two full years of traditional biology is portrayed in Table X. A significant difference ($\alpha$=.020) was observed between the mean pre-test score (M=27.00) and the mean post-test score (M=34.22) for students completing two full years of traditional biology.

TABLE IX

COMPARISON OF FIRST PRE-TEST AND FINAL POST-TEST SCORES FOR STUDENTS COMPLETING TWO YEARS OF ABC BIOLOGY

| Pre-Test (n=13) mean / s.d. | Post-Test (n=13) mean / s.d. | t-value | p |
|---|---|---|---|
| 30.68 / 6.85 | 39.31 / 10.7 | 3.67 | **.003 |

**Significant beyond .01 level

Table XI was designed to report the comparison between the mean difference in pre-test/post-test difference scores for students in either two full years of ABC or two full years of traditional biology. There was no significant difference ($\alpha$=.717) between the mean difference scores in ABC (M=6.92) and the mean difference scores in traditional (M=6.89) biology.

Table XII illustrates the distribution of the two year pre-test/post-test difference scores for students who took both ABC Biology I and II.

Table XIII shows the distribution of the two year pre-test/post-test difference scores for students who took both traditional Biology I and II. Students scored an average of

6.89 points higher on the traditional Biology II post-test than they did on the traditional Biology I pre-test.

TABLE X

COMPARISON OF FIRST PRE-TEST AND FINAL POST-TEST SCORES FOR STUDENTS COMPLETING TWO YEARS OF TRADITIONAL BIOLOGY

| Pre-Test (n=9) mean / s.d. | Post-Test (n=9) mean / s.d. | t-value | p |
|---|---|---|---|
| 27.00 / 5.88 | 34.22 / 7.97 | 2.91 | *.020 |

*Significant beyond .05 level

TABLE XI

COMPARISON OF THE DIFFERENCE BETWEEN FIRST PRE-TEST AND FINAL POST-TEST SCORES FOR STUDENTS IN TWO YEARS OF ABC VERSUS TWO YEARS OF TRADITIONAL BIOLOGY

| ABC (n=13) mean / s.d. | Traditional (n=9) mean / s.d. | t-value | p |
|---|---|---|---|
| 6.92 / 6.68 | 6.89 / 6.10 | .375 | .717 |

TABLE XII

DISTRIBUTION OF TWO YEAR PRE-TEST/
POST-TEST DIFFERENCE SCORES FOR
STUDENTS ENROLLED IN
ABC BIOLOGY
I AND II

| Std. No. | Biology I Pre-Test 1991 (n=13) | Biology II Post-Test 1992 (n=13) | Total Difference (ABC) |
|---|---|---|---|
| 1 | 25.00 | 23.00 | -2 |
| 2 | 29.00 | 51.00 | 22 |
| 3 | 35.00 | 47.00 | 12 |
| 4 | 36.00 | 45.00 | 9 |
| 5 | 50.00 | 58.00 | 8 |
| 6 | 23.00 | 37.00 | 14 |
| 7 | 25.00 | 38.00 | 13 |
| 8 | 25.00 | 26.00 | 1 |
| 9 | 30.00 | 28.00 | -2 |
| 10 | 31.00 | 37.00 | 6 |
| 11 | 32.00 | 28.00 | -4 |
| 12 | 32.00 | 45.00 | 13 |
| 13 | 36.00 | 48.00 | 12 |
| Mean Difference— ABC Biology | | | 6.92 |

Table XIV contains a comparison of the differences between pre- and post-attitude test scores for students in ABC Biology II. There was no significant difference ($\alpha$=.325) between pre-test mean score (M=2.46) and post-test mean score (M=2.53).

A comparison between pre- and post-test attitude scores for students in traditional Biology II is shown in Table XV. No significant difference ($\alpha$=.599) was observed between the pre-test mean score (M=2.39) and the post-test mean score (M=2.44) on the attitude test.

TABLE XIII

DISTRIBUTION OF FIRST PRE- AND FINAL POST-TEST SCORES FOR STUDENTS ENROLLED IN TRADITIONAL BIOLOGY I AND II

| Std. No. | Biology I Pre-Test 1991 (n=9) | Biology II Post-Test 1992 (n=9) | Total Difference (Trad.) |
|---|---|---|---|
| 1 | 18.00 | 26.00 | 8 |
| 2 | 24.00 | 31.00 | 7 |
| 3 | 26.00 | 32.00 | 6 |
| 4 | 27.00 | 29.00 | 2 |
| 5 | 27.00 | 29.00 | 2 |
| 6 | 28.00 | 37.00 | 9 |
| 7 | 30.00 | 30.00 | 0 |
| 8 | 32.00 | 44.00 | 12 |
| 9 | 34.00 | 50.00 | 16 |
| | Mean Difference— Traditional Biology | | 6.89 |

Data presented in Table XVI are for a comparison between the pre-test/post-test difference attitude scores for students in either ABC or traditional Biology II. There was no significant difference ($\alpha$=.921) between the pre-test/post-test difference attitude scores (M=.017) of students in ABC Biology II and those of students in traditional Biology II (M=.043).

Students scored an average of 7.54 points higher on the ABC Biology II post-test than they did on the ABC Biology I pre-test.

TABLE XIV

COMPARISON OF PRE- AND POST-ATTITUDE
TEST SCORES FOR STUDENTS IN
ABC BIOLOGY II

| Pre-Test (n=13) mean / s.d. | Post-Test (n=13) mean / s.d. | t-value | p |
|---|---|---|---|
| 2.46 / .19 | 2.53 / .11 | 1.05 | .325 |

TABLE XV

COMPARISON OF PRE- AND POST-ATTITUDE
TEST SCORES FOR STUDENTS IN
TRADITIONAL BIOLOGY II

| Pre-Test (n=9) mean / s.d. | Post-Test (n=9) mean / s.d. | t-value | p |
|---|---|---|---|
| 2.39 / .16 | 2.44 / .16 | .551 | .599 |

TABLE XVI

COMPARISON OF PRE-TEST/POST-TEST DIFFERENCE
ATTITUDE SCORES FOR STUDENTS IN
ABC VERSUS TRADITIONAL
BIOLOGY II

| ABC (n=13) mean / s.d. | Traditional (n=9) mean / s.d. | t-value | p |
|---|---|---|---|
| .017 / .14 | .043 / .20 | -.102 | .921 |

# CHAPTER V

# SUMMARY, CONCLUSIONS, AND RECOMMENDATIONS

## Summary

By the year 2000 the United States will have developed many more jobs in a wide variety of technological fields. It is important to note that much of the technology required for these jobs has yet to be fully developed. Almost one-half of the new jobs that will be pursued will involve some working knowledge of biology and/or chemistry (U.S. Department of Commerce, 1987).

Traditional science teaching methods may be ineffective in preparing students to enter the labor market and assume roles as productive members of a very technologically advanced workforce. It must be understood that most science oriented jobs require the ability to apply the knowledge taught in public school science courses. While most people believe this, there is still an argument that teaching students using an applied curriculum which allows them to practice using the knowledge gained in the science classroom is not as effective in providing a broad base of scientific knowledge as the traditional, rote memorization teaching method and curriculum so prevalent in schools today. It is for this reason that it was deemed necessary to investigate the effectiveness of Applied Biology/Chemistry curriculum taught using the cooperative learning method versus traditional science curriculum taught using traditional teaching methods.

The purpose of this chapter is to provide the reader with a summary of the foundations and findings of the study. It is further meant to illustrate some of the conclusions derived from the findings and recommendations made pertaining to these conclusions.

## Purpose

The purpose of this study was to assess a pilot program of the Applied Biology/Chemistry curriculum taught using the cooperative learning method as compared to the traditional biology curriculum taught using more traditional teaching methods by means of scores of students on a standardized biology test and an attitude toward science survey.

## Objectives

In order to achieve the purpose of this study, the following objectives were formulated:

1. To determine gain scores on the National Association of Biology Teachers/National Science Teachers Association (NABT/NSTA) Biology Test of those students taught the Applied Biology/Chemistry curriculum using the cooperative learning method and those taught the

traditional biology curriculum using traditional teaching methods.

2. To compare the scores on the NABT/NSTA Biology Test of the students taught the ABC curriculum using the cooperative learning method and those taught the traditional biology curriculum using traditional teaching methods.

3. To compare students' attitudes toward science as measured by the Scientific Attitude Inventory between the students taught the ABC curriculum using the cooperative learning method and those taught the traditional biology curriculum using traditional teaching methods.

## Hypothesis Testing

Since the study population was made up of two groups, the t-test was used to test for significant differences between means.

The use of t-tests to determine significant differences in the analysis of data was explained by Popham (1973) as follows:

> The t-test is used to determine just how great the difference between two means must be for it to be judged significant, that is, a significant departure from differences, which might be expected by chance alone. Another way of stating the function of the t-test is to assert that, through its use, we test the null hypothesis that two group means are not significantly different, that is, the means are so similar that the same

> groups can be considered to have been drawn from the same population (pp. 124-125).

## Scope of the Study

The population of the study included students in the secondary science program of the Thomas, Oklahoma, Independent School District. The Thomas Independent School District is comprised of Kindergarten through the 12th grade located on one central campus facility. Different buildings are used to house different programs and age groups.

Thomas, Oklahoma, is a rural town of approximately 1500 residents in the western half of Oklahoma. The surrounding area is primarily agricultural land with wheat and beef cattle being the predominant enterprises.

During the first phase of the study three sections of Biology I were used. Two of the three sections were to be taught using the ABC curriculum and one using the traditional curriculum. One section of ABC Biology was comprised of twelve 9th grade girls and one 9th grade boy when the pre-test was administered. One additional 9th grade girl moved in after the pre-test was given. Therefore, when the post-test was given this section was made up of thirteen 9th grade girls and one 9th grade boy. However, the post-test scores of the girl who had moved in were not used in the data since she had not been pre-tested. The second section of ABC Biology was made up of eight 9th grade boys and one 10th grade girl. The traditional biology section was comprised of twelve 9th grade boys and two 9th grade girls.

## Measuring Instruments

The 1990 version of the NABT/NSTA Biology Examination was used as a pre-test and post-test for all of the biology students. This test was designed by the members of the High School Biology Examination Development Committee of the National Association of Biology Teachers and the National Science Teachers Association. This committee was made up of eight individuals (four male and four female) from throughout the United States.

The examination, consisting of eighty questions, was developed to measure skills and understanding in nine science areas. These concept areas include cell structure, bioenergetics, genetics, ecology, behavior, STS (Science, Technology, and Society), systems, and taxonomy.

The Scientific Attitude Inventory was used as a pre- and post-test to measure the attitudes of students in the biology classes.

This instrument is made up of sixty statements relating to science. Students could agree strongly, agree mildly, disagree mildly, or disagree strongly with each of the statements.

## Measurement Procedures

In the fall semester of 1990, part of the researcher's teaching schedule included three sections of Biology I. These sections were intact groups that had been developed primarily due to convenience of scheduling for students. These sections had not been grouped based upon test scores, gender, race, color, creed, or national origin.

During this first year the researcher worked only with Biology I students. Both the ABC and traditional Biology I students were pre-tested on January 3, 1991. All of these students had been taught traditional biology until December 3, 1990, which was most of the first semester. The ABC students had worked a few weeks in the new curriculum before this pre-testing date.

As the fall semester 1991-92 school year began the Biology I students had become Biology II students. The post-test that had been given to the Biology I students was considered a pre-test for the second year of this research. None of the biology students attended summer school or any form of formal science oriented educational experience during the period between the spring and fall semesters. The NABT/NSTA Biology post-test was given to the Biology II students on May 6, 1992.

The Scientific Attitude Inventory was given as a pre-test to the biology students during the early part of the fall semester of 1991 as scheduling permitted.

The Scientific Attitude Inventory was given as a post-test to all of the biology students during early May of 1992 as scheduling permitted for each class section.

## Analysis Procedures

This study compared two groups of Biology I and Biology II students over a two year period. One group was instructed by the traditional method and using traditional materials. The other group was instructed by the cooperative learning method and through the use of Applied Biology/Chemistry materials.

The quantitative comparison of the students was done from difference scores between pre- and post-tests after Biology I and after Biology II.

Since this study population was made up of two groups in each situation, the t-test was used to test for significant differences between the group means. The significant level of .05 was used as the level for acceptance or rejection of each of the formulated null hypotheses. The formula used for comparison of the t-test is shown in the Appendix.

## Summary of the Findings

The purpose of this section of the chapter is to provide a summary of the findings of the study as they relate to the objectives set forth at its inception.

First and Second Year Pre- versus Post-test Comparisons

Hypothesis 1—There is no significant difference between the pre- and post-test scores of students enrolled in the ABC Biology I. There was a significant difference between the pre- and post-test scores of students enrolled in the ABC Biology I, therefore hypothesis 1 was rejected.

Hypothesis 2—There is no significant difference between the pre- and post-test scores of students enrolled in the ABC Biology II. There was a slight difference between the pre-test mean and the post-test mean for students in ABC Biology II; however, the difference was not great enough to show statistical significance, therefore, hypothesis 2 failed to be rejected.

Hypothesis 3—There is no significant difference between the pre- and post-test scores of students enrolled in the traditional Biology I. When the pre-test and post-test scores for traditional Biology I students were compared a significant difference was found, therefore hypothesis 3 was rejected.

Hypothesis 4—There is no significant difference between the pre- and post-test scores of students enrolled in the traditional Biology II. The traditional Biology II students showed only a slight difference between their mean pre-test and mean post-test scores. As a result the traditional Biology II class showed no significant difference between their pre- and post-test scores, and hypothesis 4 failed to be rejected.

Applied Biology/Chemistry versus Traditional Biology Comparisons

Hypothesis 5—There was no significant difference observed between the pre- and post-test difference scores for students in ABC Biology I versus students in traditional Biology I, therefore hypothesis 5 failed to be rejected.

Hypothesis 6—There is no significant difference between pre-test/post-test difference scores for students in ABC Biology II and traditional Biology II. A comparison of mean differences between pre-test/post-test scores for students in ABC Biology II versus traditional Biology II showed no significant difference, therefore hypothesis 6 failed to be rejected.

Hypothesis 7—There is no significant difference between the two year pre-test/post-test scores for students enrolled in both ABC Biology I and II. There was a significant difference between the two year pre-test/post-test scores for students enrolled in both ABC Biology I and II, therefore hypothesis 7 was rejected.

Hypothesis 8—There is no significant difference between the two year pre-test/post-test difference scores for students enrolled in both traditional Biology I and II. There was a significant difference between the two year pre-test/post-test difference scores for students enrolled in both traditional Biology I and II, therefore hypothesis 8 was rejected.

Hypothesis 9—There is no significant difference between two year pre- and post-test differences for students enrolled in both ABC Biology I and II versus students enrolled in both traditional Biology I and II. There was no significant difference between two year pre-/test/post-test differences for students enrolled in both ABC Biology I and II versus students enrolled in both traditional Biology I and II, therefore hypothesis 9 failed to be rejected.

Hypothesis 10—There is no significant difference between pre- and post-test attitude scores for students enrolled in ABC Biology II. There was no significant difference between pre- and post-test attitude scores for students enrolled in ABC Biology II, therefore hypothesis 10 failed to be rejected.

Hypothesis 11—There is no significant difference between pre- and post-test attitude scores for students enrolled in traditional Biology II. There was no significant difference between pre- and post-test attitude scores for students enrolled in traditional Biology II, therefore hypothesis 11 failed to be rejected.

Hypothesis 12—There is no significant difference between pre-test/post-test difference scores for students enrolled in ABC Biology II versus students in traditional Biology II. There was no significant difference between pre-test/post-test difference scores for students enrolled in ABC Biology II versus students enrolled in traditional Biology II, therefore hypothesis 12 failed to be rejected.

## Conclusions

The purpose of this section is to provide conclusions based on the findings of the study described herein. It is the further purpose of this section to provide an explanation as to the acceptance or nonacceptance of the hypotheses set forth in this study.

It was concluded that:

1. Since there were significant differences between the pre- and post-test scores for both the ABC students and the traditional students during the first year and over the two year span of the testing, it is concluded both groups of students made significant biology knowledge gain regardless of the curriculum and teaching methods.
2. As no significant differences were found between the test scores for the ABC versus the traditional students at the end of the first year, at the end of the second year and combining the two years, it is concluded that the use of the units taught in ABC versus the traditional curriculum had no effect either positively or negatively on the amount of biology learned by Biology I and Biology II students.
3. Since there were no significant differences noted between attitude toward science scores for the two groups of students at the beginning or end of year two, it was determined that the use of ABC versus traditional

curriculum had no effect on the attitude toward science of biology students at Thomas High School.

## Recommendations

The purpose of this section is to provide some recommendations concerning the outcomes of this study. It is recommended that:

1. Students be offered secondary biology using the ABC biology curriculum described in this study. While there was no statistically significant difference between the performance of students taught ABC or traditional biology, the ABC biology is, by design, more modern and relevant to the real world in which students live.
2. Since both groups of students made significant biology knowledge gain and since no significant differences were found in the knowledge gained between the two groups, students should be allowed to use ABC Biology I and II or traditional Biology I and II to meet high school graduation requirements.
3. Since both groups of students made significant biology knowledge gain and since no significant differences were found in the knowledge gained between the two groups, students should be allowed to use ABC Biology I and II or traditional Biology I and II to meet the college entrance requirements.

4. Both ABC Biology I and II as well as traditional Biology I and II should be offered in high schools where feasible to allow students the choice of their best teaching and learning approach.
5. Both ABC Biology I and II as well as traditional Biology I and II should be offered in high schools where feasible to allow further testing of the comparability of the two curricula after all units of the ABC curriculum are available.
6. Teachers be given in-service training over the various applied curriculum packages so that they may see that there are alternatives to teaching the same traditional curriculum year after year. The review of literature showed that many teachers enjoyed teaching the applied curriculum more than they did the traditional curriculum.
7. Teachers be given in-service over the cooperative learning method and how it may be implemented in a wide variety of programs.
8. More applied curriculum be developed for use in other areas of the general academic curriculum.

## Recommendations For Further Research

1. Similar research be done on a broader scale and after all units of the ABC curriculum are available.
2. Similar research be done in various sizes of school systems.

3. Follow-up studies be done in the workplace, military, and post-secondary institutions involving students that have been taught ABC Biology I and II compared to those taught traditional Biology I and II.
4. Similar research be done comparing the chemistry portion of the Applied Biology/Chemistry curriculum to the traditional chemistry curriculum.
5. Research be done involving the infusion of units of the ABC curriculum into the traditional biology program.
6. Research be done involving the infusion of units of the Applied Biology/Chemistry curriculum into the traditional chemistry program.
7. Research be done in the area of infusing units of ABC into various vocational education courses.
8. Further research be conducted over teacher perceptions of the ABC versus traditional curriculum for various academic programs.
9. Further research be done concerning school administrators' and/or counselors' perceptions of the ABC versus traditional curriculum material.
10. Academic teachers work closely with vocational teachers to help make learning more effective and enjoyable in all programs.

## Implications

If students are not offered options in the science curriculum in the public schools many of those students may not be motivated to pursue the study of science. Based upon the literature contained in this study many of the jobs that students will be seeking between now and the year 2000 will require a more in depth knowledge of science and technology. It is the duty of teachers and administrators to adopt and implement the most effective methods and materials for providing a quality program of studies in science and technology.

While attitude test scores showed no significant difference between ABC and traditional biology, it was the observation of the researcher that the ABC students showed a much greater enthusiasm for the ABC curriculum materials, class activities, occupationally related activities, and laboratories than the traditional students showed for the traditional curriculum and activities. It is believed his enthusiasm will foster a greater appreciation and understanding of science and technology as it is used in the real world today.

The Applied Biology/Chemistry curriculum allows educators the opportunity to share a very practical, nonthreatening approach to an academic subject that will keep students excited about learning. Those students who are excited about learning science and technology at a higher level are those who will become the catalysts for the successful workforce development in the 21st century.

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APPENDIXES

APPENDIX A

OKLAHOMA STATE UNIVERSITY INSTITUTIONAL

REVIEW BOARD FOR HUMAN SUBJECTS

RESEARCH

**OKLAHOMA STATE UNIVERSITY**
**INSTITUTIONAL REVIEW BOARD**
**FOR HUMAN SUBJECTS RESEARCH**

Proposal Title: Assessment of the Applied Biology Chemistry Curriculum

Principal Investigator: Dr. James Key

Date: 6-2-92 IRB # AG-92-023

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This application has been reviewed by the IRB and

Processed as: Exempt [XX] Expedite [ ] Full Board Review [ ]

Renewal or Continuation [ ]

Approval Status Recommended by Reviewer(s):

Approved [XX] Deferred for Revision [ ]

Approved with Provision [ ] Disapproved [ ]

Approval status subject to review by full Institutional Review Board at next meeting, 2nd and 4th Thursday of each month.

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Comments, Modifications/Conditions for Approval or Reason for Deferral or Disapproval:

Comments: Archival data: publicly available
no identifiers

Signature: Maria L. Tilley Date: 6-3-92
Chair of Institutional Review Board

APPENDIX B

WHAT IS YOUR ATTITUDE TOWARD SCIENCE?

# What is Your Attitude Toward Science?

(A Scientific Attitude Inventory)

There are some statements about science on the next few pages. some statements are about the nature of science, some are about how scientists work. Some of these statements describe how you might feel about science. You may agree with some of the statements and you may disagree with others. That is exactly what you will be asked to do. By doing this, you will show your attitude toward science.

After you have carefully read a statement, decide whether or not you agree with it. If you agree, decide whether you agree mildly or strongly. If you disagree, decide whether you disagree mildly or strongly. Then, find the number of that statement on the answer sheet, and put an X in the space by the correct number.

1 - if you agree strongly
2 - if you agree mildly
3 - if you disagree mildly
4 - if you disagree strongly

Example

00 I would like to have a lot of money
00. 1_x_ 2___ 3___ 4___

(The person who marked this example agrees strongly with the statement, "I would like to have a lot of money.")

Please respond to each statement and put an X in the proper box for each statement.

## What is Your Attitude Toward Science?

| | | | | | |
|---|---|---|---|---|---|
| 1___ | 2___ | 3___ | 4___ | (1) | I would enjoy studying science and using this knowledge in some scientific field. |
| 1___ | 2___ | 3___ | 4___ | (2) | Anything we need to know can be found out through science. |
| 1___ | 2___ | 3___ | 4___ | (3) | Scientific explanations can be made only by scientists. |
| 1___ | 2___ | 3___ | 4___ | (4) | Once they have developed a good theory, scientists must stick together to prevent others from saying it is wrong. |
| 1___ | 2___ | 3___ | 4___ | (5) | It is useless to listen to a new idea unless everybody agrees with the idea. |
| 1___ | 2___ | 3___ | 4___ | (6) | Science may be described as being primarily an idea-generating activity |
| 1___ | 2___ | 3___ | 4___ | (7) | Scientists are always interested in improving their explanations of natural events |

| | | | | | |
|---|---|---|---|---|---|
| 1____ | 2____ | 3____ | 4____ | (8) | If one scientist says a theory is true, all other scientists will believe him. |
| 1____ | 2____ | 3____ | 4____ | (9) | Science is so difficult that only highly trained scientists can understand it. |
| 1____ | 2____ | 3____ | 4____ | (10) | A useful scientific theory may not be entirely correct, but it is the best idea scientists have been able to think up. |
| 1____ | 2____ | 3____ | 4____ | (11) | We can always get answers to our questions by asking a scientist. |
| 1____ | 2____ | 3____ | 4____ | (12) | There are some things which are known by science to be absolutely true. |
| 1____ | 2____ | 3____ | 4____ | (13) | Most people are not able to understand the work of science. |
| 1____ | 2____ | 3____ | 4____ | (14) | Today's electric appliances are examples of the really valuable products of science. |
| 1____ | 2____ | 3____ | 4____ | (15) | Scientists cannot always find the answers to their questions. |
| 1____ | 2____ | 3____ | 4____ | (16) | When something is explained well, there is no reason to look for another explanation. |
| 1____ | 2____ | 3____ | 4____ | (17) | Most people are able to understand the work of science. |
| 1____ | 2____ | 3____ | 4____ | (18) | A scientific theory is no better than the objective observations upon which it is based. |
| 1____ | 2____ | 3____ | 4____ | (19) | Scientists believe that they can find explanations for what they observe by looking at natural phenomena. |
| 1____ | 2____ | 3____ | 4____ | (20) | The day after day search for scientific knowledge would become boring for me. |
| 1____ | 2____ | 3____ | 4____ | (21) | Scientific work would be too hard for me. |
| 1____ | 2____ | 3____ | 4____ | (22) | Scientists discover laws which tell us exactly what is going on in nature. |
| 1____ | 2____ | 3____ | 4____ | (23) | Scientific ideas may be said to undergo a process of evolution in their development. |
| 1____ | 2____ | 3____ | 4____ | (24) | The value of science lies in its usefulness in solving practical problems. |
| 1____ | 2____ | 3____ | 4____ | (25) | When one asks questions in science, he gets information by observing natural phenomena. |

| | | | | | |
|---|---|---|---|---|---|
| 1____ | 2____ | 3____ | 4____ | (26) | A good scientist doesn't have any ideas he is not willing to change. |
| 1____ | 2____ | 3____ | 4____ | (27) | Looking at natural phenomena is a most important source of scientific information. |
| 1____ | 2____ | 3____ | 4____ | (28) | Public understanding of science is necessary because scientific research requires financial support through the government. |
| 1____ | 2____ | 3____ | 4____ | (29) | Some questions cannot be answered by science. |
| 1____ | 2____ | 3____ | 4____ | (30) | Rapid progress in science requires public support |
| 1____ | 2____ | 3____ | 4____ | (31) | Scientists do not need public support, they can get along quite well without it. |
| 1____ | 2____ | 3____ | 4____ | (32) | A scientist must be imaginative in developing ideas which explain natural events. |
| 1____ | 2____ | 3____ | 4____ | (33) | The value of science lies in its theoretical products. |
| 1____ | 2____ | 3____ | 4____ | (34) | Ideas are one of the more important products of science. |
| 1____ | 2____ | 3____ | 4____ | (35) | I do not want to be a scientist because it takes too much education. |
| 1____ | 2____ | 3____ | 4____ | (36) | There is no need for the public to understand science in order for scientific progress to occur. |
| 1____ | 2____ | 3____ | 4____ | (37) | When a scientist is shown enough evidence that one of his ideas is a poor one, he should change his idea. |
| 1____ | 2____ | 3____ | 4____ | (38) | All one has to do to learn to work in a scientific manner is to study the writings of great scientists. |
| 1____ | 2____ | 3____ | 4____ | (39) | Before one can do anything in science, he must study the writings of the great scientists. |
| 1____ | 2____ | 3____ | 4____ | (40) | People need to understand the nature of science because it has such a great affect upon their lives |
| 1____ | 2____ | 3____ | 4____ | (41) | A major purpose of science is to produce new drugs and save lives. |
| 1____ | 2____ | 3____ | 4____ | (42) | One of the most important jobs of a scientist is to report exactly what his senses tell him. |

| | | | | | |
|---|---|---|---|---|---|
| 1____ | 2____ | 3____ | 4____ | (43) | If a scientist cannot answer a question, all he has to do is to ask another scientist |
| 1____ | 2____ | 3____ | 4____ | (44) | An important purpose of science is to help man to live longer. |
| 1____ | 2____ | 3____ | 4____ | (45) | I would enjoy working with other scientists in an effort to solve scientific problems. |
| 1____ | 2____ | 3____ | 4____ | (46) | Scientific laws cannot be changed. |
| 1____ | 2____ | 3____ | 4____ | (47) | Science is devoted to describing how things happen. |
| 1____ | 2____ | 3____ | 4____ | (48) | Every citizen should understand science because we are living in an age of science. |
| 1____ | 2____ | 3____ | 4____ | (49) | I may not make many great discoveries, but working in science would still be interesting to me. |
| 1____ | 2____ | 3____ | 4____ | (50) | A major purpose of science is to help man live more comfortably. |
| 1____ | 2____ | 3____ | 4____ | (51) | Scientists should not criticize each other's work. |
| 1____ | 2____ | 3____ | 4____ | (52) | His senses are one of the most important tools a scientist has. |
| 1____ | 2____ | 3____ | 4____ | (53) | Scientists believe that nothing is known to be true with absolute certainty. |
| 1____ | 2____ | 3____ | 4____ | (54) | Scientific laws have been proven beyond all possible doubt. |
| 1____ | 2____ | 3____ | 4____ | (55) | I would like to work in a scientific field. |
| 1____ | 2____ | 3____ | 4____ | (56) | A new theory may be accepted when it can be shown to explain things as well as another theory. |
| 1____ | 2____ | 3____ | 4____ | (57) | Scientists do not have enough time for their families or for fun. |
| 1____ | 2____ | 3____ | 4____ | (58) | The products of scientific work are mainly useful to scientists, they are not useful to the average person. |
| 1____ | 2____ | 3____ | 4____ | (59) | Scientists have to study too much and I would not want to be one for this reason. |
| 1____ | 2____ | 3____ | 4____ | (60) | Working in a laboratory would be an interesting way to earn a living. |

## Summary of Scientific Attitude Inventory

Count all x's in number 1 and put total in space below. Count all x's in number 2 and put total in space below and follow same procedure for 3 and 4

1________ 2________ 3________ 4________

APPENDIX C

BIOLOGY I LEARNER OUTCOMES

# BIOLOGY I LEARNER OUTCOMES

BI.1 The student will use basic process skills.
**Descriptive Statement:** Basic process skills are:

a. observing--using the five senses and appropriate equipment such as microscopes;
b. classifying--using dichotomous keys;
c. communicating--sharing information or data verbally and/or through writing, drawings, and graphs;
d. investigating--collecting and recording data about organisms through a hands-on manipulative manner;
e. interpreting--arranging data to look for cause and effect;
f. measuring--making comparison by using familiar objects and metric measurements;
g. model-building--study should enable students to construct models which illustrate various biological concepts.

BI.2 The student will use chemicals, scientific tools, and equipment in a safe and appropriate manner.
**Descriptive Statement:** Examples of science equipment include such tools as hand lenses, metric rules, balances, microscopes, dissecting instruments, and computers.

BI.3 The student will demonstrate proper handling and care of organisms (plants, animals, and protists) and show respect for life and property.
**Descriptive Statement:** Provisions should be made for maintaining the health and safety of students and organisms.

BI.4 The student will work independently and as a member of small and large groups within the classroom and in the appropriate laboratory.
**Descriptive Statement:** Experiences will provide the opportunity to develop independence, cooperative skills, and attitudes as a part of social growth.

★BI.5 The student will identify cell structures, cells, tissues, and their functions.
**Descriptive Statement:** Students will observe cell structure and tissues using a microscope and drawings. From these observations they will be able to identify major cell structures, cells, tissues and their functions, including genetic coding.

★BI.6 The student will classify organisms according to similarities and differences.
**Descriptive Statement:** Observable characteristics of several organisms will be compared. A dichotomous key may be introduced. Students should be aware of scientific classification schemes and of binomial nomenclature.

★ The student must learn to attain minimum competencies.

(NEW)

BI.7 The student will recognize that organisms carry on metabolic processes to maintain life.
**Descriptive Statement:** Gas exchange and transport, cellular respiration, digestion, absorption and assimilation in plants and animals, use of enzymes, vitamins, and minerals are topics that can be taught in laboratory or lecture.

★BI.8 The student will recognize plants as producers of food and oxygen.
**Descriptive Statement:** The sun is the ultimate source of energy. The students will perform experiments and interpret data illustrating the process of photosynthesis.

★BI.9 The student will illustrate the movement of materials through food chains, food webs, and pyramids.
**Descriptive Statement:** Through a variety of observations of local flora and fauna the students will interpret food chains, webs, and pyramids.

★BI.10 The student will identify living and nonliving things in the ecosystem.
**Descriptive Statement:** Living and nonliving factors of local ecosystems and their interactions will be compared and contrasted through a variety of observations.

★BI.11 The student will describe methods of conserving our present living resources.
**Descriptive Statement:** Activities should include topics such as extinct, endangered, threatened species and destruction of habitat.

BI.12 The student will study basic principles of genetics.
**Descriptive Statement:** Topics may include RNA, DNA, chromosomes, mutations, and laws of genetics.

BI.13 The student will study changes that occur in organisms.
**Descriptive Statement:** Adaptation and natural selection as means of change should be studied.

BI.14 The student will examine the internal structures of representative organisms.
**Descriptive Statement:** Various structures and systems will be examined.

★BI.15 The student will list and compare the major characteristics of the invertebrates.

★ The student must learn to attain minimum competencies.

(NEW)

**Descriptive Statement:** The major characteristics of invertebrate phyla will be presented through the study of several organisms.

★ BI.16 The student will compare major characteristics of vertebrates.
**Descriptive Statement:** Several examples of vertebrate classes and orders will be examined and their structures compared.

BI.17 The student will identify the major structures of vascular and nonvascular plants.
**Descriptive Statement:** Vascular and nonvascular plants will be studied for comparative purposes.

★BI.18 The student will study the process of reproduction in several organisms.
**Descriptive Statement:** Activities will include interpreting that sexual reproduction is a process by which new individuals are formed from the union of the sperm and egg, and observing examples of asexual reproduction such as binary fission, budding, regeneration, and vegetative propagation.

BI.19 The student will observe that organisms receive and respond to stimuli from the environment.
**Descriptive Statement:** Topics to be investigated are:
a. reflexes
b. sensory structures
c. reactions to specific stimuli such as the avoidance reaction
d. chemical response

BI.20 The student will study major characteristics of virus, bacteria, protozoa, algae, and fungi.
**Descriptive Statement:** Several examples of these organisms will be examined and their structure compared.

BI.21 The student will develop an interest in biology.
**Descriptive Statement:** A list of resource personnel, field trip locations, etc. should be compiled and utilized to stimulate student interest.

BI.22 The student will study principles of cellular transport.
**Descriptive Statement:** Examples should include osmosis, diffusion, and active transport.

★BI.23 The student will identify the basic characteristics of all living things.

★ The student must learn to attain minimum competencies.

(NEW)

**Descriptive Statement:** The student will examine processes that are characteristic of all living things by observing a variety of plants and animals.

## BIOLOGY II LEARNER OUTCOMES

BII.1 The student will experience reinforcement and expansion of the skills and concepts introduced in Biology I.
**Descriptive Statement:** Activities that review the Biology I concepts should be included.

BII.2 The student will identify basic cell organelles and their functions.
**Descriptive Statement:** Activities should include some of the following:
- a. observations of cells and cell organelles
- b. model-building of cells and the organelles
- c. identification of the role of the cell organelles
- d. examination of various tissues

BII.3 The student will recognize the major processes in photosynthesis.
**Descriptive Statement:** Photosynthesis will be examined to identify the following:
- a. chemical processes
- b. role of light
- c. role of chlorophyll

BII.4 The student will recognize that energy is released during cellular respiration.
**Descriptive Statement:** Activities should include examples of aerobic and anaerobic respiration and the role of enzymes in respiration.

BII.5 The student will identify the processes of digestion in humans.
**Descriptive Statement:** Experiments should illustrate mechanical and chemical processes.

BII.6 The student will identify processes involved in gaseous exchange and transport in humans.
**Descriptive Statement:** The student will examine models and perform experiments to illustrate how respiratory and circulatory systems function.

BII.7 The student will identify the skeletal muscles and the major bones of the skeleton.
**Descriptive Statement:** Examine bone structure and compare types of bones. Show that muscles and bones work together.

(NEW)

BII.8 The student will identify the role of genes and chromosomes in determining the characteristics of individual organisms.
**Descriptive Statement:** Studying traits will illustrate principles of genetics.

BII.9 The student will recognize that mitosis produces new cells in organisms.
**Descriptive Statement:** The student will realize that changes occur in mitosis.

BII.10 The student will study meiosis.
**Descriptive Statement:** Examine the role of meiosis in keeping the chromosome number constant from generation to generation.

BII.11 The student will study the diversity of organisms.
**Descriptive Statement:** Compare organisms and classify the organisms into groups. Identify characteristics specific to each group. Activities may include use of dichotomous key or comparative anatomy studies.

BII.12 The student will identify the mechanisms of response in organisms.
**Descriptive Statement:** Studies should include the following:
a. hormones
b. nervous system
c. sense organs
d. behavior
e. chemicals

BII.13 The student will study principles of ecology.
**Descriptive Statement:** Daily, seasonal, and long-term changes which occur in ecosystems should be studied.

BII.14 Students will study reproduction and development of plants and animals.
**Descriptive Statement:** Studies should include anatomy, physiology, fertilization, and early stages of development.

## CHEMISTRY I LEARNER OUTCOMES

CHI.1 The student will demonstrate laboratory procedure and safety.
**Descriptive Statement:** This will be illustrated by
a. identification of variables in the experiment
b. application and usage of equipment
c. application of scientific method
d. location and use of safety materials
e. wearing safety apparel

(NEW)

CHI.2 The student will demonstrate an understanding of the atomic model.
**Descriptive Statement:** This will be accomplished by the study of:

a. atomic particles
b. historical models
c. present day models
d. orbital shapes: s, p, d, f, and the number of each
e. mass number and atomic number
f. isotopes
g. average atomic mass
h. atomic theory

CHI.3 Mathematical skills will be used by the student to solve problems in chemistry.
**Descriptive Statement:** The skills emphasized will be:

a. International System of Measurement
b. scientific notation
c. arithmetic operations
d. graphing
e. ratio and proportion
f. factor-label method for conversions
g. accuracy and precision
h. significant figures
i. combining SI units to form derived units

CHI.4 The student will demonstrate an ability for balancing chemical equations and formula development.
**Descriptive Statement:** This will be illustrated by:

a. symbols
b. coefficients and subscripts
c. oxidation numbers
d. monatomic and polyatomic ions
e. nomenclature
f. empirical and molecular formulas
g. reactants and products
h. types of reactions
i. formula units
j. parts of chemical equations

CHI.5 The student will demonstrate ability in the usage of the periodic table.
**Descriptive Statement:** This ability will be developed by studying:

a. historical development
b. families/groups and periods/series
c. periodic properties
d. electron configurations
e. basis for modern periodic law
f. differences between metals, nonmetals, and metalloids

(NEW)

CHI.6 The student will use stoichiometric and quantitative relationships to solve a given chemical problem.
**Descriptive Statement:** The following concepts will be developed quantitatively for solving problems:

a. mole concept
b. mass-mass
c. molecular and formula mass (weight)
d. percentage composition
e. Avogadro's principle
f. mass-volume
g. volume-volume
h. molar solutions
i. limiting reactants

CHI.7 The student will interpret chemical bonding in terms of electrostatic force.
**Descriptive Statement:** This will be developed by studying:

a. properties of electron, protons, and neutrons
b. attraction of unlike charges
c. covalent and ionic bonding
d. electronegativit
e. ionization
f. electron affinity
g. atomic and ionic radii

CHI.8 The student will study chemical equilibrium.
**Descriptive Statement:** The nature of equilibrium systems will be described by studying the following:

a. Le Chatelier's principle
b. factors affecting equilibrium
c. properties of acids, bases, and salts
d. reversible reactions
e. reaction rate and activation energy
f. characteristics of acid-base theories
g. formulas of acids and bases
h. describing and predicting anhydrides
i. strengths of acids and bases

CHI.9 The student will gain an understanding of the classes of matter and their properties.
**Descriptive Statement:** This will be accomplished by exploring the following topics:

a. classes of matter
b. physical and chemical changes
c. endothermic and exothermic reactions
d. heat of formation

(NEW)

e. phases of matter
f. elements and compounds
g. extensive and intensive properties
h. methods of physical separation

CHI.10 The student will study the gas laws.
**Descriptive Statement:** This will be accomplished by studying the following:
a. characteristics of gases
b. standard conditions
c. application of Charles's, Boyle's, and the ideal gas law
d. Dalton's law of partial pressure
e. limiting reactants

CHI.11 The student will relate the behavior of matter with the kinetic theory.
**Descriptive Statement:** This relationship will be accomplished by examining the following areas:
a. assumptions of the kinetic theory
b. effect on the phases of matter
c. factors that affect molecular motion (pressure, temperature)

CHI.12 The student will be introduced to the chemistry of carbon compounds.
**Descriptive Statement:** This will be carried out by exploring:
a. classification of organic substances
b. nomenclature of organic compounds
c. properties and uses
d. isomers

CHI.13 The student will gain an exposure to nuclear chemistry.
**Descriptive Statement:** This exposure should include:
a. forms of radiation (alpha, beta, gamma)
b. half-life
c. subatomic particles related to nuclear chemistry

CHI.14 The student will investigate oxidation-reduction reactions.
**Descriptive Statement:** Investigations should include:
a. characteristics of oxidations and reductions
b. determining oxidation numbers
c. balancing redox equations

CHI.15 The student will become aware of some of the practical applications of electrochemistry.
**Descriptive Statement:** This awareness will be accomplished by examining:

(NEW)

a. practical applications of chemical conductivity
b. types of electrochemical cells (voltaic and electrolytic)
c. electricity produced from a chemical voltaic cell

CHI.16 The student will develop an interest in chemistry.
**Descriptive Statement:** A list of resource personnel, field trip locations, etc. should be compiled and utilized to stimulate student interest.

CHI.17 The student will solve word problems.
**Descriptive Statement:** Problems will be answered verbally and in writing. Skills involved with estimating answers and the appropriate use of a calculator should be developed. Problems involving multistep situations will be included.

## CHEMISTRY II LEARNER OUTCOMES

The study of Chemistry II should include a comprehensive review and study of the materials covered in Chemistry I. In addition to these items, the following should be introduced or reinforced:

CHII.1 The student will become more aware of career opportunities in chemistry.

CHII.2 The student will be exposed to a review and continued emphasis in the use of mathematical skills in solving problems in chemistry.

CHII.3 The student will expand quantitative relationships by examining molarity, normality, formality, and molality.

CHII.4 The student will explore energy changes in matter.

CHII.5 The student will examine some of the properties of materials as a result of hybrid orbitals.

CHII.6 The student will further study equilibrium systems by working with equilibrium constants.

CHII.7 The student will gain further understanding of inter- and intra-molecular forces.

CHII.8 The student will study activation energy and catalysis.

CHII.9 The student will learn more organic chemistry including a study of polymers and differentiating types of organic reactions.

(NEW)

CHII.10 The student will gain a greater exposure to nuclear chemistry.
**Descriptive Statement**: This will be accomplished by examining:
a. nuclear instruments and apparatus
b. nuclear equations dealing with transmutations
c. practical uses of radioactive nuclides
d. fission and fusion reactions

CHII.11 The student will study more about oxidation-reduction.
**Descriptive Statement**: This study should include:
a. balancing redox reactions
b. identifying reactions as redox or nonredox
c. oxidizing and reducing agents

CHII.12 The student will gain additional knowledge of electrochemistry by investigating the characteristics of electrolytes.

CHII.13 The student will solve word problems.
**Descriptive Statement:** Problems will be answered vebally and in writing. Skills involved with estimating answers and the appropriate use of a calculator should be developed. Problems involving multistep situations will be included.

# APPENDIX D

## NABT/NSTA 1990 BIOLOGY EXAMINATION TEST CONCEPTS

## NABT/NSTA 1990 Biology Examination Test Concepts

1. Cell structure
2. Bioenergetics
3. Genetics
4. Ecology
5. Evolution
6. Behavior
7. STS
8. Systems
9. Taxonomy
10. Cell structure
11. Evolution
12. Bioenergetics
13. Bioenergetics
14. Bioenergetics
15. Evolution
16. Genetics
17. Ecology
18. Behavior
19. STS
20. Systems
21. Taxonomy
22. Cell structure
23. Evolution
24. Genetics
25. Ecology
26. Behavior
27. STS
28. Systems
29. Taxonomy
30. Cell structure
31. Evolution
32. Genetics
33. Ecology
34. Behavior
35. STS
36. Systems
37. Taxonomy
38. Cell structure
39. Bioenergetics
40. Genetics
41. Ecology
42. Behavior
43. STS
44. Systems
45. Taxonomy
46. Cell structure
47. Behavior
48. Evolution
49. Bioenergetics
50. Ecology
51. Behavior
52. STS
53. Genetics
54. Systems
55. Behavior
56. Taxonomy
57. Behavior
58. Ecology
59. Cell structure
60. Behavior
61. Evolution
62. Genetics
63. STS
64. Systems
65. Evolution
66. Evolution
67. Behavior
68. Bioenergetics
69. STS
70. Systems
71. Cell structure
72. Genetics
73. Ecology
74. Evolution
75. Genetics
76. Genetics
77. Evolution
78. Genetics
79. Evolution
80. Genetics

# NABT/NSTA 1990 Biology Examination Test Concepts

## Breakdown of Test Questions Relating to Concept Area

| Biology Concept | Test Question Numbers | Total Relating to Concept |
|---|---|---|
| Cell Structure | 1, 10, 22, 30, 38, 46, 59, 71 | 8 questions |
| Bioenergetics | 2, 12, 13, 14, 39, 49, 68 | 7 questions |
| Genetics | 3, 16, 24, 32, 40, 53, 62, 72, 75, 76, 78, 80 | 12 questions |
| Ecology | 4, 17, 25, 33, 41, 50, 58, 73 | 8 questions |
| Evolutaion | 5, 11, 15, 23, 31, 48, 61, 65, 66, 74, 77, 79 | 12 questions |
| Behavior | 6, 18, 26, 34, 42, 47, 51, 55, 57, 60, 67 | 11 questions |
| *STS | 7, 19, 27, 35, 43, 52, 63, 69 | 8 questions |
| Systems | 8, 20, 28, 36, 44, 54, 64, 70 | 8 questions |
| Taxonomy | 9, 21, 29, 37, 45, 56 | 6 questions |

*Science, Technology, and Society

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Doctor of Education

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