The purpose of this study was to investigate several hypotheses concerning specific demonstrable attitudes toward education, critical thinking ability, and affective behaviors as these were manifested by students in the BSCS environmental module, Investigating Your Environment (IYE), and in more structure-oriented biology classes. Participants in the study were students in 32 high school classes throughout the United States. Sixteen classes were randomly assigned to the IYE module, which constituted one factor of the treatment groups (T1). Sixteen classes involved in more structure-oriented biology classes taught by the same teachers were randomly assigned to the second treatment. The second factor consisted of two levels, with T2 constituting the classes using one of the BSCS Biological
Science versions, and $T_3$ constituting the classes using *Modern Biology* by Otto and Towle. A total of 355 students were in the IYE program, and 375 students were in one of the more structure-oriented biology programs.

The criterion instruments used were the *Attitudes Toward Education Survey (ATES)*, the *Cornell Critical Thinking Test (CCTT)*, *Level X*, and the *Biology Students Behavioral Inventory (BSBI)*, *Form C*.

Students in the IYE program worked for nine weeks on independent research investigations of their own choosing, based upon what they identified as important to them at the time. Students in the more structured biology programs continued their studies with no change in the instructional mode.

The experimental design was a Posttest-Only, using two-factor analysis of variance with an F-test to compare treatment results of class means. Scores on the *Comprehensive Test of Basic Skills* were used for covariance analysis.

**The Findings**

Two major hypotheses which asserted that there was no significant difference in the two modes of instruction upon student attitudes toward education or upon specific affective behaviors among classes in the treatment groups were tested and not rejected. The major
hypothesis asserting that there was no significant difference among classes in the treatment groups in the ability of students to think critically was rejected at the .05 level of significance with the BSCS Biological Science classes showing higher performance ratings in overall critical thinking ability than the IYE classes.

Concerning the minor hypotheses, no significant F-values were found in the class means of the treatment groups on four of the six sub-scales in the ATES. Two sub-scales showed significant differences at the .05 and .10 probability levels with the IYE classes consistently rating more favorably. Except for ratings in two sub-scales, the absence of a significant difference in the class means of the treatment groups in the ATES showed that in this research study the methodology used was not a factor in the outcomes of the particular attitudes examined.

In the CCTT an inverse correlation appeared in which the combined IYE classes scored lower, although non-significantly, in three of the four sub-scales. The IYE classes scored significantly lower at the .05 probability level in one sub-scale as compared with the combined structure-oriented biology classes.

No significant differences were found between the class means of the treatment groups for three of the four sub-scales in the BSBI. The hypothesis relating to Openness was rejected at the .05 level of
significance with the structure-oriented classes showing more openness as compared to the IYE classes.

**Conclusion**

Within the framework of this study, students who participated in the IYE module, which allows maximum latitude for each student to select and pursue independently an investigation of his own choosing, did not appear to differ significantly in the achievement of the overall outcomes examined from students in more structure-oriented biology programs.
A Study of the Effect
of Two Programs in High School Biology
Upon Critical Thinking Ability, Specific Affective Behaviors,
and Attitudes Toward Education

by

Sister Corinne Clay

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A STUDY OF THE EFFECT
OF TWO PROGRAMS IN HIGH SCHOOL BIOLOGY
UPON CRITICAL THINKING ABILITY, SPECIFIC AFFECTIVE
BEHAVIORS, AND ATTITUDES TOWARD EDUCATION

I. INTRODUCTION

The Biological Sciences Curriculum Study (BSCS) since 1958 has produced a variety of instructional programs in biology designed to answer a recognized educational need at a specific time in history. In the early 1960s after completing the three secondary biology textbooks, commonly referred to as blue, green and yellow versions, the BSCS staff then began work on a specialized program to interest the slower learner. Close to follow was a program designed for the advanced secondary students in biology. Having made available a diverse and flexible series of programs for secondary students, the BSCS then directed attention to planning suitable life science programs at the junior high school level for students of average ability as well as for students classified as educable mentally handicapped. Attention has since been focused by the writers of the Biological Sciences Curriculum Study on preparing instructional materials appropriate for elementary and college level learners, and on developing specialized programs to provide opportunities for interlacing science concepts with societal issues having biological roots. Among the most recently developed specialized materials designed to relate
the impact of science upon society is a new environmental module called Investigating Your Environment, (hereafter referred to as IYE) published by Addison-Wesley in 1975. It is a curriculum package which implements the BSCS philosophy in a somewhat unique manner, wherein experience in scientific inquiry is provided through student commitment to investigating a problem of personal interest and choosing.

In the new IYE program, the pervading philosophy of the Biological Sciences Curriculum Study remains unchanged. Fundamental goals and objectives expressed by the BSCS (Grobman, 1969) in the early 1960s remain basically the same. The hallmark of the Biological Sciences Curriculum Study materials has ever been to provide opportunity for students to demonstrate ability to recognize problems; to formulate hypotheses; to design experiments; to utilize experimental controls; to record, analyze and interpret data; to use quantitative measurements when investigating natural phenomena; to devise methods of solving unexplained problems; to develop awareness of and explore solutions to problems facing the human species; and to grow in the ability to communicate findings. All of these processes are aspects of critical thinking ability.

In the construction of learning materials over the past 15 years the BSCS has been ever mindful of the importance of aiming to develop scientific literacy and a positive attitude toward science and learning.
The role of the teacher as facilitator and resource person likewise has been stressed from the beginning.

The rationale behind the IYE module is to allow students to have maximum latitude and responsibility for self-direction. It provides students the opportunity to pursue meaningful investigations that relate knowledge to first-hand experience of life in society. The conceptual framework is based on sound learning theory, and has broad support in recent educational literature. In the *Journal of Research in Science Teaching*, Tyler (1974) writes:

> It is becoming clear to me that we have been greatly pre-occupied with investigating learning as this process is commonly perceived by the teacher or curriculum maker, in which the task is to direct the learning of students in the classroom and laboratory. We have largely neglected to look at the way learning is viewed by the student himself (p. 135).

Alvin Toffler (1974) in his visionary book, *Learning for Tomorrow*, points out that the learning process is closely bound to motivation, and is directly connected with "experiential performance"—ability to live, cope, and grow in a high-change society.

In an article discussing the relationship between self-directed and teacher-oriented eighth grade students in an *Earth Science Curriculum Project* laboratory block, Kline (1971) quotes Butts as saying, 
"... the learning of science will be at its best when the student himself initiates actions and interprets the results of his data" (p. 263).

Does providing the opportunity for high school students to
identify their own environmental problem to be researched constitute fitting content and methodology in biology? Does it supply the stabilizing qualities of a psychoemotional and social climate for learning? By selecting a problem of personal interest, will high school students be better able to design and conduct investigations, obtain and record data, analyze and interpret data, draw conclusions and report findings? In a program in which students commit themselves to researching a problem of personal interest, will they be better able to utilize intellectual and motor skills which enable them to discover and apply new knowledge? Will the pursuit of an investigation of personal choosing more favorably influence affective behavior? Will students have more positive attitudes toward school and education by personally selecting what to investigate, and designing the procedures for carrying out the study?

These are questions that can be examined by a controlled comparative study of the new BSCS environmental module with an earlier BSCS learning model for high school biology based on the same philosophy, but differing in that problems and procedures for investigations are to a great extent teacher selected and structured.

Statement of the Problem

The purpose of this study is to investigate several hypotheses concerning specific demonstrable attitudes toward education, critical
thinking ability, and affective behavior as these are manifested in the new IYE module, and in more structured BSCS Biological Science classes using one of the versions, or using Modern Biology (Otto and Towle, 1973) with BSCS philosophical emphasis. It is the intent of this research to compare the two instructional modes in the achievement of outcomes related to the previously stated human processes measured by three selective tests.

In the secondary level of the BSCS versions, students are introduced to biological themes and concepts through a wide variety of well chosen laboratory and field investigations. In the new IYE module secondary students identify valued things in the environment which particularly interest them and which they wish to learn more about. Both programs emphasize inquiry and problem solving. In the IYE program, after identifying a specific problem, the students proceed to design and carry out an investigation of their own choosing related to an environmental problem. This involves formulating specific investigable questions; collecting, processing, and evaluating data; and communicating findings to an appropriate audience. Both the structured BSCS programs and the new environmental module are process oriented with emphasis on growth in learning through discovery. Both programs are intended to provide students with experience in generating knowledge from nature directly. Criteria such as ability to identify a problem, ability to collect and record data
scientifically, ability to interpret and evaluate outcomes, and ability to communicate results, are inherent in the philosophy of all BSCS secondary programs including the new environmental module.

The intent of this study is to determine if possible to what extent students who participate in the IYE module are able to achieve the objectives common to the BSCS secondary programs as compared to students who participate in one of the more structured secondary biology courses.

The Assumptions

In order to conduct the study, the following assumptions are made:

1. The goals and objectives of all BSCS instructional materials at the secondary level aim to provide opportunity for growth in the ability to think critically, to make responsible decisions, to develop positive attitudes toward education, albeit through diverse channels of emphases.

2. The methodology used by teachers in classes using Modern Biology in this research study emphasizes the same goals and objectives as those of the structured BSCS classes.

3. The Attitudes Toward Education Survey (ATES) is a valid and reliable instrument for measuring outcomes related to the basic
philosophy and fundamental goals of BSCS secondary instructional materials.

4. The Cornell Critical Thinking Test (CCTT), Level X, is a valid and reliable instrument for measuring critical thinking in the areas of induction, deduction, assumption finding, and reliability.

5. The Biology Students Behavioral Inventory (BSBI) is a valid and reliable instrument for measuring operations in the affective domain in the areas of curiosity, openness, satisfaction, and responsibility.

6. Random assignment eliminates the confounding variables of history, testing, statistical regression, and selection, thus allowing for a Posttest-Only design.

7. Experimenter bias is minimized by randomization procedures.

8. It is possible for other factors not measured to influence the outcomes being investigated.

The Hypotheses

The three major hypotheses to be tested assert that there is no significant difference in the effect of two programs in high school biology upon attitudes toward education, critical thinking ability, and specific affective behaviors of the participating classes involved in the research study.

The minor hypotheses to be tested likewise assert that there is
no significant difference in the effect of two modes of instruction in high school biology in any of the sub-scales of the three criterion tests used with the participating classes in this research study. The hypotheses to be tested are:

$H_1$: There is no significant difference in the two modes of instruction in influencing students' attitudes toward education as measured by the ATES.

$H_{1.1}$: There is no significant difference between the two modes of instruction in influencing students' views of secondary education as a preparation for college.

$H_{1.2}$: There is no significant difference between the two modes of instruction in influencing students' views of secondary education as a preparation for self-learning.

$H_{1.3}$: There is no significant difference between the two modes of instruction in influencing students to perceive themselves as responsible for self-learning.

$H_{1.4}$: There is no significant difference between the two modes of instruction in influencing students to view learning as process.

$H_{1.5}$: There is no significant difference between the two modes of instruction in influencing students to view learning primarily as memorizing facts.

$H_{1.6}$: There is no significant difference between the two modes of
instruction in influencing students to view school as relevant and important to real life.

H₂: There is no significant difference between the two modes of instruction in stimulating critical thinking in students as measured by the CCTT.

H₂₁: There is no significant difference between the two modes of instruction in students demonstrating ability for inductive reasoning.

H₂₂: There is no significant difference between the two modes of instruction in the ability of students to evaluate reliability of information.

H₂₃: There is no significant difference between the two modes of instruction in students demonstrating ability for deductive reasoning.

H₂₄: There is no significant difference between the two modes of instruction in the ability of students to identify plausible assumptions.

H₃: There is no significant difference in the two modes of instruction in students fostering specific affective behaviors as measured by the BSBI.

H₃₁: There is no significant difference between the two modes of instruction in students generating curiosity.

H₃₂: There is no significant difference in the two modes of
instruction in students demonstrating openness.

H₃.₃: There is no significant difference between the two modes of instruction in influencing students to view the inquiry process as a rewarding experience.

H₃.₄: There is no significant difference between the two modes of instruction in influencing students to exercise personal responsibility.

Definition of Terms

Affective behavior is a way of manifesting psychological processes in terms of feelings, emotions, values.

Assumption finding as used in the CCTT (Ennis and Millman, 1971b) is the ability to apply assumptions to the validity of arguments.

Critical thinking as used by Ennis and Millman (1971b) is the reasonable assessing of statements.

Curiosity as used in the BSBI (Steiner and Lee, 1970a) is intellectual and affective inquiry into the "why" and "how" of things.

Deduction as used in the CCTT (Ennis and Millman, 1971b) is the ability to judge whether a statement follows logically from premises.

Induction as used in the CCTT (Ennis and Millman, 1971b) is the ability to evaluate evidence for and against hypotheses, and the ability to choose a plausible explanation from a set of facts.
Learning as process as used in the ATES (Steele, 1969a) is a series of progressive and interdependent experiences that lead to conceptual learning.

Mode of instruction refers to the teaching methodology utilized to facilitate learning. Two modes of instruction compared in this research are:

1. The **IYE module approach**, in which students independently identify a specific problem of their own choosing to be studied for approximately nine weeks. With the help of the teacher each student determines the procedures to be used, carries out the investigation, evaluates the data, and reports the findings to an appropriate audience.

2. The **structure-oriented approach**, in which students are introduced by the teacher to biological themes and concepts through carefully selected, short-term laboratory and field investigations. The class as a group or in teams pursues the investigation and discusses outcomes together at the completion of the study.

Motivation is that which gives direction and intensity to behavior. Relevance of school as used in the ATES (Steele, 1969a) implies that school does or does not deal with matters that are important to real life situations of students.

Reliability as used in the CCTT (Ennis and Millman, 1971b) is
the capability of evaluating the accuracy of information. As used in the statistical analysis of data, **reliability** is the consistency with which a test yields the same results in measuring whatever it purports to measure.

**Responsibility** as used in the BSBI (Steiner and Lee, 1970a) is the participation of learners in deriving conclusions based on adequate and sound evidence, and the interaction of learners in providing rationale for criticism and evaluation.

**Satisfaction** as used in the BSBI (Steiner and Lee, 1970a) is a condition of self-esteem, self-acceptance, or self-fulfillment, based on the belief that the learning activity enables one to reach future goals.

**Self-responsibility** as used in the ATES (Steele, 1969a) is exercising personal initiative for making decisions about self-learning.

**Need for the Study**

Since 1960 there has been a plethora of biological science materials emerging from numerous book companies, and subsequently lining biology classroom bookcases. Most of the materials purport to utilize inquiry methods in laboratory centered context. Science educators are called upon to meet with district and state textbook commissions to help evaluate and select science textbooks for adoption. Science teachers look to science educators for advice on the
merits of one course design as compared with another. For the sake of example, at the secondary level the BSCS materials alone at the present time include eight textbooks, 13 laboratory blocks, a series of 24 paperbacks and 14 pamphlets on biological topics, three books of research investigations in biology for students, a series of single-author topics in biology, a science and society series of issue-centered biological topics, and 12 clusters of 76 individualized mini-courses from which teachers may select appropriate course materials for students. In addition, the BSCS continues to produce a wide variety of audio-visual learning tools including a series of 16mm color sound films, and 8mm filmloops; single-topic inquiry films; activities using stereo pictures; sound-slide packets; and 20 sequences of inquiry slides for chalkboard projection. It is no small wonder that busy teachers are often at a loss concerning the selection of materials which might be the most fitting to use with specific students.

Since BSCS instructional materials are widely used, and since the effectiveness of another new BSCS program now needs to be examined in the light of the students' ability to achieve the objectives, the importance of a study such as this is apparent.

It is the intent of this research to attempt to show to what extent ability in the area of critical thinking, responsible behavior, and attitudes toward education is demonstrated among classes in two biology programs having the same basic objectives while utilizing different
emphases for the selection of investigations. The study can provide valuable data to evaluate the effectiveness of the pedagogy used in the treatment groups to stimulate critical thinking, foster responsible behavior, and influence attitudes toward education. By analyzing areas that show significant discrepancies in class performance between the treatment groups in the results obtained from the three instruments with their various sub-scales, real differences in the courses can be identified. It is possible that results of a study such as this may cast more light on what types of programs are most appropriate for different students and classes in terms of intellectual and emotional developmental levels.

**Limitations**

The investigation reported in this study is subject to the following limitations:

1. The study is limited to randomly selected classes of 16 teachers who participated in a training program for the implementation of the new IYE module, and who likewise use one of the BSCS Biological Science textbook versions, or who use the BSCS teaching philosophy with Modern Biology (Otto and Towle, 1973) concurrently in other biology classes. Four of the 16 participating BSCS teachers are in schools that adopted class sets of Modern Biology, but who, nonetheless are process oriented teachers committed to
the BSCS pedagogical rationale, and who use the inquiry approach in their teaching methodology.

2. The study is further limited to one randomly selected experimental class of high school students using IYE per teacher in each of the test sites in the school year of 1974-1975, and to one randomly selected control class of students using one of the BSCS high school textbook versions or Modern Biology per teacher in each of the test sites in the school year of 1974-1975.

3. The study is limited to discerning measurable outcomes related to the basic philosophy and fundamental goals of BSCS instructional materials with the treatment groups as determined by a posttest, ATES. This instrument is designed to assess attitudes on six sub-scales in the areas of Future Orientation, Learning How to Learn, Self Responsibility, Learning as Process, Learning as Knowing Facts, and Relevance of School.

4. The study is limited to a posttest comparison of experimental and control groups in ability to think critically as measured by the CCTT, Level X. This instrument is designed to assess operations in the cognitive domain on four sub-scales:
   a. Induction: evaluating evidence for and against hypotheses,
   b. Reliability: evaluating the reliability of information,
   c. Deduction: demonstrating logical reasoning ability, and
   d. Assumption finding: showing recognition of assumptions.
5. The study is limited to a posttest comparison of experimental and control groups in the BSBI which is designed to assess operations in the affective domain on four sub-scales: curiosity, openness, satisfaction, and responsibility.

Delimitations

The following delimitations further determine the parameters of this investigation:

1. No inferences are made regarding teachers' ability to motivate students.
2. No attempt is made to equate teachers' ability to implement the philosophy of BSCS programs and the success of students in achieving the goals and objectives of the respective instructional programs.
3. No attempt is made to match students in experimental and control groups according to ethnic origin or social and economic background.

Design of the Study

The study included 16 secondary biology teachers in high schools throughout the United States each of whom taught a minimum of one biology class using the IYE module, and one or more structured biology classes which was either a BSCS Biological Science textbook
version, or *Modern Biology* by Otto and Towle. The instructional programs were tested during the spring term of 1975.

The 16 randomly selected classes using IYE constituted one experimental factor in the research study. Sixteen randomly selected classes using a more structured biology program constituted the second, or control factor.

The treatment variables were the following three test instruments:

1. The ATES (Steele, 1969a),
2. The CCTT, Level X (Ennis and Millman, 1971b), and
3. The BSBI (Steiner and Lee, 1970a).

The students in the IYE program for nine weeks worked on independent research investigations of their own choosing based upon what they identified as most important to them at the time. The students in the more structured biology program continued their studies using one of the BSCS secondary versions or *Modern Biology* as the basic reference source, with no change in the instructional mode.

The experimental design selected for the study was that of Campbell and Stanley's (1963, p. 25) Posttest-Only, using analysis of variance for the statistical treatment of the data. Covariance analysis was accomplished by using the *Comprehensive Test of Basic Skills* (1971) with reading, language and arithmetic as the covariants.
Organization of the Remainder of the Study

The remainder of this study is separated into four chapters. Chapter II presents a review of the literature related to goals of science education particularly in the next decade. It explores various teaching methodologies that purport to implement current science educational goals, and presents a brief survey of selected studies conducted to test specific methodologies. It examines current theories pertaining to attitudes toward education, critical thinking ability, and the place of creativity in cognitive and affective development of learners. It reviews some new instruments for assessing cognitive and affective development. Finally, it reflects upon contemporary views related to the educational implications of the convergence of human value systems and social responsibility now and in the future.

Chapter III describes in detail the procedure used in the study. It includes a description of the research population, methods of random sampling, the instruments used in the study, and the experimental design.

An analysis of the data is reported in Chapter IV indicating the results of the hypotheses tested.

The final chapter contains a summary, conclusions, and recommendations for further study.
II. REVIEW OF RELATED LITERATURE

Chapter II is organized into the following sections: (1) The Goals of Science Education Particularly in the Next Decade, (2) Teaching Methodologies that Purport to Implement the Goals of Science Education, (3) A Survey of Selected Studies to Test Specific Methodologies, (4) Current Theories Pertaining to: Attitudes Toward Education, Critical Thinking Ability, and the Place of Creativity in Cognitive and Affective Development; (5) Some New Instruments for Assessing Cognitive and Affective Performance Levels, (6) Contemporary Views Related to the Educational Implications of Values and Social Responsibility, and (7) Summary.

Goals of Science Education in the Next Decade

The National Science Teachers Association in November of 1971 published a position statement (NSTA, 1971) in which the goals of science education for the 70s endorsed by the association were presented. The statement reads (p. 47):

The major goal of science education is to develop scientifically literate and personally concerned individuals with a high competence for rational thought and action. This choice of goals is based on the belief that achieving scientific literacy involves the development of attitudes, process skills, and concepts necessary to meet the more general goals of all education.

In writing about the changing curriculum patterns in science,
mathematics and social studies, David Ost (1975) points out that:

The pressure is ever increasing to prepare a public which is literate in the interactions of the science-technology-society complex. This is in spite of reactionary activities pressing for skill development, short range limited objectives, and job orientation (p. 48).

Prompted by extensive changes in secondary science curricula since 1960, the American Association for the Advancement of Science (AAAS) has played an active role during the past ten years in the development of guidelines for the preparation of science teachers that would encompass timely goals of science education. Members of the Commission on Science Education, a committee of the AAAS charged with the responsibility of examining new science programs, and commissioned to revise the 1961 guidelines for the education of science teachers, report (AAAS 1971, p. 1):

New directions for science education for the 1970's are already widely debated in the professional literature, the public press, and in the journals representing academic disciplines. There is consensus that the schools must keep pace with cultural change, and that a mismatch may now exist between science and mathematics education and the condition of society. This condition demands that teacher education institutions examine the degree to which their programs reflect progress in science, in new emphases in education, and changes in society.

Paul deHard Hurd (1973) notes that there is growing conviction on the part of the American public that science programs of the 60s are inadequate for the 70s. Hurd states (1973, p. 18):

Profound changes in society and increased dissonance in American culture; public disenchantment with science and
suspicion of technology--these factors, combined with a prevailing lack of confidence in schools, signify the end of an educational era. Discipline-centered science curricula developed during the 1960's are being assessed as inappropriate for the 1970's and 1980's. The specialization reflected in conventional science courses not only limits an understanding of modern science but also the resolution of problems besetting society. A search is on for a higher order curriculum for science education, one which reflects the current challenges to science and technology and is more sensitive to mankind's present and future condition.

Writing about educational goals for the seventies, Albert Baez (1973, p. 1) states:

... science and technology have been called the most powerful forces for social change that have ever existed in the history of man. They have affected every aspect of our lives. For that reason, their importance must be appreciated by all people of the future, not just by the future scientists and technologists. That presents a special challenge to education, namely, the creation of a new generation of people who will understand the power, the responsibility, and the limitations of science.

The concerns expressed by Ost (1975), Hurd (1973), and Baez (1973), are mirrored in the science objectives developed by the NSTA (1971) and the science education goals developed by the AAAS (1971). These guidelines are intended to assist educators in the reassessment of existing science programs, and to provide direction for further innovation. The magnitude of such an endeavor is reflected in the introduction to the Science Framework for California Public Schools (1970, p. 1):

The original intent was to update the subject matter of the curriculum to bring it in line with contemporary thinking
on science, particularly with reference to modern theories, laws, and systems of ideas. But some scientists and educators saw the need to redirect the goals for teaching science as well as to reorganize the courses. They would have science taught for the contribution it makes to intellectual development. To accomplish this purpose, the development of inquiry processes was identified as a major purpose of science instruction. The scientists and educators also recognized the overload of factual information in science courses, and they selected the content for the new courses in terms of a limited number of fundamental concepts and basic theories.

Burkman (1972) writes that the 1960s were characterized as a decade of revolutionary and for the most part beneficial changes in the teaching of science, but that the programs which emerged are seriously limited in terms of meeting educational needs now. In the 1970s Burkman feels there is "... an urgent need for... an alternative form of science teaching... radically different in content and style" (1972, p. 42).

In a report on procedures for developing revised science objectives for the National Assessment of Educational Progress, Voss and Barnes (1972, p. 3) quote Tyler and Merwin:

A comprehensive program in science education must consider two unequal groups of students, those who may eventually pursue scientific careers, and the great majority of those who will not... In a free society it is the citizens from all walks of life who make the public decisions, and as we proceed in a technological age more of these decisions can be intelligently made only with the knowledge of the scientific considerations which bear upon them.

The revised science objectives delineated in the National Assessment of Educational Progress are intended to reflect the observations
of Tyler and Merwin, and are expressed in terms of three basic outcomes to be achieved by learners in any science program. As stated by Voss and Barnes (1972, p. 8), these science objectives are:

I. Know the fundamental aspects of science.

II. Understand and apply the fundamental aspects of science in a wide range of problem situations.

III. Appreciate the knowledge and processes of science, the consequences and limitations of science, and the personal and social relevance of science and technology in our society.

The objectives are broad and sweeping. How they are to be implemented most effectively at the elementary, secondary, and post secondary levels becomes the herculean task of the science educators.

The curriculum reform of the 1960s might be considered Phase I of a continuing effort to sharpen science education in an attempt to keep the teaching of science close to the cutting edge of knowledge explosion and cultural change. The mood in which science operates is changing. The California State Advisory Committee on Science Education (Science Framework, 1970, p. 13) writes:

The investigative procedures of science and the applications of the knowledge generated by these procedures have become major forces in shaping the modern world. Science is now broadly integrated into all of life, its intellectual as well as its humane phases. In America today, one is likely to become a stranger to his own culture if he lacks an understanding of the influence of the scientific enterprise upon his life.

This calls for teachers of science dedicated to the development of citizens who have an understanding of science that is reflected in
their own lives by critical observations, careful analysis, rational deliberation, and responsible choices in decision making.

The period from 1960 to 1970 saw major reforms in the teaching of science which necessitate the need for on-going refinement in science teaching methodology. In describing goals of science education in the next 25 years, the Advisory Committee on Science Education (Science Framework, 1971, p. 78) comment:

The period from 1970 to the year 2000 will be a time for further examination of the science curriculum. The cultural implications of science have not as yet been written into courses. One aim of science learning is the contribution it can make to the intellectual use of leisure; another is the application of scientific knowledge to humane ends. Neither of these goals was emphasized in the reform movement of the 1960s. For the most part, the subject matter of conventional science courses has been selected for its classical rather than its social values. Students learn the science of historical significance rather than the science useful for resolving contemporary social problems, such as pollution, inadequacy of world food resources, and over-population. And there are other problems, which have too often been suppressed in science courses, that have been brought about by the application of science to technological ends. There is also little emphasis on the aesthetic and philosophical aspects of science. A general education in science exists only in a social context, and its goal is to improve the welfare of mankind. The social, economic, and political interrelationships of the scientific enterprise are of increasing importance for designing the future we want in America. The reform movement during the 1960s was directed to modernizing the content of science courses; for the next decade the task is one of making it relevant to human needs.

Schwab (1969) suggests that one essential ingredient to activating the kind of change in science education goals expressed in the Science
Framework is to emphasize more and more the advantages of self-education, not only for teachers, but for students as well. Schwab (1969, p. 347) offers two reasons for this suggestion:

First, self-instruction is the only practical solution to the problem of "coverage". I now suggest that a substantial part of "coverage" be "covered" by the student on his own. . . . Second, self-instruction skill is of great post-school value.

Elsewhere Schwab writes (1960, p. 9):

If a student is to keep rapport with the changing face of science when he is no longer a student, he must be freed as far as possible from the need for schools and schooling. He needs to develop the competencies and the habits to read and learn for himself.

And in the same vein, Stotler (1970, p. 17) points out:

. . . by the time the 21st century begins, all observers must be provided continuous, convenient lifelong opportunities to self-educate and increase in productivity—all this while being a mobile part of a highly mobile population.

At the annual meeting of the American Association for the Advancement of Science in San Francisco in March of 1974, several probing addresses focused on challenges for science education in the 1970s. Among the presentations was an address given by Phillips (1974) in which he says:

As we move into the 1970's, curriculum developers, scientists, and science educators and, indeed, the lay person, are questioning some of the emphases of science education in the 1960's. . . . We are concerned not only with the advancement of technology but also with the assessment of technology; we are concerned not only with increasing the body of scientific knowledge, but also with the application
of science and technology to societal problems. The science curriculum projects of the 1970's must reflect these additional concerns (p. 1).

Phillips reminds us that advancements in science and technology have helped to contribute to the evolution of societal problems today, which in turn offers a challenge to science educators to help society learn how to cope with these complex problems.

Zoller and Watson (1974), in discussing teacher training in the next decade reiterate the importance of preparing novice teachers to become adept in designing and using curricula that deal "... with science-based social problems and the interaction of science-technology-society ..." (p. 94).

In conclusion, the goals of science education presented here are trend setters. The objectives of new science curricula in the 70s reflect these trends, by way of no single path. Teachers engaged in implementing the new science programs need to view themselves as on-going learners of science, and persistent explorers of effective teaching practices. In the words of Andersen and Koutnik (1972, p. 232):

... the teacher must continue studying science and teaching as long as he remains in the classroom. Without continuous study the teacher is doomed to gain but one year of experience twenty times rather than gaining twenty full years of experience.

Ericksen (1974) directs a colorful and enlightening chapter to the "apprentice teacher" in which he discusses the need for continuous
learning, and emphasizes the importance of generating:

... teachers who present the intrinsic challenge of learning as the major motivating influence in the academic lives of students; teachers who like ideas and students more than they like "teaching"; teachers who have a deep and pervasive identification with their discipline and the curiosity to know more, and who share these qualities openly and generously with their students (p. 244).

It is in such a fertile environment that the goals of science education most readily may come to fruition, aided by effective, multi-form, teaching and learning methodologies.

**Goal Directed Teaching Methodologies**

Science educators are responding courageously to the clarion note of urgency for a revolution in science teaching methods. Howard Birnie (1975) draws an analogy between Kuhn's revolutions in science (Kuhn 1962) and revolutions in science teaching by stating (p. 13):

My position is that a revolution in science teaching in the Kuhnian sense, began in the middle 1950s. The present status of the revolution is not clear. We may already have replaced one paradigm in which the student was essentially passive with another in which the student is essentially active—or we may be in the pre-paradigm stage of selecting from competing models of science education. I believe that we are in the "extraordinary" stage of selecting new models, and that the most likely candidates are models whose roots are firmly based in corresponding psychological models. Furthermore, I believe that a paradigm built around science education as serving vocational interests (vocational paradigm) was replaced in the early 60s by a discovery paradigm, which is currently in competition with a humanistic paradigm.
Katz (1971) maintains, "We are today experiencing the third major movement for urban educational reform in American history" (p. 342).

Charles Reich (1971) predicts a revolution coming that will not be like revolutions of the past.

It will originate with the individual and with culture, and it will change the political structure only as its final act... It promises a higher reason, a more human community, and a new and enduring wholeness and beauty—a renewed relationship of man to himself, to other men, to society, to nature, and to the land. This is the revolution of the new generation (p. 2).

Victor Ferkiss (1969) speaks of an existential revolution evolving wherein:

Mankind, it is alleged by the prophets of the new man, is on the threshold of a new age. He has, so they tell us, within or almost within his grasp new powers over himself and his environment that will radically transform the whole character and meaning of human existence (p. 92).

It appears that science instruction is in a period of transition, a time of searching for a way to actualize the humanistic paradigm described by Birnie (1975), and cherished by the late Abraham Maslow (1970b).

Carl Rogers (1969) professes similar views as those of Maslow concerning the importance of humanistic psychology and its place in education.

Evans (1973) maintains any meaningful approach to learning needs to be based on humanistic developmental factors.
In his book entitled *A Humanistic Curriculum*, Duane Manning (1971) identifies factors that have special priority in humanistic education. He suggests, "First-level priority would be accorded those learnings which make the greatest contribution to the well-being of the individual and society" (p. 35).

Science educators are exploring hitherto untried ways to coalesce man's relationship to his creator, to himself, to society, and to nature. Kuhn (1962) offers reassuring advice for those who are caught up in the transition from a paradigm in crisis to a new one.

During the transition period there will be a large but never complete overlap between the problems that can be solved by the old and by the new paradigm. But there will also be a decisive difference in the modes of solution. When the transition is complete, the profession will have changed its view of the field, its methods, and its goals (p. 84).

The problem, then, is to synthesize methods for achieving goals in science education that produce those desired criterion behaviors in students which are identified by leaders in the field of learning theory. Klopfer (1971) views this as a "two-edged sword" controversy, in that changing a methodology is ineffective without the freedom to alter the environment (classroom) where instruction is carried out. Klopfer asserts:

As education plunges into the decade of the 1970's, probably the most serious problem of evaluation in science is the disparity between the methods and techniques which are available to the science teacher and what generally happens in the science classroom (1971, p. 637).
Nonetheless, science educators are making a valiant effort to foster meaningful change. Some of the specific approaches to teaching and learning that are being explored include the following.

**Individualized Approach**

A number of educators are investigating and testing variations of individualized, self-paced modes of instruction. Ericksen (1974) promotes the concept of self-instruction and self-paced learning.

Quoting Professor Fred S. Keller, the author of the widely used Keller Plan, Ericksen (1974) captures the enthusiasm of the retired Columbia University Professor:

The world is going to see an enormous change in its techniques of education within the coming years, within the coming decade even. . . . This change will, I think, eventually maximize the pleasure of scholarly endeavor and occupational training, also increase the respect of everyone for such endeavors. . . . In our educational institutions, it will involve less emphasis on rigid time requirements and more attention to the individual, greater opportunity for success but with nothing provided gratis, more privacy for the person and less invidious comparison with others, less competition and more cooperation with others, and a greater respect for human dignity than has ever been shown before in large-scale education (p. 112).

Ericksen (1974) personally favors individuating instruction and states, "... the self-paced arrangement gives the student more freedom and dignity. He becomes a self-managing student rather than an echo of the teacher and the text" (p. 112).
Streubel and colleagues (1974) have experienced success with mini-courses in biology for non-science majors that are self-contained, single concept units.

Humphreys (1972) associates individualized instruction with improved self-image and academic achievement.

Kline (1971) reports similar experiences in a study comparing self-directed and teacher-oriented eighth grade students involved in an open-ended Earth Science Curriculum Project (ESCP) laboratory block.

Goar (1972) distinguishes four types of individualization which are meant to be selected according to the intellectual development of the student.

Clarizio (1971) stresses that "Students should be permitted as much self-direction as they are capable of handling" (p. 154). He adds:

Mature self-direction does not arise without opportunities to develop it. Thus the teacher's role at times may consist in informing the student as to possible outcomes of a given behavior, and then in assuming the role of an interested bystander who allows students to experience the natural consequences (favorable as well as unfavorable) of his actions.

Mayhew (1971) assumes a more reserved stance after reviewing the McKeachie (1971) reports on individualized instruction research studies. Mayhew summarizes, "At present there are not good
criteria for selecting those fields in which independent study is or is not appropriate" (p. 30).

**Integrated Approach**


Dennis Chisman (1973) explains his understanding of the nature of integrated science in the following statement:

Integrated science teaching can be said to cover all those approaches to science teaching (a) in which concepts and principles are presented in such a way as to express the fundamental unity of scientific thought, (b) which emphasize the processes and methodology of the scientific outlook, and (c) which embody a scientific study of the environment and the technological requirements of everyday life (p. 20).

Munn (1973) describes the **Science Foundations** course in the British system as integrated and multidisciplinary in nature. He writes:

It is hoped the injection of this novel idea into the mainstream of educational thought by an academically conservative country will force us all to reappraise our current approaches to science teaching at all levels (p. 28).
Haddad (1974) states that the interaction of science and society is increasing both in degree and scope.

Writing about the natural harmony of integrated science and social science, Romey (1973) reflects, "I see no reason why we should not move toward a totally integrated school experience" (p. 30).

Gennaro and Glenn (1975) recognizing the interdependence of science and social concerns, advocate a closer collaboration of science with social studies, and recommend:

To meet the challenges of a modern curriculum, science and social studies teachers must begin to work more closely together in those areas in which cross-disciplinary materials and instructional activities may be developed. Such exchanges are not only possible but also beneficial to both groups (p. 92).

Marjorie Gardner (1973) suggests a way to integrate the sciences effectively is to use modules, such as the Interdisciplinary Approaches to Chemistry (IAC), which combine two or more sciences in each microcourse.

Hayward (1973) compares integrated science to the "untidy field". He points out that most subject matter courses are individually compartmentalized in "neat and tidy" packages, but when the student gets out of school:

The rest of his life he will be required to consider problems that weren't in the book, to phrase questions that haven't been asked, to identify as problems situations which were never so recognized before. . . . The fact is that science outside the classroom is integrated science. It deals largely with real problems. It isn't "neat and tidy" (p. 32).
Eclectic Approach

Other forward looking educators including Fox (1965), Gagné (1966), Rogers (1969), Maslow (1966a), Zahorik and Brubaker (1972), Bingman (1969), Lawson and Renner (1975), take a more eclectic position. They contend that students vary among themselves in ability to adapt to learning situations.

Norris (1975) observes that individuals all through life are on different cognitive levels, and therefore, conceptualization occurs differently for each. He explains that "... each level of conceptual complexity has a teaching approach appropriate for it" (p. 296). In describing the intellectual differences among students, and the implications this has upon teaching methodologies utilized, Norris (1975) quotes Sieben and Basso (1973):

Although it would be desirable to have impulsive or memory oriented students become more capable of independent abstract thought and self-reinforcement, the sudden placement of these students in an unstructured classroom situation invariably causes them to become frustrated, insecure, less ambitious, and more unhappy than in the more structured teacher-centered classrooms (p. 295).

Barnett (1974) recommends that appropriate teaching strategies ought to be based on the cognitive style of the students.

Writing about alternatives to individualized biology, Walters and Sieben (1974) state that on the basis of current evidence, it seems safe to conclude that some students (analytical or field independent) thrive
in self-directed study, while others (global or field dependent) are threatened by the instrucctured environment. Walters and Sieben (1974) further observe:

... the literature suggests that global children would experience difficulty in unstructured learning situations (p. 66).

Zoller and Watson (1974) likewise feel that emphasis needs to be placed by educators on studying the student to discover his intellectual and emotional capabilities. Only then can the maturing person be wisely channeled into the instructional program style which will assist him in achieving to his full potential.

In carrying out this role of program guide, the teacher is intent on facilitating internal motivation in the learner. Wallen and Travers (1963) believe:

Motivation energizes action and also gives direction to action. Many who have studied the problems of effective teaching hold that the main function of the teacher is to arrange conditions so that the pupil directs his energies toward worth-while goals (p. 495).

Bernard and Huckins (1974) in Humanism in the Classroom: An Eclectic Approach to Teaching and Learning, discuss how teachers can establish humanistic goals for themselves, and develop independent, self-directed learning experiences for students by means of personally programmed learning modules.

Burkman (1972) prescribes revamping the one-year science courses and introducing transdisciplinary topics. He states, "A
flexible three-year program composed of distinct one- to three-week program units would appear to have many advantages" (p. 43).

Samples (1974) in Toward the Synergic School Room opts for differentiated learning through "access" teaching rather than "process" teaching, stating that emphasis in teaching/learning situations should be placed on "access" as opposed to "delivery" modes, which enhances an attitude toward access to and seeking of content, instead of delivery of and responding to content.

In conclusion, regardless of whether the style of teaching/learning is individualized, integrated, eclectic, process, or access, one pervasive thread appears throughout: curriculum does not exist in a vacuum. There is a world existing out there beyond the school that approximately 40 million children who are age twelve and younger in 1975 (Shane and Shane, 1974) will be stewards of in the year 2000. In the words of McDaniel (1974):

If we have a concern for social reality, we must link the instructional program of the school to the instructional program implicit in the culture (p. 109).

The vehicles educators use to consummate the union of learning and living no doubt will continue to undergo substantial over-hauling. Wren-Lewis (1974), in Educating Scientists for Tomorrow, shares his own thinking on this subject:

I would hazard a personal speculation here that we are heading for a time, not far hence, when science in many areas will undergo dramatic changes in its ways of thinking, leading to fresh ideas about the world, and whole new areas of human activity, undreamed of in most of our present philosophies (p. 166).
Science educators who have a concern for preparing learners to deal constructively with social reality will continue designing and experimenting with a "modus operandi" for teaching to assist in achieving a more desirable "modus vivendi" for society.

**Selected Methodology Studies**

A number of science educators are fully aware of the expectations of the public today for evaluative research to determine to what extent both current and new programs are meeting the challenges of a world caught up in accelerative thrust. Names that appear and reappear in the literature include Mayer (1967, 1975), Walberg and Andersen (1968), Welch and Pella (1968), Mayhew (1971), Steele et al. (1971), Hunter (1974), Howey (1975), Marek (1975), among others. To this point Suchman (1967) writes:

> There comes a time . . . when there is likely to be a demand for careful appraisals of old and new programs--research studies designed to test the relative worth of the longstanding, established activities as compared to the new or proposed programs (p. 5).

Several research studies pertinent to evaluating the efficacy of teaching methodologies and new instructional materials have been reported in the literature.

**Inquiry Role Approach**

The Inquiry Role Approach (or IRA) refers to a biology program
in which each student has a distinct role and responsibility as a member of a team of four working together to achieve inquiry skills, attitudinal qualities, and communicative skills. Students learn and use these skills with the IRA Inquiry Guide and the LEIB (Laboratory Explorations in Biology). Student role assignments include discussion coordinator, technical advisor, data organizer, and process advisor.

Each team chooses its own problem to study, formulates the hypotheses, and plans an experiment to test the hypotheses. The team researches related literature concerning the problem selected, interprets the data, and applies the findings where appropriate to human life situations.

Seymour and associates (1974) compared inquiry methodology between IRA classes and non-IRA classes in cognitive inquiry and associated attitudes. Reporting in the American Biology Teacher, Seymour et al. (1974) state:

The IRA methodology is based on the premise that biology content, understanding, inquiry skills, social skills, and attitudes are interdependent and can be achieved best in a program that integrates them (p. 349).

The design of the study was a posttest-only, comparing IRA classes to non-IRA classes on several measures. Three instruments were used:

1. Views and Preferences of Students (V-P), which measured social
operation, cognitive operations, and teacher practices;

2. **Biology Students Behavioral Inventory (BSBI)**, which measured four specific attitudes: curiosity, openness, satisfaction, and responsibility;


   Basically, the researchers raised four questions:

1. Can students develop inquiry skills;

2. How does development in the inquiry-oriented classes compare with the non-IRA classes;

3. Do students prefer settings in which inquiry is emphasized; and

4. Can teachers learn and implement the new methodology in a manner to attain the intended outcomes?

The findings showed considerable differences between the two groups, with the IRA classes excelling in the performances tested.

Bingman and Koutnik (1970) explain that the IRA program goals emphasize acquiring cognitive skills, social interaction skills, and attitudes consistent with cognitive inquiry. The materials are meant to complement, not supplement or substitute for a biology text.

The IRA inquiry methodology has also been reported in the literature by John Anderson et al. (1969), Bingman (1969), Koos (1969), Lee and Steiner (1970), Andersen et al. (1971), and Marek and Renner (1975).
Other Investigations

Howe (1964) investigated the relationship of five learning outcomes to selected teaching methods in secondary biology classes. The objectives were to determine to what extent students demonstrate increased knowledge of basic science concepts, ability to think critically, and show evidence of favorable attitudes toward science. Students were asked to identify, through pre and post performance on five test instruments, the two methods that helped them most to achieve the objectives. The methods to be rated were: recitation from assignments, assigned discussion topics, lecture-demonstration combination, demonstration-discussion combination, lecture, laboratory, laboratory-discussion combination, project, or other. Outcomes of the investigation showed that (1) greater student involvement in classes facilitate learning and the ability to think critically, and (2) attitudes toward science tend to appear more favorable with increased intelligence.

Another investigation of the relative merits of three teaching methods in biology classes was carried out by Oliver (1961) in which he compared (1) the difference in mean achievement of classes exposed to lecture-discussion, (2) lecture-discussion plus demonstration, and (3) lecture-discussion plus demonstration and laboratory exercises. Criteria for judging effectiveness of the three teaching methods were
changes in attitudes, and cognitive achievement as measured on the Nelson Biology Test and the Indiana High School Biology Test. The findings showed that the different teaching methods examined did not affect student attitudes toward science nor cognitive achievement in any appreciable way.

In conclusion, clear cut, unequivocal directions do not seem to be offered in the research conducted on pedagogical studies, but one thing is certain. The teaching/learning process should continue, with the teacher more as a diagnostician and interactive participant than formerly. Methodologies will continue to be designed and tested. And in a seminal little book, Toward More Humanistic Instruction, Zahorik and Brubaker (1972) suggest that "Homo esperans" (the hoping man) look forward to better times.

Ginsburg and Opper (1969) offer wise advice for educators who are looking forward to better times. Quoting Piaget, the authors write:

The principal goal of education is to create men who are capable of doing new things, not simply of repeating what other generations have done--men who are creative, inventive, and discoverers. The second goal of education is to form minds which can be critical, can verify, and not accept everything they are offered (p. 232).

Current Theories Pertaining to Attitude Formation

The literature abounds in studies related to attitudinal research. Among the pioneers who led in attitude measurement studies in the
thirties are the familiar names of Likert (1932) and Allport (1935). Kutner et al. (1952), Coombs (1953), and Katz and Stotland (1959) were among the leaders in the fifties. They were followed in the sixties by a vast array of researchers in the field, among them Doob (1960), Maslow (1962), Bloom (1963), Gallagher and Jenne (1963), Stern (1963), Cook and Selltiz (1964), Newcomb (1964), Deutscher (1965), Lowery (1965), Raths et al. (1966), Wallace (1966, 1967), Roos (1968), and McGuire (1969).

Walberg and Anderson (1968) conducted a study on the theory of the classroom as a social system. Eighteen subscores on student perceptions of classroom climate were obtained from 76 classrooms throughout the United States, and were used to predict nine cognitive, affective, and attitudinal measures of learning at the end of the school year. More than four times as many correlations as the chance expectancy were significant at the .05 level.

In the seventies Bloom et al. (1971) continued researching the interplay of attitudes and values. Another research study conducted by Bloom (1973) focuses on the association of learning with attitude toward subject matter.

Scales for attitude measurement were designed and tested by Bohrnstedt (1970), Osgood et al. (1970), Seiler and Hough (1970), Sherif (1970) and Lemon (1973). A study on measuring attitudes toward school was investigated by Ballard (1973). Three approaches
to attitude development was researched by Leventhal (1974), and four different attitude scales to measure attitudes toward environmental problems were described by Weigel et al. (1974).

Researchers who have conducted studies on measuring scientific attitudes include Moore and Sutman (1970), Bruvold (1974), Ayers (1975), and Billeh and Zakhariades (1975).

Two German writers, Hartman and Wakehut (1974), writing in Zeitschrift fur Sozial Psychologie, criticized the alleged shortcomings of traditional attitude measurement instruments.

Johnson and Ryan (1974) compared the effects of different teaching situations on the attitudes of sixth grade pupils toward science. The methodologies tested were: (1) textbook approach without laboratory activities, (2) combination textbook and laboratory approach, and (3) activity centered, inquiry situation. In terms of the development of positive attitudes, the study indicated that students engaged in more active enterprises in the classroom developed significantly more positive attitudes toward science. This finding supports the views of Moore and Sutman (1970), and Summers (1970).

In Motivation for Learning, Ericksen (1974) lists seven discerning assumptions that he adapted from Carl Rogers (1969), and which are appropriate to any consideration of theories pertaining to attitude formation.
1. Human beings have a natural potential for learning.

2. Significant learning takes place when the subject matter is perceived by the student as having relevance for his own purposes.

3. Much significant learning is acquired through doing.

4. Learning is facilitated when the student participates responsibly in the learning process.

5. Self-initiated learning, involving the whole person of the learner—feelings as well as intellect—is the most pervasive and lasting.

6. Creativity in learning is best facilitated when self-criticism and self-evaluation are primary, and evaluation by others is of secondary importance.

7. The most socially useful learning in the modern world is the learning of the process of learning, a continuing openness to experience, an incorporation into oneself of the process of change (p. 73-74).

In conclusion, if instruction is properly concerned with creating for the learner an environment in which he can respond as a total person (Ekistics, 1973, p. 50), the importance of appropriate methodology is brought rather forcibly home. By concentrating on effective teaching methods, perhaps favorable attitudes toward learning will take care of themselves.

Current Theories Pertaining to Critical Thinking

Critical thinking is a product of the cognitive domain. Prominent among educators in the recent past who have contributed appreciably to current theories regarding thought processes and critical thinking are Gardner (1953), Inhelder and Piaget (1958), Piaget (1960,

Some of the pertinent critical thinking studies include that of Follman (1969), who researched the dimensions of critical thinking through factor analysis of three purported critical thinking tests: the Watson-Glaser Critical Thinking Appraisal, Form ZM; A Test of Critical Thinking, Form G; and the Cornell Critical Thinking Test, Form Z. Based on his research Follman concluded that critical thinking is not a general ability but rather a composite of specific factors, such as recognition of assumptions, and judgments if conclusions follow logically from assumptions.

In a study on discriminant analysis of school children in integrated and non-integrated schools using tests of critical thinking, Miller et al. (1970) administered the Watson-Glaser Critical Thinking Test and the Cornell Critical Thinking Test to 811 children in four
integrated, four black, and four white schools. Discriminant analysis of scores obtained on the nine subtests of the critical thinking tests yielded significant discrimination among the three groups. The results suggest that critical thinking tests, like achievement tests, are useful for determining educational strengths and weaknesses.

In a research study correlating critical reading with critical thinking, Follman and Lowe (1975) found that critical reading and critical thinking have little or no unique variance and can be accounted for almost entirely by language ability. The authors conducted two parallel series of three sets of statistical analyses of critical reading and critical thinking, one with fifth and one with twelfth grade students. The overall objective was to obtain empirical evidence from analyses of the test scores, from which inferences could be made about the relationships of critical reading, critical thinking, and scholastic aptitude and achievement. Two critical reading tests were used: the Intermediate Reading Test-Science (Maney, 1952), and the Intermediate Reading Test-Social Studies (Socher, 1952). One critical thinking test was used, the Cornell Critical Thinking Test, Form X (Ennis and Millman, 1961). For covariance analysis a scholastic aptitude test, the California Test of Mental Maturity, Level 2, Short Form (California Test Bureau, 1964) was used; and an achievement test, Metropolitan Achievement Test Intermediate Level, Form Am (Durost, et al., 1959).
For the fifth grade sample population the conclusion reached by the investigators was that:

... critical reading consists of a number of language, reading, and thinking activities, particularly vocabulary and various critical reading and critical thinking activities (p. 5).

Regarding the twelfth grade sample population, the investigators report:

It was concluded that critical reading overlaps substantially with language, reading, and thinking activities particularly vocabulary and also with some critical thinking activities. The critical reading-critical thinking overlap over the two grade levels represents interpretation of information, relation of evidence to conclusions, and validity of conclusions (p. 7).

The fifth grade sample consisted of 58 pupils at Ballast Point Elementary School in Tampa, Florida. The twelfth grade sample consisted of 57 students from Robinson High School in Tampa. The authors report that conclusions are only tentative because of the small sample size used in the study.

Kastrinos (1961), Sorenson (1966), and Brown (1967) in separate studies relating the development of critical thinking to methods of instruction seem to support the theory of Scriven (1960) that transfer training in critical thinking is hard to assess because of the difficulty in constructing valid experimental designs to test the effect of methodology on critical thinking ability.

In a study of the relationships among teacher behavior,
creativity, and critical thinking ability in a speech communication
course, Moore (1973) used Flanders Interaction Analysis System to
identify modes of teacher behavior. The Watson-Glaser Critical
Thinking Test was used to measure critical thinking ability. Creativ-
ity was assessed by a battery of four selected creativity tests designed
to measure sensitivity to problems, spontaneous flexibility, semantic
redefinition, and originality. The analysis of the data revealed a
general negative relationship between behavior and creativity. The
only positive relationship between behavior and critical thinking was
in the subtest, recognition of assumptions. On the basis of the find-
ings, the major conclusion reached by Moore was that academic pre-
paration had greater influence on behavior than cognitive ability.

Raven and Polanski (1974) constructed a Science Content Com-
prehension Test using Piaget's (1964) logical operations model to test
relationships among science content comprehension, critical thinking,
and creativity. The findings of the study strongly support the validity
and usefulness of the instrument for the purpose it was designed.

In conclusion, although many of the researchers in cognitive
studies are examining all aspects of "knowing" as it relates to the total
human person, Samples (1975) is of the opinion that proportionately
the greatest emphasis in education today continues to favor cognitive
development. In referring to new theories pertaining to the relation-
ship of the hemispheres of the brain to critical thinking and problem
solving ability, Samples (1975) suggests that totally new teaching techniques are needed in order to educate for both sides of the human mind. Regarding this phenomena, Samples notes:

There are two minds in our brain. One is rational-linear and logical in function, and the other is metaphoric-intuitive and analogic. . . . The right cerebral hemisphere is the metaphoric-intuitive hemisphere. It performs analogic functions and tumbles through myriads of data simultaneously. The left cerebral hemisphere is far more constrained, and it sifts through inputs and reduces functions to logical-rational form and acts more like a digital computer. . . . Education in general and science education in particular are highly biased toward the left cerebral functioning (p. 21).

Without a doubt, serious study and reflection is called for. Current modes of teaching are "sous feu". In a discussion of Piagetian theory as applied to biology teaching, Lawson and Renner (1974, p. 558) express serious concern that over half the tenth grade students in the nation are concrete operational while a significant amount of the subject matter, particularly in science, is formal operational.

The Honorable Shirley Chisholm (1973), speaking at the National Science Teachers Association convention in Detroit, said, "The student brings to the classroom his entire person. Let us, then, educate the whole of it" (p. 24). That is what teaching is all about.
Research studies on creativity as an adjunct of critical thinking have been conducted by numerous educators in recent years. Korb (1973) investigated aptitudes, cognitive styles and personality characteristics as facilitators and differentiators of creativity in four disciplines: art, writing, mathematics, and music. The primary purpose was to determine if creativity in different disciplines was a function of differential or of generalized cognitive ability. The sample population consisted of 146 upper division students majoring in one of the four disciplines selected. A battery of creative ability tests were administered and statistically analyzed. The findings of the study supported the theory that individuals have specifically different cognitive aptitudes, and that personality traits are differentiators as well as facilitators of creativity.

In a study conducted to test a proposition from Roger's (1962) theory on the fully functioning person, Koenig (1973) showed that the creative thinking domain encompasses cognitive, affective, and socio-cultural domains. His study supported Roger's theory that a fully functioning person is, indeed, creative.

Brown (1973) linked affective process development with creative thinking in a study of the Science Curriculum Improvement Study (SCIS). The investigator compared the performance of students in
conventional science curricula for six years with students involved with the SCIS materials for six years, using the Scientific Curiosity Inventory, the Scale of Attitudes Towards Science and Scientists, and the Torrance Tests of Creative Thinking. Statistically significant differences in favor of the SCIS group were found at the .01 level of confidence for scientific curiosity, scientific attitude, and creative thinking.

An individual testing approach to assess creative abilities was designed and tested by Risser (1966).

Ogletree and Ujlaki (1973) conducted a creativity study in several European countries which included over one thousand primary school children. The research showed that children of upper class families obtained significantly higher creativity scores, both verbal and non-verbal, than children of middle and lower class families. Lower class children performed better on non-verbal tasks than they did on the verbal tasks, but in no country did they perform as well as their higher class peers. The authors assert:

Social class is such an overpowering factor that race and ethnic origin do not appreciably influence test results (p. 149).

In an earlier study Lesser (1964) found that children of high social standing regardless of race or ethnic origin performed consistently superior to lower class children in all mental abilities tested.

Sadler (1973) has shown that "expectation" is a factor in tasks
related to creativity. Arising from the question, "How do biology students demonstrate learning through behavioral performance?", Schock (1973) carried out a study to examine the relationship which exists between cognitive and affective educational objectives in the biology classroom. The Nelson Biology Test, Form E, was used to determine cognitive skills attained. Schock (1973) developed a Scientific Literacy Test as an instrument to determine which affective educational objectives had been attained by the students. Conclusions reached were that neither age (14, 15, 16, 17), nor sex were factors in cognitive and affective development. No significant relationship existed between cognitive and affective development. However, a direct relationship was shown between biology class levels and cognitive development.

Rushman (1974) argues that educators should emphasize growth in personal creativity and a sense of individuality among students.

Lancaster et al. (1974) observe that the most important duty of teachers is to develop in each student the confidence that he can contribute; that he can create. Delineating the teacher's role in fostering creativity in students, Lancaster comments:

The students must be encouraged to be non-traditional, to criticize, to question, to doubt, to explore, to try new procedures, to observe, to associate, to predict. They must be taught to obtain success through a series of failures" (p. 191).

In conclusion, there is considerable support shown in the literature to attest that creativity can be developed. At the Western Psychological Association convention in Portland, Oregon, in 1964, Donald MacKinnon (1965) delivered the Presidential Address in which he drew a picture of three "types" of people. The first is the "Adaptive Type", the ones who in early life identified their wills with that of their parents, and thereby were spared the pain of developing their own wills independently. Later in life they find it easy to adapt to the will of society and to accept its norms. The second is the "Searching
Type", the persons who take a step toward individuation, who strike out on their own and attempt to form goals and ethical standards other than socially approved ones. The third is the "Creative Type", those who accept reality with its demands and yet search for creative expression of their own individuality. The latter are more fully free to discover their own uniqueness as persons, to be themselves, and to realize their own ideals in life.

All three types appear in the classroom. While current literature suggests creativity cannot be taught, it can be fostered to some degree in each of the types described by MacKinnon.

Some New Instruments for Assessing Cognitive and Affective Performance Levels

Considerable research by educators in the field of test construction is in progress to improve evaluative instruments. Some recently constructed testing instruments are cited here.

Explorations in Biology

Explorations in Biology (Lee and Steiner, 1970) is a novel instrument developed under the joint auspices of the Biological Sciences Curriculum Study (BSCS), and Mid-continent Regional Educational Laboratory (McREL) in Kansas City, Missouri, to assess cognitive and affective learning processes. An outgrowth of the McREL-BSCS
document, Inquiry Objectives in the Teaching of Biology, the instrument tests student attainments of inquiry objectives as well as the effectiveness of classroom activities related to the objectives.

As a part of the test, the student is presented photographs depicting biological phenomena and is asked a question about each circumstance, such as, "What do you think is the most puzzling condition illustrated?" The student selects a problem from a multiple-choice list and proceeds to another situation which is determined by his choice on the preceding item, through a type of self-directed inquiry. The result is a branching configuration that can be useful in studying patterns students follow in conducting inquiry. The score obtained is a measure of the student's inquiry ability as defined in the objectives assessed.

Lee and Steiner (1970) report:

It is well understood by scientists that tools or instruments for gathering information are important to success of their research efforts. As more precise and more sophisticated instruments have been developed for gathering scientific information, the quality of the research product has been improved (p. 544).

Other McREL/BSCS Evaluative Instruments

McREL and BSCS are attempting to design effective instruments for evaluation purposes. Additional examples of instruments developed at McREL include one called COMIC, Cognitive Operations.
Monitored in the Classroom (Anderson and Bingman, 1969); the BSBI, Biology Students Behavioral Inventory (Steiner, 1970); and ORAB, Observational Record of Affective Behaviors (Steiner, 1970).

The McREL/BSCS document on Inquiry Objectives in the Teaching of Biology has been reported in the literature by several authors including John Anderson et al. (1969), Bingman (1969), Koos (1969), Bingman and Koutnik (1970), Hurd (1970), Lee (1970), Hans Andersen et al. (1971), and Andersen and Koutnik (1972).

Class Activities Questionnaire

To investigate how closely a teacher's "intention" match his "practice" in teaching, Joe Steele (1969b) devised an instrument for assessing to what extent the ideals and objectives (intentions) of teachers are actually the outcomes (practices) experienced by the students. Steele et al. (1971), reporting in the American Educational Research Journal, describe the instrument designed by Steele (1969b) called CAQ, Class Activities Questionnaire, which is intended to assess instructional climate. It is a 25-item instrument in which teachers and students agree or disagree on a four-point scale to statements describing classroom activities. Factors on the CAQ are clustered into "dimensions", grouping lower processes and higher processes modeled after Bloom's (1956, 1963) taxonomy of behavioral objectives in the cognitive, affective and psychomotor domains. Extensive field
testing of the CAQ supports validation of the instrument for the intended purpose. It is appropriate for use at the junior high school level and above.

**Attitude Toward Education Survey (ATES)**

The ATES was originally prepared by Steele (1969a) for use as an evaluative instrument accompanying the new BSCS module, *Investigating Your Environment*. The student indicates "Agree" or "Disagree" to 43 items pertaining to his impressions of school experiences. Upon completion of the survey a profile sheet is provided to the student to record his responses in six scale groupings categorized in such a way that the student immediately sees his "attitude profile". Scales are constructed so that as many as eight possible responses might appear on any one scale. Responses are grouped so that a person can identify from the scale description where he ranks on an eight-point continuum in the attitude being examined.

The ATES helps the teacher learn more about the values, ideas, and attitudes of students concerning education. It helps students to know themselves better. An example of an ATES student profile sheet appears in Appendix B.

**Cornell Critical Thinking Test (CCTT)**

Ennis and Millman (1971a) used scenario style in the design of
an intriguing instrument for assessing critical thinking ability in the areas of induction, deduction, assumption finding, and reliability. In the CCTT students are spared the conventional format of isolated test items with multiple choice options. Instead they are introduced to a scenario in which they are taken exploring in Nicoma, a newly discovered planet, in 1990. They are charged to investigate conditions and bring a report back to earth. Responses to their "options" in each circumstance in which a judgment is made or an action is taken reveal their critical thinking ability.

An impressive list of references in which the CCTT has been used effectively is provided with the 1971 edition of the Manual for Level X and Level Z (Ennis and Millman, 1971b). A few of the research studies in which the CCTT was used, in addition to the present investigation, are those of Ennis (1958), Craven (1966), Brown (1967), Doughlin (1967), Tamir (1968), Follman (1969), Tolman (1969), Small (1969), Miller et al. (1970), Nielson (1970), and Follman and Lowe (1975).

The CCTT is available in two forms from the Critical Thinking Project at the University of Illinois in Urbana. Level X is designed for use with secondary students. Level Z is for use in higher education.

In conclusion, although representative, these are but few of the instrument samples that are being researched and tested at the present
time for the purpose of formative as well as summative evaluation of learning. There is much yet to be done. Traditional tests for the most part are inadequate. Boulding has said that "If the human race is to survive, it will have to change more in its ways of thinking in the next 25 years than it has done in the last 25,000 years" (Toffler, 1974, p. 197). Certainly this is true in test construction.

**Contemporary Views Related to the Educational Implications of Values and Social Responsibility**

A survey of contemporary views related to the implications of values in the educational arena reveals that more and more emphasis is being given to personal responsibility for acts of commission and omission in the expression of living as our nation moves toward its tertiary. In *Escape from Phoniness* Ungersma (1969) writes:

> What all this adds up to, therefore, is a new sort of personal responsibility: a responsibility to self, in the fulfillment of which we also meet our responsibilities to others. Whether viewed (as by Sartre) as the ultimate responsibility, in default of a living God to share it, or (as by Frankl) as a divinely imposed duty to find and realize a personal meaning in life, we recognize an obligation to life itself, as long as it lasts (p. 127).

At the Center for Bioethics at Georgetown University, serious interest is being shown for futures planning. Addressing the topic of biology, society, and ethical education, Kieffer (1975) writes:

> One certainty is that education will have to provide not only adequate knowledge of science, but also a system of value analysis (call it moral education). Furthermore,
since many of these concerns impinge directly upon our perceptions of humanness, educators cannot long ignore the contribution that the new biology can make to the search for human meaning (p. 11).

Jacobsen (1972) writes, "The need to relate science to the value structure of our society is presently a major area of concern in science teaching" (p. 52).

Gotesky (1973) reflects the same ideas in writing about values in scientific research.

Gennaro and Glenn (1975) advise that students be encouraged in science classes to consider and discuss value questions which arise that have an impact on their immediate lives.

Kirschenbaum (1974b) and Kiefer (1975), in separate studies agree that it is impossible to dissociate values from the futures movement in education.

Maslow (1962, 1966a) points out that a convergence of self fulfillment and social responsibility hinges on establishing values.

Raths et al. (1966), Harmin et al. (1970), Knapp (1973), and Schrader (1973), all stress the importance of teaching science with a focus on values.

Several educators support, encourage, and offer leadership for conceiving more humanistic, value-oriented curricula. Among them are Bronowski (1956), Butler (1970), Maslow (1970b), Taylor (1970), Manning (1971), Peck (1971), Bell (1972), Bloom (1972), Zahorik
In the works of Smith (1970) and Rescher (1973), theories of values are related to problems of education.

Studies which involve working with values in the classroom are described in the writings of Raths (1966), Scriven (1966), Simon et al. (1972), Smith (1973), and Curwin et al. (1975).

As early as 1584 a distinguished teaching society, the Jesuits (Herbermann, 1911, p. 654), enumerated among the primary objectives in teaching, the education of the total person, which included the formation of clearly defined value systems. Describing the character and contents of the Ratio Studiorum, the pedagogical manual of Jesuit educators written in 1584 and revised in 1591, Schwickerath (1911) states:

... training or formation of the mind means the gradual and harmonious development of the various powers or faculties of the soul—of memory, imagination, intellect, and will. ... In this regard the Ratio stands in opposition to various modern systems which aim at the immediately useful and practical or, at best, allot a very short time to general education; it stands in sharp contrast with those systems which advocate the earliest possible beginning of specialization (p. 655).

Meehan (1973) comments that at the present time "... scientific inquiry and the study of values are widely regarded as separate and distinct enterprises" (p. 54). He suggests there is a need to link the meaning of value to the problems that people actually must solve in the
environment. Meehan (1973) reasons that a relation between empirical and normative inquiry (between fact and value) can be developed, and states:

An epistemological base can provide the conceptual apparatus needed to relate science and values because it provides a foundation from which the meaning of those two terms can be built and related to human needs and capacities" (p. 56).

In conclusion, it is said that "Biological evolution and cultural evolution both have made man what he is, but not necessarily what he will be" (Ekistics, 1973, p. 14). The salient message which continues to surface in the literature pertaining to the educational implications of values and social responsibility is for educators not to abdicate personal responsibility for teaching "both hemispheres" of the brain in the educational process. Value formation certainly is a facet of one of them.

Stotler (1970), quoting Glenn Seaborg writes:

Nobel Prize Winner Glenn Seaborg points out that even today man's "technology and his morality have come face to face, where he can scarcely treat fact and value separately, and where he may see principles as diverse as the Second Law of Dynamics and the Golden Rule being considered side by side in the making of decisions which determine his future". Science directed toward man interacting productively with his universe underlies the new humanism. . . . The need for wise science-related decision making is urgent (p. 9).

Harmin et al. (1970) quite well express the general consensus of thought among educators in regard to the place of values in science teaching. Viewing subject matter content as consisting of three levels:
fact level, concept level, and value level, Harmin and colleagues (1970) state:

All three levels are important; yet we like to think of a teacher's job as that of elevating subject matter to the third level, that is making the information taught relevant to the students' lives (p. 18).

The literature shows that contemporary views concerning the educational implications of values and social responsibility give top priority to the emergence of science and values in teaching.

Summary

A review of the literature shows that many and varied research studies are being conducted to test the goals of science education today, and to assess the methodologies used to achieve these goals. In this chapter, several pedagogical studies illustrating current theories pertaining to attitudes toward education, critical thinking ability, and the place of creativity in cognitive and affective development were described.

The literature shows that attitudes toward education, critical thinking, and affective behaviors strongly influence learning. Literature has been cited to support that proper attitudes toward education are necessary for building an appreciation and understanding of science, that critical thinking ability is essential to the learning process, and that value judgments are needed to make reasoned and responsible
decisions. Instruments have been developed to determine the acquisition of these cognitive and affective traits.

A review of the literature suggests that the study proposed in this investigation: to compare the effects of two methodologies in high school biology upon attitudes toward education, critical thinking ability, and specific affective behaviors, has instructional value.
III. THE STUDY

This chapter is divided into the following major sections: (1) Research Population, (2) Description of the Experimental Program, (3) Method of Random Sampling, (4) Selected Instruments, (5) Experimental Design, (6) Procedure Used in Collecting Data, (7) Processing the Data, and (8) Summary.

**Research Population**

In August of 1974 eight high school biology teacher and university supervisor teams met in Boulder for a two-week briefing session to explore both the learner and the teacher roles in the new BSCS module, *Investigating Your Environment*. Among criteria used for the selection of each high school/university team, three are pertinent to this research study.

1. The secondary/university teams selected to participate in the two-week briefing session were chosen by the project leaders because of their recognized proficiency in applying the BSCS philosophy in teaching, and for their experience and competence in utilizing BSCS materials to maximum advantage with secondary students.

2. The high school biology teacher participants agreed to implement the new environmental module in at least one biology class at their own local high school in the Fall of 1974.
3. Each high school/university team committed themselves to conduct a similar in-service training program for teachers in their own local area upon their return home.

A criteria for the acceptance of local high school teachers in the in-service program for the IYE module was agreement, as part of the earned 3-units of graduate credit, to implement the 9-week module during the second semester of the 1974-1975 school year in a minimum of one biology class per teacher.

This research study grew out of experiences gained and questions raised at the briefing session in Boulder, and as a consequence of the in-service training program for teachers in Fresno, California in the Fall of 1974. Letters describing the proposed research study, and invitations to participate in the field study and data collecting were sent in November 1974 to the eight secondary teachers who took part in the Boulder briefing session, as well as to the twenty secondary teachers who participated in the Fresno in-service training program. A total of twenty teachers responded favorably to the invitational proposal, out of which 16 accepted the responsibility of cooperating in the research study. Participants and their addresses are listed in Appendix A.

Desire for broad geographic, ethnic, and social population distribution was a critical factor in the selection of participating teachers and classes. Test sites were located in seven states representative
of Northeast, Southeast, Central, Midwestern, and Far Western United States. The schools include private and public; large (consisting of student populations of more than 2000) and small (consisting of student populations of less than 1000); rural, urban, and inner city. Each teacher participating in the research study used the IYE module, published in 1975 by Addison-Wesley Company, in at least one randomly chosen, intact biology class. The IYE class constituted one factor of the treatment groups, $T_1$. Each teacher likewise had one or more classes of general high school biology, with one, intact class constituting the second factor in the research study. The second factor consisted of two levels, with $T_2$ identifying the classes using one of the BSCS Biological Science versions (BSCS, 1973); and $T_3$ constituting the classes using Modern Biology (Otto and Towle, 1973) as the basic reference source, yet with a BSCS philosophical approach. Two teachers used Biological Science: Molecules to Man, (BSCS Blue Version); four teachers used Biological Science: An Ecological Approach, (BSCS Green Version); four teachers used Biological Science: An Inquiry into Life, (BSCS Yellow Version); one teacher used Biological Science: Invitations to Discovery, (BSCS 2nd level course); and five teachers used Modern Biology by Otto and Towle.

Between school classes varied in number from 11 to 34 students. Within school treatment groups, however, showed slight variations of only one or two students. In all, 32 biology classes were involved in
the research study, with 16 classes totalling 355 students in the IYE experimental module and 16 classes totaling 375 students in one of the other more structured biology programs.

Description of the Experimental Program

A succinct description of the IYE program appears in the BSCS Newsletter (1974). A cogent report of the module's use is presented in the April 1975 issue of the BSCS Newsletter (1975a), from which the following is taken:

Students working individually or in small groups, select the program to be investigated, formulate researchable questions, plan and conduct investigations, and communicate their findings in a way they consider appropriate. No investigations are pre-designed. No questions are predetermined. Rather, students work in an atmosphere of freedom and cooperation to devise and conduct investigations that have meaning for them (p. 4).

Investigating Your Environment is non-graded and can be appropriately adapted to all ages and trans-disciplines.

In the IYE module students working in small groups first identify and prioritize their own personal "valued things" in the environment. After rank ordering five or six environmental issues of immediate concern to them, each group prepares a chart to display in the room to serve as a focal point for a general discussion of valued things and how present day life styles relate to environmental quality.

With this introduction each student then selects an environmental topic
of personal interest to him, and plans an appropriate scientific investigation to examine that problem. The Student Handbook provides basic techniques for carrying out both scientific and sociological investigations. The Teachers Handbook suggests methods and ways of assisting individual students in their investigations.

Reduced from pages 6-9 in the IYE Teachers Handbook (BSCS, 1975), the over-all rationale of the program can be summarized as follows:

1. Significant questions about the environment require searching into several disciplines.

2. Learning how to deal with a question is as important as collecting the data related to the question.

3. The interpretation of findings, and actions to be recommended as a result of them, involves value judgments and social consequences.

4. Communicating investigative findings to an appropriate audience is an indispensable facet of developing personal and corporate responsibility.

5. Students need to be provided opportunities to identify, formulate, and carry out investigable problems that are worthwhile to them.

6. Students should be treated in ways that will enhance their intellectual and psychological growth, and their attitudes about education.

The six articles representing the rationale of IYE might well become a science teacher's compendium in any course. The literature reveals that numerous science educators support such principles, particularly as they relate to value formation.

Growing in awareness of an obligation to life itself while learning
about "life" in biology classes is a vital aspect of the module. The IYE program is a novel instructional unit with an emphasis on learning how to learn, and responsible decision making. Defining the environment as "anything external to you that affects you", it gives learners the freedom to choose and investigate a question that is important to themselves as well as to others.

In conclusion, one of the major premises of the IYE module provided the impetus for this research investigation.

Students should be treated in ways that will enhance their intellectual and psychological growth, and their attitudes about school (BSCS, 1975, Teachers Handbook, p. 7).

An excerpt from The Open Classroom (Kohn, 1969) set the course for this research investigation.

The whole community ought to be the school, and the classroom a home base for the teachers and kids, a place where they can talk and rest and learn together, but not the sole place of learning. The classroom ought to be a communal center, a comfortable environment in which plans can be made and experiences assessed (p. 75).

And Maslow's (1966b) words, "What needs doing is worth doing even though not very well" (p. 14) gave the courage to launch into the study.

The BSCS philosophy purports to enhance attitudes toward education, critical thinking ability, and responsible affective behaviors. The investigator wondered if the rationale of the new IYE module, which allows maximum latitude and responsibility for self-direction,
would be more effective in achieving the expressed goals than conventional biology materials.

Method of Random Sampling

Random sampling of the treatment groups was achieved in the following manner. First, names of cooperating teachers were alphabetized and a number from 1-16 was drawn to determine the random assignment of teachers to randomized classes. Then, using Snedecor's (1956) Table of Random Numbers, a number between 0 and 6, representing five biology classes per day taught by each participating teacher, was selected 16 consecutive times. The first number represented the random assignment of $T_1$ to a given class period for Teacher One. The second number provided the random assignment of $T_2$ or $T_3$ to a given class period for Teacher One. The random selection of numbers was continued in the same manner for all 16 participating teachers. Results of the random selection of classes are shown in Table 1. Treatment groups 9-16 fall into the same sampling pattern as treatment groups 1-8.

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<tr>
<th>Teacher</th>
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<td></td>
<td>$T_1$ (IYE)</td>
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Table 2 shows a fairly equitable relative distribution of treatment groups to class periods.

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<thead>
<tr>
<th>T₁</th>
<th>T₂, T₃</th>
</tr>
</thead>
<tbody>
<tr>
<td>Per 1 = 2</td>
<td>Per 1 = 3</td>
</tr>
<tr>
<td>Per 2 = 1</td>
<td>Per 2 = 2</td>
</tr>
<tr>
<td>Per 3 = 2</td>
<td>Per 3 = 1</td>
</tr>
<tr>
<td>Per 4 = 2</td>
<td>Per 4 = 2</td>
</tr>
<tr>
<td>Per 5 = 1</td>
<td>Per 5 = 1</td>
</tr>
</tbody>
</table>

It is interesting to note that random distribution of T₁ and T₂, T₃ classes to class periods are such that an equal number of each precedes or follows the other in the course of the 5-period day. For example, the IYE class (T₁) in eight schools precedes the conventional biology class involved in the research study (T₂ or T₃), for teachers 2 and 10; 3 and 11; 7 and 15; 8 and 16. Visa versa, the conventional biology classes involved in the research study precede the experimental class within eight schools: that of teachers 1 and 9; 4 and 12; 5 and 13; 6 and 14.

Random sampling was of considerable importance in this research study because of using a Posttest-Only statistical design with intact classes, and using class means on the criterion tests to examine
group differences. Engelhart (1972) supports this position in the following statement:

An alternative in experiments conducted in a random sample of schools is to use intact classes as the experimental unit and class averages, as on pretests and posttests, or posttests alone, as the data. Classes can be randomly assigned to treatments (p. 395).

Selected Instruments

Criterion tests used in the study are described in the following section.

Attitudes Toward Education Survey

The ATES was selected to study specific outcomes in the treatment groups related to the basic philosophy and fundamental goals of the BSCS instructional materials.

The instrument was designed by Dr. Joseph M. Steele (1969a), a BSCS test consultant, for use in evaluating student attitudes toward educational experiences. The instrument is included in the experimental edition of the Teachers Handbook, pages 58 a, b, c, which accompanied the spiral bound, revised experimental student edition of Investigating Your Environment (1973). Permission to reproduce and use the instrument is granted under the copyright by Addison-Wesley Publishing Company.

In the environmental module, the survey is given to the students
before starting the course to stimulate thought and discussion of ideas related to learning. It is given again at the end of the program to assess outcomes related to BSCS goals and objectives, and to ascertain differences, if any, in attitudes felt by the students at the completion of the learning experience.

The survey consists of 43 items to which the student responds "Agree" (A), or "Disagree" (D), to each statement. An example of the 43-item attitude survey is included in Appendix B.

After completing the survey, the student is given a profile sheet consisting of six scales which represent six fundamental attitudes being examined. The scale categorizes responses into groups of eight possible response patterns in such a way that the student can immediately visualize his general disposition toward the six attitudes, calculate the total for each scale, and plot his profile accordingly. An example of an individual student profile is included in Appendix C.

From the individual profiles, a class profile is prepared and posted for class discussion and evaluation. An example of an actual Class Attitude Profile is included in Appendix D.

The class profile is obtained by preparing a class tally chart with "Agree--Disagree--No Response" categories for the 43 items. The questions are then asked, "How many agree to number 1? How many disagree? How many have no response?" Hand tallies are recorded on the chart. Students then circle items on the tally chart.
showing greatest disagreement in responses. These are the items that stimulate discussion and give rise to animated exchange of ideas concerning educational values and how these might best be achieved. An example of an actual Class Attitude Survey Tally Chart showing items of greatest discrepancy circled (items 1, 5, 12, 25, 38, 40) is included in Appendix E.

The purpose of obtaining a class survey is to encourage students to reflect on their educational experiences, and to give some thought to what the purpose and goals of education should be. The results provide direction for the teacher in planning curricula and providing learning experiences that assist students in achieving their stated goals and objectives.

Because little differences appeared in the pre and post test results for the ATES in the pilot classes in 1973 and 1974, it was decided to use the posttest only to assess class attitudes toward education in this research study. It was of interest to the researcher to compare attitudes toward education in classes involved in two different biology programs. After a term of instruction, the survey was administered to the 16 IYE classes, and to the 16 more structured biology classes in an attempt to determine whether attitudes toward education would differ significantly as a result of differing teaching methodologies.

The ATES makes use of a valuable resource readily available to
teachers for analyzing instructional goals: the perceptions of students. Prevailing patterns of educational emphasis are identified and reacted to by students. The instrument has been useful to many teachers involved in piloting the new BSCS environmental module in 1972, 1973, and 1974, according to the feedback reports provided by the teachers to the BSCS consultants. Many teachers report that the instrument has provided direction to them for modifying instructional procedures in order to make learning more meaningful to students.

**Cornell Critical Thinking Test**

The CCTT, Level X, constructed by Robert H. Ennis and Jason Millman (1971) was selected to compare operations in the cognitive domain which involve ability to think critically in the areas of induction, assumption finding, deduction, and reliability, among students involved in two different biology programs. The CCTT is available commercially through the Critical Thinking Project at the University of Illinois, Urbana. Level X is designed by the authors for use with Grades 7-12.

Several commercial tests of critical thinking ability were carefully examined by the researcher before a selection was made. The literature on reliability indices and construct validity of several critical thinking tests was thoughtfully reviewed. A sampling of sophomore students in high schools of Fresno who were not involved in the
research study were invited to examine several critical thinking tests prior to the study, and to rate the tests in order of preference. The secondary students rank-ordered the CCTT as most preferred in categories of: appropriate time length, non-threatening, appealing style, clarity of content, challenge to thought processes, range of cognitive levels reached, involvement of personal values in forming judgments, and relevance to "real life situation" decision making. 

In reviewing the literature it was found that the CCTT has been used effectively in research studies by Ennis (1958), Craven (1966), Brown (1967), Follman (1969), Tolman (1969), Miller et al. (1970), and Follman and Lowe (1975).

Based on the insights gained from a careful search for an appropriate critical thinking instrument, and influenced by the fact that the CCTT is designed to test critical thinking ability in the areas of assumption finding, deduction, induction and reliability; and since these cognitive operations are a viable component of the ESCS program goals; the decision was made to use the CCTT in this research study in an attempt to determine whether the cognitive elements measured would differ significantly in classes subjected to two different teaching methodologies.

**Biology Students Behavioral Inventory, Form C**

The BSBI (Steiner and Lee, 1970a), was selected to be used to
assess operations in the affective domain in the areas of curiosity, openness, satisfaction, and responsibility between two populations of biology students exposed to two different modes of instruction. The instrument was designed and field tested by Dr. H. Edwin Steiner, currently Associate Professor in the College of Education at the University of South Florida, Tampa. A letter from Dr. Steiner granting permission to use the instrument appears in Appendix F.

The BSBI, Form C, is a 39-item instrument designed to measure the frequency of occurrences of specific behaviors pertinent to four affective dispositions which are considered necessary for cognitive inquiry, and which the BSCS instructional materials attempt to foster. A biological situation is described and a selection of possible behaviors or actions the student may take is presented. The student indicates what he would do in the situation by selecting one behavior. Scores are awarded according to a point system in which the "expected" or "preferred" responses are behaviors indicative of one of the four attitudes which the inventory measures.

Preliminary forms of the BSBI (Steiner 1970) were tested with two groups of high school biology students in 1969 with 864 students in the first sample and 1,153 students in the second sample. The population for the study was 43 high school biology classes. Pearson product-moment coefficients of correlation were computed between class scores on each scale of the BSBI, and scores for teachers on
53 different classroom practices. A total of 610 correlation coefficients were obtained providing an indication of the relationships between teacher practices in the classroom and student performance in particular affective behaviors.

Validity was studied in three ways: by a panel of nine judges, by correlation of student item scores with sub-scale scores, and by correlations with a second instrument, Observational Record of Affective Behaviors (ORAB), which measures the same attitudes in an observational approach. An estimate of the reliability of each sub-scale was determined by using a split-half technique. Pearson product-moment coefficients of correlation were found and adjusted using the Spearman-Brown formula. Data obtained during the development and revision of the BSBI indicate that Form C yields valid and reliable class scores for the categories it purports to measure, according to Steiner (1970).

The BSBI has been used by the Mid-continent Regional Educational Laboratory (McREL) in Kansas City, Missouri on several occasions in the evaluation of the Inquiry Role Approach project (Lee 1970, Seymour et al. 1974). A review of the literature shows that the BSBI has been used effectively in the research studies of Bingman (1969), Bingman and Koutnik (1970), Lee and Steiner (1970), Andersen et al. (1971), and Seymour et al. (1974).

Because of its effective use in the recent past by McREL and
BSCS for assessing specific affective behaviors among students, the researcher chose the Biology Students Behavioral Inventory in an attempt to compare the effect two different modes of instruction have upon curiosity, openness, satisfaction, and responsibility among students participating in the two separate biology programs.

Comprehensive Test of Basic Skills, Form Q

Class means of the Comprehensive Test of Basic Skills (1971), hereafter referred to as CTBS, are used in this research study for covariance analysis to test for comparability of the groups. Form Q is designed for use with Grades 8-12.

The CTBS uses graphic materials to test student abilities in reading, language and arithmetic. In reviewing the CTBS for The Seventh Mental Measurement Yearbook (1972), Dr. Walter Pauk, Professor of Education and director of the Cornell Reading-Study Center at Cornell University states, "The graphic materials in this test are on a high level of the type that one would find in textbooks" [p. 1206]. In summing up his review of the batteries of the CTBS, Dr. Pauk (1972) concludes:

Despite the problems mentioned, these tests are the finest yet devised. The rationale is clear and logical; the design a masterpiece of sequential and interlocking categories; the test items polished almost to perfection; the format inviting; the content challenging; the supporting research plentiful; and the overall coordination almost flawless. A great team must have put the pieces together to create the complete picture [p. 1206].
Two other reviews and three excerpts relating to the CTBS batteries are included in Buros (1972) Seventh Mental Measurement Yearbook.

Because of the validity and reliability of the test in measuring fundamental aptitude in reading, language, and arithmetic, and because the CTBS is used extensively in the secondary schools throughout the nation for grade placement scores, the decision was made to use CTBS class means in this research study for covariance analysis.

Experimental Design

Campbell and Stanley (1963) describe several experimental and quasi-experimental designs for research of which Design 6, the Post-test-Only Control Group Design, with two-factor analysis of variance using the F-test, seemed most appropriate for this investigation.

In Methods of Educational Research, Engelhart (1972) states:

In the case of experimentation concerned with treatments or methods of instruction, a posttest may provide the crucial factor in the acquisition of concepts or skills (p. 398).

According to Campbell and Stanley, Design 6 controls for testing as main effect and interaction, and is appropriate to all of the settings in which Designs 4 and 5 might be used where true randomization is possible.

The analysis of variance as a statistical measurement is advisable where several means are being compared. Gage (1963, p. 148-
151) points out that there is less risk of a Type I (alpha) error, rejecting a true null hypothesis, in using analysis of variance. Likewise, *Anova 12 allows the use of factorial experimental design with less risk of a Type II (beta) error, failing to reject a null hypothesis. Analysis of variance also lends itself to a significance test for possible interaction of the factors on the dependent variables, in this research study, the interaction of two modes of instruction on three criterion tests.

The form of the Posttest-Only Control Group Design in this investigation is as follows:

\[ \begin{align*}
R_1 & \quad X \quad O_1 \quad O_2 \quad O_3 \\
R_2 & \quad O_1 \quad O_2 \quad O_3
\end{align*} \]

The intent of this research study is to compare the effectiveness of two teaching methodologies in achieving specific outcomes where:

- \( R_1 \) represents the random assignment of intact classes to IYE,
- \( R_2 \) represents the random assignment of intact classes to more structured biology classes,
- \( O_1 \) represents the ATES,
- \( O_2 \) represents the CCTT, Level X,
- \( O_3 \) represents the BSBI, Form C, and
- \( X \) represents the variable, in this investigation, the IYE module.
Since "attitudes" and "behavior" are among factors to be analyzed in this study, the nature of the inquiry is such that pretesting could very well be reactive. In studies where instructional methods or attitudinal changes are being assessed, Campbell and Stanley (1963) recommend that covariance analysis of prior vital statistics, such as grades or test scores, be used in lieu of a pretest. This procedure has the advantage of "... avoiding an experimenter-introduced pretest session, and ... avoiding the giveaway repetition of identical or highly similar unusual content (as in attitude change studies)" (p. 26). According to the same authors:

... many problems exist for which pretests are unavailable, inconvenient, or likely to be reactive, and for such purposes the legitimacy of Design 6 still needs emphasis in many quarters. In addition to studies of the mode of teaching novel subject materials, a large class of instances remains in which (1) the X and posttest O can be delivered to students or groups as a single natural package, and (2) a pretest would be awkward. Such settings frequently occur in research on testing procedures themselves, as in studies of different instructions. ... Where student anonymity must be kept, Design 6 is usually the most convenient (p. 26).

Due to the amended Family Education Rights and Privacy Act which became effective in 1974 (Sec. 513 of P.L. 93-380) to protect the privacy of student records, care was taken to respect the anonymity of the students participating in this research study. Data were analyzed by computing group means from intact classes rather than individual scores.
Campbell and Stanley (1963) explain the rationale and formulas for correct statistical analysis in cases where intact classes have been assigned to treatments by saying,

... the class means are used as the basic observations, and treatment effects are tested against variations in these means (p. 23).

Gage (1963, p. 178) points out that a posttest-only design, where applicable, protects internal validity. Sources such as: history, maturation, testing, instrumentation, statistical regression, differential selection, experimental mortality, and interaction are all controlled by the posttest design.

In this research study an attempt is made to increase external validity, which refers to generalizability of populations, settings, treatment variables, and measurement variables, by:

1. geographical distribution of teachers and classes involved in the study to represent Northeast, Southeast, Central, Midwestern, and Far Western sections of the United States;

2. selection of schools to represent private and public high schools; rural, urban, and inner city high schools; schools with student populations over 2000 and schools with student populations under 1000;

3. random assignment of intact classes and class periods to treatment groups within each school, which controls for testing as main effect and interaction; and
4. selection of instruments designed to measure application of course philosophy, as well as cognitive and affective aspects of learning.

In all schools students were randomly assigned to biology classes and were not tracked.

Class means of the CTBS in reading, language, and arithmetic were used for covariance analysis.

Procedure Used in Collecting Data

The method for identifying teachers and classes to participate in the study is presented earlier in the section, Research Population.

In January 1975 the random assignment of treatments to class periods was accomplished by postcard announcement. Participating teachers detached a second stamped, self-addressed postcard to return to the investigator with information on the number of students in each treatment group, and approximate dates when the three criterion tests would be administered. Packages of testing materials sufficient for a class set, directions for administering, answer sheets for the total number of students involved in each treatment group, and stamped return mailers were then sent by first class mail to the cooperating teachers.

Criterion tests were administered by the teachers to their own classes on three different days near the end of the term. Directions for administering tests were clearly provided in the manuals.
accompanying each set of tests. Identification numbers were assigned to students to use in place of names. Teachers informed students that they had been selected to participate in a research study, that all students would remain anonymous, that answer sheets would not be scored by the teacher, and that outcomes of the tests would not be used for grading purposes. At the conclusion of each testing session, answer sheets were gathered; an ID sheet was stapled to each set of answer sheets; and they were placed in the return mailer. A sample of the Vital Statistics ID Form appears in Appendix G.

Processing the Data

The design of the ATES is such that students in all treatment groups completed their own profile charts and prepared a composite class profile. Only the profile sheets and composite class profiles were returned to the researcher for further data analysis.

Both the CCTT and the BSBI are designed so that test booklets are reusable when standard answer sheets for convenience of machine scoring are used. IBM Form ITS 1000 A445, or Optical Scanning Form DC 3329, are satisfactory to use with the CCTT. Optical Scanning Form DS 1120-A is appropriate to use for the BSBI. Separate answer sheets were provided for all students and only the answer sheets were returned to the investigator for data processing.

Directions for scoring the CCTT were included in the manual
accompanying the test. Treatment group means for each subtest of the CCTT, and total scores using the formula, rights minus one-half the number wrong, were computed in accordance with the directions provided in the manual.

The BSBI was scored according to directions included in the Scoring Key accompanying the Materials for Administering the BSBI. Item scores for each sub-scale were combined, and a mean score obtained using the formula provided.

Class means and standard deviation were obtained for all sub-scales and total tests in the three criterion tests for all classes in the treatment groups. The F-test was used to establish levels of significance.

Class means on the CTBS which students took in May 1974 were obtained from cooperating teachers for analysis of covariance.

All raw data were transferred to IBM cards and statistically processed by the CDC 3300 computer at Oregon State University under the direction of Mr. Dave Niess.

Summary

Chapter III described the research population and the method of random sampling. A description of the IYE experimental program was provided. Each of the three criterion tests used with the treatment groups was introduced, and reasons for selecting these
particular instruments were presented. The instrument used to obtain covariance analysis was described. Finally, the experimental design was presented, and the procedures used in collecting and processing the data were explained.
IV. RESULTS OF THE STUDY

Chapter IV is divided into the following major sections: (1) Method of Statistical Analysis, (2) Hypotheses Test Results, (3) Discussion of the Findings, and (4) Summary.

Method of Statistical Analysis

This research has dealt with a study of the effect of two teaching methodologies in high school biology upon attitudes toward education, critical thinking ability, and specific affective behaviors as demonstrated by class performance of two treatment groups on three specific tests.

The statistical analysis used was that of Campbell and Stanley's (1963) Design 6, the Posttest-Only model which controls for testing as main effect and interaction. The data were computed by two-factor analysis of variance, *Anova 12, under the direction of Mr. Dave Niess at Oregon State University Computer Center. The F-test was used to compare treatment results. Campbell and Stanley (1963) recommend the F-test of significance for studies involving two or more treatment variables each having several levels.

According to Lindgren (1962) "... the real value of analysis of variance methods lies in its providing a means of studying one factor in the presence of other factors" (p. 373). Glass and Stanley (1970)
state that another advantage of *Anova 12 is that it permits "... testing more than one hypothesis about main effects; ... and makes possible, where two or more factors are used, to study how the factors interact" (p. 490).

Treatment group means obtained on the three criterion tests: the ATES, the CCTT, and the BSBI; were used as the unit of analysis, since it was group differences rather than individual differences that were examined.

The CTBS was used for covariance analysis. Correlations between total group means on each of the three criterion tests and the CTBS were non-significant for all variables: namely, reading, language, and arithmetic skills.

Seventeen variables were calculated to test the three major hypotheses and the 14 minor hypotheses.

The first factor, \( T_1 \), represents classes using the new IYE module in which students work on investigations of their own choosing at their own pace.

The second factor, consisting of two levels, represents more structured biology programs. \( T_2 \) represents classes using one of the BSCS Biological Science versions (1973). \( T_3 \) represents classes using Modern Biology by Otto and Towle (1973).

Each major and minor hypothesis test result is presented in the analysis of the data and discussion of the findings.
Hypotheses Test Results

Attitudes Toward Education Survey

The ATES consists of six sub-scales designed to diagnose specific attitudes toward education. These sub-scales are: (1) Future Orientation, (2) Learning How to Learn, (3) Self Responsibility, (4) Learning as Process, (5) Learning as Knowing Facts, and (6) Relevance of School. Table 3 shows class mean data for the treatment groups $T_1 \times T_2$, $T_1 \times T_3$, and $T_1 \times T_2 T_3$ combined for each of the six sub-scales and the total survey.

Table 3. Treatment mean for the ATES

<table>
<thead>
<tr>
<th>Treatment Groups</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>$T_1$</td>
<td>2.63</td>
<td>5.84</td>
<td>6.48</td>
<td>5.57</td>
<td>1.56</td>
<td>4.50</td>
<td>4.43</td>
</tr>
<tr>
<td>$T_2$</td>
<td>3.00</td>
<td>5.72</td>
<td>6.36</td>
<td>5.64</td>
<td>1.75</td>
<td>4.85</td>
<td>4.55</td>
</tr>
<tr>
<td>$T_3$</td>
<td>2.68</td>
<td>5.88</td>
<td>6.50</td>
<td>5.64</td>
<td>2.28</td>
<td>5.25</td>
<td>4.70</td>
</tr>
<tr>
<td>$T_1$</td>
<td>3.68</td>
<td>5.18</td>
<td>5.96</td>
<td>5.08</td>
<td>2.60</td>
<td>5.39</td>
<td>4.65</td>
</tr>
<tr>
<td>$T_2 T_3$</td>
<td>2.64</td>
<td>5.85</td>
<td>6.48</td>
<td>5.59</td>
<td>1.79</td>
<td>4.73</td>
<td>4.52</td>
</tr>
<tr>
<td>$T_1$</td>
<td>3.22</td>
<td>5.55</td>
<td>6.23</td>
<td>5.47</td>
<td>2.02</td>
<td>5.02</td>
<td>4.58</td>
</tr>
</tbody>
</table>
Table 4 shows the F-values for each of the six sub-scales: (1) Future Orientation, (2) Learning How to Learn, (3) Self Responsibility, (4) Learning as Process, (5) Learning as Knowing Facts, and (6) Relevance of School, as well as the total survey of the ATES.

Table 4. Analysis of variance schematic for the ATES

<table>
<thead>
<tr>
<th>Treatment Groups</th>
<th>d.f.</th>
<th>Sub-Scales</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>1</td>
</tr>
<tr>
<td>( T_1 \times T_2 )</td>
<td>1</td>
<td>2.41</td>
</tr>
<tr>
<td>( T_1 \times T_3 )</td>
<td>1</td>
<td>6.80*</td>
</tr>
<tr>
<td>( T_1 \times T_2 \times T_3 )</td>
<td>1</td>
<td>7.30**</td>
</tr>
</tbody>
</table>

* Level of significance = .10  ** Level of significance = .05

Tables 3 and 4 illustrate the statistical findings from comparing two teaching methodologies used with the treatment groups. A discussion of the hypothesis test result in each of the six sub-scales follows. All hypotheses assert that there is no significant difference in class means of treatment groups in any of the sub-scales.

1. Future Orientation

Secondary students scoring high on Future Orientation appear to view the purpose of education as primarily preparing them for college. On a rating scale of 1.00 through 8.00 with 4.00 as the median,
all treatment groups show ratings below 4.0 on Table 3 in sub-scale 1, indicating that the 32 classes participating in this research study tend not to view the purpose of high school education as primarily a preparation for college.

In Table 3 for each of the three treatments, the mean data reveal that the combined 16 classes involved in the experimental program, IYE (T_1), consistently rate lower on sub-scale 1 (Future Orientation) than the more structured counterpart biology classes, an outcome consistent with the IYE program philosophy.

An F-value < 4.54 and > 7.71 for T_1 x T_3 is significant at the .10 level. The F-value for sub-scale 1 in Table 4 for T_1 x T_3 is seen to be 6.80. Therefore, the ratings of classes in the experimental program (T_1) for Future Orientation are significant at the .10 level compared to the ratings of classes in Modern Biology (T_3).

An F-value < 4.54 and > 8.68 for T_1 x T_2 T_3 is significant at the .05 level. The F-value for sub-scale 1 in Table 4 for T_1 x T_2 T_3 is seen to be 7.30. Therefore, the ratings of classes in the experimental program (T_1) for Future Orientation are significant at the .05 level as compared with the ratings of classes in the combined conventional biology programs (T_2 T_3). The null hypothesis:

There is no significant difference between the two modes of instruction in influencing students' views of secondary education as a preparation for college

is therefore rejected at the .10 level of significance for T_1 x T_3, and
at the .05 level of significance for $T_1 \times T_2 T_3$ combined.

2. **Learning How to Learn**

Secondary students scoring high on sub-scale 2 (Learning How to Learn) appear to view the purpose of education as preparing for learning on one's own. On the rating scale of 1.00 through 8.00 with 4.00 as the median, all treatment groups show ratings above 5.00 in sub-scale 2, indicating that the 32 classes participating in this research study tend to view the purpose of education as preparing students for self-learning.

An F-value < 4.54 and > 7.71 is significant at the .10 level for $T_1 \times T_3$. The results of the combined experimental classes show a rating of 5.04 in sub-scale 2 compared with the results of the combined Modern Biology classes. The null hypothesis:

There is no significant difference between the two modes of instruction in influencing students' views of secondary education as a preparation for self-learning

is therefore rejected at the .10 level of significance.

3. **Self Responsibility**

Secondary students scoring high on sub-scale 3 (Self Responsibility) appear to think that the students should be responsible for making decisions about their own learning. On the rating scale of 1.00 through 8.00 with 4.00 as the median, all treatment groups show ratings above 5.9 in sub-scale 3, indicating that the 32 combined
classes participating in this research study tend to think students should be responsible for their own learning.

Although the experimental classes show higher ratings in Table 3 for sub-scale 3, the F-values in Table 4 for Self Responsibility do not indicate significant differences among the treatment groups. Therefore, the null hypothesis:

There is no significant difference between the two modes of instruction in influencing students to perceive themselves as responsible for self-learning is not rejected.

4. **Learning as Process**

Secondary students scoring high on Learning as Process (sub-scale 4) appear to view learning as processes, such as asking questions, seeking answers, gathering information, formulating hypotheses, recording data, and performing investigations. On a rating scale of 1.00 through 8.00 with 4.00 as the median, all treatment groups show ratings above 5.00 in sub-scale 4, indicating that the combined 32 classes participating in this research study tend to view learning as process.

Although mean scores in Table 3 for sub-scale 4 show that the combined 16 experimental classes (T1) have higher ratings in two out of three comparative studies, the F-values in Table 4 do not indicate significant differences. Therefore, the null hypothesis:
There is no significant difference between the two modes of instruction in influencing students to view learning as process is not rejected.

5. **Learning as Knowing Facts**

Secondary students scoring high on sub-scale 5 (Learning as Knowing Facts) appear to view learning primarily as accumulating and memorizing facts. On a rating scale of 1.00 through 8.00 with 4.00 as the median, all treatment groups show ratings below 3.00, indicating that the 32 classes participating in this research study tend not to view learning in terms of memorizing facts.

Although mean scores in Table 3 for sub-scale 5 show that the combined 16 experimental classes (T₁) have consistently lower ratings in all comparative studies than the more structured counterpart biology classes, the F-values of sub-scale 5 in Table 4 do not indicate significant differences in treatment groups. Therefore, the null hypothesis:

There is no significant difference between the two modes of instruction in influencing students to view learning primarily as memorizing facts is not rejected.

6. **Relevance of School**

Secondary students scoring high on sub-scale 6 (Relevance of School) tend to think that school deals with matters that are relevant
and important to life in the real world. On a rating scale of 1.00 through 8.00 with 4.00 as the median, all treatment groups show ratings between 4.50 and 5.40 in sub-scale 6 on Table 3, indicating that the 32 classes participating in this research study tend to take a somewhat "middle-of-the road" view of the relevance of school to the real world.

F-tests for sub-scale 6 in Table 4 do not show significant differences in the outcomes of the treatment groups. Therefore, in sub-scale 6, the null hypothesis:

There is no significant difference between the two modes of instruction in influencing students to view school as relevant and important to real life

is not rejected.

In conclusion, looking at the overall profile of the ATES, the total data of Table 3 and Table 4 show that the total differences in the performance of the treatment groups are insignificant. The major null hypothesis:

There is no significant difference in the two modes of instruction in influencing students' attitudes toward education as measured by the ATES

is, therefore, not rejected.

**Cornell Critical Thinking Test**

The CCTT consists of four sub-scales designed to assess specific operations in the cognitive domain. These are: (1) Induction, (2)
Reliability, (3) Deduction, and (4) Assumption Finding. Table 5 shows class mean data for the treatment groups \( T_1 \times T_2, T_1 \times T_3, \) and \( T_1 \times T_2T_3 \) combined for each of the four sub-scales and the total test.

Table 5. Treatment mean for the CCTT

<table>
<thead>
<tr>
<th>Treatment Groups</th>
<th>Sub-Scales</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>( T_1 )</td>
<td></td>
<td>2.45</td>
<td>3.01</td>
<td>3.34</td>
<td>3.18</td>
<td>2.99</td>
</tr>
<tr>
<td>( T_2 )</td>
<td></td>
<td>2.49</td>
<td>3.08</td>
<td>3.26</td>
<td>3.17</td>
<td>3.00</td>
</tr>
<tr>
<td>( T_1 )</td>
<td></td>
<td>2.35</td>
<td>2.68</td>
<td>3.10</td>
<td>2.85</td>
<td>2.75</td>
</tr>
<tr>
<td>( T_3 )</td>
<td></td>
<td>2.40</td>
<td>3.06</td>
<td>3.26</td>
<td>3.19</td>
<td>2.97</td>
</tr>
<tr>
<td>( T_1 )</td>
<td></td>
<td>2.42</td>
<td>2.91</td>
<td>3.27</td>
<td>3.07</td>
<td>2.91</td>
</tr>
<tr>
<td>( T_2T_3 )</td>
<td></td>
<td>2.46</td>
<td>3.07</td>
<td>3.26</td>
<td>3.18</td>
<td>2.99</td>
</tr>
</tbody>
</table>

Table 6 shows the F-values for each of the four sub-scales and the total test.

Table 6. Analysis of variance schematic for the CCTT

<table>
<thead>
<tr>
<th>Treatment Groups</th>
<th>d.f.</th>
<th>Sub-Scales</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>( T_1 \times T_2 )</td>
<td>1</td>
<td>1.92</td>
<td>3.82*</td>
<td>2.98</td>
<td>.86</td>
<td>7.13**</td>
<td></td>
</tr>
<tr>
<td>( T_1 \times T_3 )</td>
<td>1</td>
<td>.08</td>
<td>.27</td>
<td>.18</td>
<td>2.09</td>
<td>.21</td>
<td></td>
</tr>
<tr>
<td>( T_1 \times T_2T_3 )</td>
<td>1</td>
<td>.95</td>
<td>1.37</td>
<td>2.04</td>
<td>2.81</td>
<td>3.09*</td>
<td></td>
</tr>
</tbody>
</table>

* Level of significance = .10  ** Level of significance = .05
Tables 5 and 6 illustrate the statistical findings from comparing two teaching methodologies used with the treatment groups. A discussion of the four sub-scales and the hypothesis test result in each of the sub-scales follows. All hypotheses assert that there is no significant difference in class means of the treatment groups in any of the sub-scales.

1. **Induction**

The first section of the scenario, "Exploring in Nicoma", consists of 22 items which ask for the bearing, if any, of information on an hypothesis. These items are concerned with whether a simple generalization is warranted, whether an hypothesis is warranted, and whether a reason is relevant. According to the test constructors, Ennis and Millman (1971), responses to these items reflect direction of support, assuming that judgments about the direction of support and about relevance are crucial to judgments about whether an hypothesis is warranted. It also assumes that skill in making such judgments is indicative of skill in making the total judgment (Ennis and Millman, 1971b).

Sub-scale 1 (Induction) in Table 5 reveals that in each treatment group, classes in the more structured, conventional biology programs consistently demonstrate higher ability to think inductively as compared with classes involved in the IYE experimental program ($T_1$),
insofar as the criterion test truly measures inductive processes in the 22 items of the scenario.

However, F-values for sub-scale 1 in Table 6 do not reveal significant differences among the three groups. Therefore, the null hypothesis:

There is no significant difference between the two modes of instruction in students demonstrating ability for inductive reasoning is not rejected.

2. Reliability

According to the test constructors, Ennis and Millman (1971), the second section of "Exploring in Nicoma" (items 27-50) is primarily concerned with ability to judge the reliability of information on the basis of its source and the conditions under which the information was secured (reliability of authority providing the information).

Sub-scale 2 (Reliability) in Table 5 shows that the BSCS Biological Science classes in this research study demonstrate higher ability to judge the reliability of statements insofar as the test items truly measure this ability as compared to the combined classes involved in the IYE experimental program.

An F-value < 3.28 and > 4.96 for $T_1 \times T_2$ is significant at the .10 level. It can be seen that the F-value for sub-scale 2 in Table 6 for $T_1 \times T_2$ is 3.8, which is indicative of a difference at the .10 level.
of significance in the performance of BSCS Biological Science classes \((T_2)\) as compared with the performances of the experimental IYE classes \((T_1)\). The null hypothesis:

There is no significant difference between the two modes of instruction in the ability of students to evaluate reliability of information

is therefore rejected at the .10 level of significance.

3. Deduction

The third section of "Exploring in Nicoma" (items 52-65), purports to measure the basic principles of deductive logic, the ability to judge whether a statement follows logically from premises.

Sub-scale 3 (Deduction) of Table 5 shows that the combined 16 more structured conventional biology classes consistently demonstrate higher ability to apply deductive reasoning as compared to the 16 classes in the experimental IYE \((T_1)\) program, insofar as items 52-65 truly measure deductive processes. But the F-values for sub-scale 3 in Table 6 do not show differences at a level of statistical significance. Therefore, the null hypothesis:

There is no significant difference between the two modes of instruction in students demonstrating ability for deductive reasoning

is not rejected.

4. Assumption Finding

The fourth section of the scenario (items 67-76) focuses on the
identification of the most plausible assumptions, and the relevance of assumptions to the validity of arguments.

Sub-scale 4 (Assumption Finding) of Table 5 again shows that the 16 conventional biology classes consistently demonstrate higher ability to apply intellectual processes in analyzing assumptions in comparison with the 16 classes involved in the IYE experimental program ($T_1$), to the extent that the test items truly measure ability to identify most plausible assumptions. However, $F$-values for sub-scale 4 in Table 6 do not show differences at a level of statistical significance. Therefore, the null hypothesis:

There is no significant difference between the two modes of instruction in the ability of students to identify plausible assumptions is not rejected.

In conclusion, for the over-all performance of the 32 classes in the CCTT, the total treatment means as shown in Table 5 reveal that the 16 combined conventional biology classes demonstrate higher critical thinking ability as measured by this criterion test compared with the 16 combined classes involved in the experimental IYE ($T_1$) program.

For $T_1 \times T_2$ an $F$-value < 4.96 and > 10.04 is significant at the .05 level of significance. Table 6 shows that the $F$-value for the total performance rating of $T_1 \times T_2$ is 7.13, which indicates that the BSCS Biological Science classes ($T_2$) demonstrated higher over-all
performance ratings as compared with the experimental IYE \( (T_1) \) program at the .05 statistical level of significance.

For \( T_1 \times T_2T_3 \) and F-value \(< 3.07 \) and \( > 4.54 \) is significant at the .10 level of significance. Table 6 shows that the F-value for \( T_1 \times T_2T_3 \) is 3.09, which indicates that the more structured conventional biology programs combined \( (T_2T_3) \) demonstrated higher overall performance in the CCTT than that of the experimental IYE \( (T_1) \) program at a .10 statistical level of significance.

On the basis of the data obtained in this research study, the major hypothesis:

There is no significant difference between the two modes of instruction in stimulating critical thinking in students as measured by the CCTT is rejected at the .05 significance level for \( T_1 \times T_2 \), and at the .10 significance level for \( T_1 \times T_2T_3 \).

**Biology Students Behavioral Inventory**

The BSBI consists of four sub-scales designed to assess specific operations in the affective domain. These are: (1) Curiosity, (2) Openness, (3) Satisfaction, and (4) Responsibility.
Table 7 shows class mean data for the treatment groups $T_1 \times T_2$, $T_1 \times T_3$, and $T_1 \times T_2 T_3$ combined for each of the four sub-scales and the total survey.

Table 7. Treatment mean for the BSBI

<table>
<thead>
<tr>
<th>Treatment Groups</th>
<th>Sub-Scales</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>$T_1$</td>
<td></td>
<td>2.45</td>
<td>3.01</td>
<td>3.34</td>
<td>3.18</td>
<td>2.99</td>
</tr>
<tr>
<td>$T_2$</td>
<td></td>
<td>2.49</td>
<td>3.08</td>
<td>3.26</td>
<td>3.17</td>
<td>3.00</td>
</tr>
<tr>
<td>$T_1$</td>
<td></td>
<td>2.35</td>
<td>2.68</td>
<td>3.10</td>
<td>2.85</td>
<td>2.75</td>
</tr>
<tr>
<td>$T_3$</td>
<td></td>
<td>2.40</td>
<td>3.06</td>
<td>3.26</td>
<td>3.19</td>
<td>2.97</td>
</tr>
<tr>
<td>$T_1$</td>
<td></td>
<td>2.42</td>
<td>2.91</td>
<td>3.27</td>
<td>3.07</td>
<td>2.91</td>
</tr>
<tr>
<td>$T_2 T_3$</td>
<td></td>
<td>2.46</td>
<td>3.07</td>
<td>3.26</td>
<td>3.18</td>
<td>2.99</td>
</tr>
</tbody>
</table>

Table 8 shows the F-values for each of the four sub-scales and the total inventory.

Table 8. Analysis of variance schematic for the BSBI

<table>
<thead>
<tr>
<th>Treatment Groups</th>
<th>d.f.</th>
<th>Sub-Scales</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>$T_1 \times T_2$</td>
<td>1</td>
<td>.18</td>
<td>.02</td>
</tr>
<tr>
<td>$T_1 \times T_3$</td>
<td>1</td>
<td>.78</td>
<td>2.36</td>
</tr>
<tr>
<td>$T_1 \times T_2 T_3$</td>
<td>1</td>
<td>.43</td>
<td>1.18</td>
</tr>
</tbody>
</table>

* Level of significance = .10
** Level of significance = .05
Tables 7 and 8 illustrate the statistical findings from comparing two teaching methodologies used with the treatment groups. A discussion of the four sub-scales and the hypothesis test result in each of the sub-scales follows. All hypotheses assert that there is no significant difference in class means of the treatment groups in any of the sub-scales.

1. **Curiosity**

In a 39-item instrument, 11 items are used to determine the curiosity sub-score which is described by the authors, Steiner and Lee (1970a), as a measure of the desire for additional information related to the study.

Sub-scale 1 (Curiosity) in Table 7 reveals that in each of the treatment groups, classes in the more structured conventional biology programs consistently demonstrate a slightly higher interest level in searching for the 'hows' and the 'whys' of problems as compared with classes involved in the experimental IYE (T₁) program, insofar as the criterion test truly measures "curiosity" in the 11 items.

However, since an F-value < 3.07 would be required to demonstrate a significant difference for any comparison of class means in the treatment groups at the .10 level of significance or higher; and since F-values for sub-scale 1 in Table 8 show a performance level
rating below 1.0 in all treatment group comparisons, the null hypothesis:

There is no significant difference between the two modes of instruction in students generating curiosity is therefore not rejected.

2. **Openness**

The 39-item instrument uses 17 items for the openness subscore, which is described by the authors as a measure of willingness to subject data, assumptions, and opinions to criticism and evaluation.

Sub-scale 2 (Openness) in Table 7 reveals that in each of the treatment levels, classes in the more structured conventional biology programs consistently demonstrate a higher degree of openness to external scrutiny as compared with the experimental IYE (T1) classes, insofar as the test items measure "openness".

For T$_1$ x T$_3$, an F-value < 7.71 and > 21.19 is significant at the .05 level. Table 8 shows that the F-value for T$_1$ x T$_3$ is 8.21, which indicates that the combined Modern Biology classes (T$_3$) demonstrated a higher performance rating in Openness at the .05 level of significance as compared with the experimental IYE (T$_1$) classes.

For T$_1$ x T$_2$T$_3$, an F-value < 3.07 and > 4.54 is significant at the .10 level. Table 8 shows that the F-value for T$_1$ x T$_2$T$_3$ in subscale 2 is 4.28, which indicates that the more structured conventional biology classes combined (T$_2$T$_3$) demonstrated higher performance
ratings in Openness at the .10 level of significance as compared with the experimental IYE (T₁) classes.

In light of the data obtained in sub-scale 2 related to Openness, the null hypothesis:

There is no significant difference in the two modes of instruction in students demonstrating openness is therefore rejected at the .05 level of significance for T₁ x T₃, and at the .10 probability level for T₁ x T₂ T₃.

3. Satisfaction

In the 39-item instrument, seven items are specifically designed to identify personal satisfaction gained from engaging in the inquiry process of learning. Sub-scale 3 (Satisfaction) in Table 7 reveals that the experimental classes (T₁) show a slightly higher rating in two out of three treatment groups than the classes in the more structured conventional biology programs, insofar as the criterion instrument truly measures personal satisfaction in the seven items. However, F-values for sub-scale 3 in Table 8 indicate that all treatment levels rate "satisfaction" very low. Where an F-value < 3.07 would be necessary to show a .10 level of significance for any comparison of class means, all treatment groups show a level >1.5. In view of this outcome, the null hypothesis:
There is no significant difference between the two modes of instruction in influencing students to view the inquiry process as a rewarding experience is not rejected.

4. **Responsibility**

Four items in the inventory provide the responsibility subscore. It is described by the authors as the participation of learners in deriving conclusions based on adequate and sound evidence; and the interaction of learners in providing rationale for criticism and evaluation.

Sub-scale 4 (Responsibility) in Table 7 reveals that classes in more structured conventional biology programs in general tend to show slightly higher responsibility indices than classes involved in the experimental program, insofar as the four items in this criterion test truly measure "responsibility" as defined by the designers of the instrument, Steiner and Lee (1970a). However, as shown in Table 8 for sub-scale 4, where an F-value < 3.07 would be necessary to show significance at the .10 level for any comparison of class means in the treatment groups, all ratings hover in the >1.03 range. Based on the findings in sub-scale 4 of Tables 7 and 8, the null hypothesis:

There is no significant difference between the two modes of instruction in influencing students to exercise personal responsibility

is therefore not rejected.
In conclusion, the over-all ratings of the treatment groups in the BSBI as shown in Tables 7 and 8 are inconsequential. In the total 39-item inventory, the more structured conventional biology classes tend to show slightly more favorable behaviors relative to the four attitudes of the affective domain which the criterion instrument purports to measure. However, since F-values in Table 8 for total performance are all $>2.36$, where $<3.07$ is necessary for a significance level at .10 in the comparison of class means for any of the treatment groups, the major null hypothesis:

There is no significant difference in the two modes of instruction in students fostering specific affective behaviors as measured by the BSBI

is not rejected.

Analysis of Covariance

The CTBS was used for covariance analysis. The CTBS class mean scores were obtained from tests administered in May of 1974 when the majority of the participating classes were in the ninth grade. The research study was conducted during the following school year of 1974-1975 when the majority of the participating classes were in the tenth grade.
Table 9 shows the CTBS class mean of all treatment groups 
\((T_1 \times T_2, T_1 \times T_3, T_1 \times T_2 T_3)\) in the areas of reading, language, arithmetic, and composite ratings.

Table 9. CTBS class mean

<table>
<thead>
<tr>
<th>Treatment Group Means</th>
<th>1 Reading</th>
<th>2 Language</th>
<th>3 Arithmetic</th>
<th>Total Composite</th>
</tr>
</thead>
<tbody>
<tr>
<td>(T_1)</td>
<td>10.28</td>
<td>9.55</td>
<td>10.44</td>
<td>10.09</td>
</tr>
<tr>
<td>(T_2)</td>
<td>10.46</td>
<td>9.84</td>
<td>10.59</td>
<td>10.30</td>
</tr>
<tr>
<td>(T_1)</td>
<td>9.18</td>
<td>8.90</td>
<td>9.38</td>
<td>9.16</td>
</tr>
<tr>
<td>(T_3)</td>
<td>9.46</td>
<td>8.58</td>
<td>9.64</td>
<td>9.24</td>
</tr>
<tr>
<td>(T_1)</td>
<td>9.94</td>
<td>9.34</td>
<td>10.11</td>
<td>9.80</td>
</tr>
<tr>
<td>(T_2 T_3)</td>
<td>10.15</td>
<td>9.44</td>
<td>10.29</td>
<td>9.97</td>
</tr>
</tbody>
</table>

The combined 16 classes assigned to the more structured, conventional biology program appear to be slightly more advanced in grade placement by one to three months in all three basic skills as compared to the combined 16 classes involved in the experimental IYE program, \((T_1)\). However, Table 9 reveals that class averages in treatment groups being compared appear to show minimal variation and high correlation in basic skills of reading, language, and arithmetic.
F-values for the CTBS scores appear in Table 10.

### Table 10. Analysis of covariance schematic for CTBS

<table>
<thead>
<tr>
<th>Criterion Tests</th>
<th>d.f.</th>
<th>CTBS Sub-Scales</th>
<th>Criterion Test Sub-Scales</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>ATES</td>
<td>1</td>
<td>Reading</td>
<td>1.91</td>
<td>.82</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Language</td>
<td>.03</td>
<td>2.07</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Arithmetic</td>
<td>.24</td>
<td>1.67</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Composite</td>
<td>.11</td>
<td>2.16</td>
</tr>
<tr>
<td>CCTT</td>
<td>1</td>
<td>Reading</td>
<td>.36</td>
<td>2.31</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Language</td>
<td>.01</td>
<td>.57</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Arithmetic</td>
<td>.69</td>
<td>.33</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Composite</td>
<td>.01</td>
<td>1.33</td>
</tr>
<tr>
<td>BSBI</td>
<td>1</td>
<td>Reading</td>
<td>.62</td>
<td>.70</td>
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<td>Language</td>
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<td></td>
<td>Arithmetic</td>
<td>.15</td>
<td>.96</td>
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<tr>
<td></td>
<td></td>
<td>Composite</td>
<td>.01</td>
<td>.39</td>
</tr>
</tbody>
</table>

**Criterion Test Sub-Scales**

**ATES**

1. Future Orientation
2. Learning How to Learn
3. Self Responsibility
4. Learning as Process
5. Learning as Knowing Facts
6. Relevance of School

**CCTT**

1. Induction
2. Reliability
3. Deduction
4. Assumption

**BSBI**

1. Curiosity
2. Openness
3. Satisfaction
4. Responsibility Finding

Since an F-value < 3.07 is necessary for a .10 significance level in the comparison of class means for any of the treatment groups, and since the highest F-value shown in Table 10 on any sub-scale is 2.31, the F-values for the CTBS scores show that correlations between total...
group means on each of the sub-scales of the three criterion tests and the CTBS were non-significant for all covariant variables: namely, reading, language, and arithmetic skills.

Discussion of the Findings

This research has dealt with a study of the effect of two teaching methodologies in high school biology upon attitudes toward education, critical thinking ability, and specific affective behaviors as demonstrated by class performance of two treatment groups on three specific tests.

The hypotheses stated that there was no significant difference between the two modes of instruction in class performance of the treatment groups on any criterion test for any sub-scale.

Attitudes Toward Education Survey

Of the six sub-scales in the ATES, four sub-scales showed non-significant positive correlations, and two sub-scales showed significant differences at the .05 and .10 probability levels.

In "Self Responsibility" (sub-scale 3), all classes in the treatment groups scored between 5.96 and 6.50, with 4.0 as the median. Although the combined 16 experimental IYE classes (T1), consistently scored slightly higher on the scale in "Self Responsibility" than the more structured counterpart biology classes, no significant statistical
relationship was shown. The outcome of the IYE classes is consistent with the program philosophy. However, the fact that no classes scored above 6.50 on an 8.0 scale raises the question as to whether students in general feel comfortable with being responsible to any high degree for making decisions about their own learning.

Regarding "Learning as Process" (sub-scale 4), all classes in the treatment groups scored between 5.08 and 5.64, slightly above the median 4.0, which indicates that all 32 classes do appear to view learning somewhat as a process involving a series of participatory activities: asking questions, seeking answers, gathering data, formulating hypotheses, performing investigations. Since no class in the treatment groups scored above 5.64 on an 8.0 scale, the question again arises concerning student views in general regarding the learning process. Do students in general desire more directed learning experiences?

All 32 classes in the research study scored below 2.60 with 4.0 as the median in "Learning as Knowing Facts" (sub-scale 5). The data shows that students do not appear to view learning primarily as accumulating and memorizing facts. Although a significant statistical relationship does not exist, the combined 16 experimental classes (T1) have consistently lower ratings for "Learning as Knowing Facts" in all comparative studies than the more structured counterpart biology classes. This outcome is consistent with the IYE program philosophy.
Scores obtained on "Relevance of School" (sub-scale 6) for the combined 32 classes in the research study range from 4.50 to 5.39, indicating that the 32 classes participating in this research study tend to take a somewhat middle-of-the-road view of the relevance of school to the real world. With 4.0 as the median, the data shown in the treatment means are particularly intriguing in that the combined 16 classes in the experimental program ($T_1$) show lower ratings than the combined counterpart, more structured biology classes. This outcome indicates that even though F-tests in Table 4 for sub-scale 6 do not show significant differences in the treatment groups, the combined 16 classes of the IYE program consistently report that school is less relevant to them than is reported by the other biology classes involved in this research study, an outcome not anticipated in the IYE treatment group.

Data for both "Future Orientation" and "Learning How to Learn" (sub-scales 1 and 2) show significant statistical differences in the ATES.

In "Future Orientation" (sub-scale 1) a significant difference at the .10 level between $T_1 \times T_3$, and a significant difference at the .05 level between $T_1 \times T_2 T_3$ appears in Table 4. All classes in the research study rate "The purpose of education is primarily a preparation for college" below 3.70 on an 8.0 scale. The IYE ($T_1$) classes consistently rate lower on the scale than the counterpart, more
structured biology classes, with significant differences appearing in two out of three comparisons made. The outcome supports one of the major program goals for the IYE module: to help students recognize that the purpose of education is to prepare for life rather than necessarily for college.

Although a significant difference at the .10 probability level appears only between $T_1 \times T_3$ in Table 4 for "Learning How to Learn" (sub-scale 2), the treatment mean data reveal that the combined 16 classes involved in the experimental program ($T_1$) consistently rate somewhat higher than the more structured counterpart biology classes. This outcome is consistent with the IYE program goals. However, all 32 classes show a rating range between 5.18 and 5.88, slightly above the median 4.0 for "Learning How to Learn". Since students scoring high on this scale (1.0 to 8.0) appear to view the purpose of education as preparing for learning on one's own, and since the highest rating of any class means was 5.88, it seems clear as a result of this study that the 32 classes participating in the research are not convinced that the purpose of education is in fact preparing for learning on one's own.

In conclusion, with the exception of "Future Orientation" and "Learning How to Learn", the absence of a significant difference in the class means of the treatment groups in the ATES indicates that in
this research study the methodology used was not a factor in the outcomes of the particular attitudes examined.

**Cornell Critical Thinking Test**

In the CCTT for "Induction" (sub-scale 1), "Deduction" (sub-scale 3), and "Assumption Finding" (sub-scale 4), an inverse correlation appears in Table 5 in which it can be seen that the combined IYE (T₁) classes scored lower, although non significantly, in these critical thinking operations than the more structured biology classes, as measured by the CCTT instrument.

In "Reliability" (sub-scale 2) the inverse relationship is shown in Tables 5 and 6 at the .10 level of statistical significance for T₁ x T₂ with class means of the BSCS Biological Science classes (T₂) showing higher ability to judge the reliability of statements, insofar as the test items truly measure reliability, as compared with the combined class means of the experimental (T₁) classes.

In the over-all total scores of the treatment groups on the CCTT, Table 6 shows that the BSCS Biological Science classes (T₂) scored significantly higher at the .05 probability level, and that the combined conventional biology classes (T₂T₃) scored significantly higher at the .10 probability level as compared with classes involved in the experimental IYE (T₁) program.

A possible inverse relationship is suggested by the results of the
performance of the treatment groups on the CCTT. It would appear from the results of this study that achievement in cognitive processes as measured by the CCTT is more tenable in more structured biology programs than in the IYE program which allows each student to select and pursue an investigation of his own choosing.

It may be contested that the CCTT is not the most appropriate instrument for measuring cognitive processes in students engaged in independent learning. This might suggest the suitability of constructing such an instrument designed specifically for measuring cognitive achievement in students participating in non-structured, independent learning activities.

**Biology Students Behavioral Inventory**

Of the four sub-scales in the BSBI three showed non-significant correlations.

For "Curiosity" (sub-scale 1), the more structured conventional biology classes scored slightly higher, although non-significantly, in demonstrating interest in searching for the "hows" and "whys" of things as compared with combined classes in the experimental IYE program. This outcome was not anticipated by the investigator in respect to the performance of IYE classes.

Regarding "Openness" (sub-scale 2), an inverse relationship appears at a significance level of .05 probability in the comparison of
T₁ x T₃ with the combined Modern Biology classes rating higher in the measurement of willingness to subject data, assumptions and opinions to criticism and evaluation compared with the combined IYE (T₁) classes. This outcome is not in conformity with expected performance for the IYE classes.

Both "Satisfaction" (sub-scale 3) and "Responsibility" (sub-scale 4) show non-significant correlations. Concerning "Satisfaction", however, classes in the experimental IYE (T₁) biology program, with the exception of T₁ x T₃, show a slightly higher rating in two out of three treatment comparisons. It can be seen in sub-scale 3 of Table 7 that in T₁ x T₃, the Modern Biology classes (T₃) appear to gain greater satisfaction than the IYE (T₁) classes from engaging in the inquiry process of learning. This outcome is contrary to the expectations of the investigator since satisfaction in discovery learning and inquiry processes is a major goal of the IYE module. The outcome proposes a very interesting observation. Writing about discovery as an aspect of learning, Evans (1969) points out that the mid-seventies have no monopoly on discovery learning. Tracing the history of intellectual inquiry methods from the ancient Greeks to the present, Evans (1969) states, "Learning by discovery is certainly not a phenomenon unique to the Twentieth Century. It is a fundamental form of learning as old as man himself" (p. 555). It would seem that a call for "enosis"--or union of the best of the past and the present to
achieve the desires of the future—is in order. It is perhaps not any one unique methodology which produces the best results all of the time.

With regard to "Responsibility" (sub-scale 4), Table 7 reveals that classes in more structured programs in general tend to show slightly higher, though non-significant, reliability indices as compared to the IYE (T₁) classes, insofar as the 4 items in the criterion instrument truly measure "Responsibility". The same is true in the outcomes shown in Table 7 for the comparisons of total test results.

There may be any number of factors which might have contributed to the inverse outcomes in several instances of treatment group comparisons in the CCTT and the BSBI. Classes involved in the experimental IYE (T₁) program were switched from the more structured biology program they had been used to during the first part of the school year to pilot the experimental module in the last 9-11 weeks of the school year. A psychological adjustment process might have influenced student performance. Difficulty in adapting to change, inability to cope with greater freedom, and rather sudden personal responsibility for time utilization are but a few additional factors which may have contributed to a sense of instability on the part of some students in each of the 16 experimental classes. The short time factor of 9 to 11 weeks exposure to the IYE module may not have provided
sufficient opportunity for some students to feel comfortable with self-directed learning methodology.

In conclusion, with the exception of the "Openness" sub-scale, the absence of a significant difference in the ratings of the treatment groups indicates that methodology is not a factor in class performance on the BSBI in this research study.

Summary

Chapter IV was presented in three major sections. The first section included the method of statistical analysis used to interpret the data.

Section two presented the hypotheses test results for the three major and the fourteen minor hypotheses. One of the three major hypotheses was rejected. The hypothesis which stated there was no significant difference between the two modes of instruction in stimulating critical thinking among students as measured by the CCTT was rejected at the .05 probability level. Four of the 14 minor hypotheses were rejected. In the ATES the minor hypothesis pertaining to Future Orientation was rejected at the .05 level of significance, and the minor hypothesis relating to Learning How to Learn was rejected at the .10 probability level. In the CCTT the minor hypothesis pertaining to Reliability was rejected at the .10 level of significance, and in
the BSBI the minor hypothesis pertaining to Openness was rejected at the .05 probability level.

A discussion of the findings in each of the criterion tests was considered in section three.
V. SUMMARY, CONCLUSIONS, AND RECOMMENDATIONS

This chapter is divided into four major sections. The first section presents a summary of the study including a review of the purpose, the pilot study, the experimental design, procedures, and statistical analysis. Section two recapitulates the outcomes of the hypotheses test results. Major hypotheses test results are discussed first, and a discussion of the 14 minor hypotheses test results follow. Conclusions are presented in Section 3, and Section four is devoted to recommendations for further study.

Summary

Purpose of the Study

The intent of this study was to investigate several hypotheses concerning specific demonstrable attitudes toward education, critical thinking ability, and affective behavior as these are manifested by students in structure-oriented biology classes, and in the new IYE module.

A review of the literature related to (1) the goals of science education for the next decade; (2) teaching methodologies that purport to implement the goals of science education; (3) current theories pertaining to attitudes toward education, critical thinking, and the place of creativity in human development; and (4) contemporary views
concerning the implications of values and social responsibility; revealed that major efforts are being directed to the design and evaluation of curricula that links science realistically to life, and to the management of science related societal problems in this period of history fast approaching Century-21.

One specific experimental program frequently referred to in the literature as representing a departure from the more traditional teaching methodologies and a response to present day pedagogical needs provided the impetus for this study.

Pilot Study

This research investigation was conducted in the 1974-1975 school year following a two-week briefing session at Boulder, Colorado, in which the cooperating teachers explored both the learner and the teacher roles of the new IYE module.

Participants in the study were students in 32 classes throughout the United States representing broad geographic, ethnic, and socio-economic distribution. Sixteen classes were randomly assigned to the IYE module, which subsequently has been published in 1975 by Addison-Wesley Company. Sixteen classes were randomly assigned to the structure-oriented biology program taught by the same cooperating teachers. Although all 16 teachers were BSCS teachers by preference and training, the choice of the course used in the structure-
oriented classes was determined by the school adoption where the teachers were located. Therefore, two teachers used Biological Science: Molecules to Man, (BSCS Blue Version); four teachers used Biological Science: An Ecological Approach, (BSCS Green Version); four teachers used Biological Science: An Inquiry into Life, (BSCS Yellow Version); one teacher used Biological Science: Invitations to Discovery, (BSCS 2nd level course); and five teachers used Modern Biology by Otto and Towle (1973). There were 355 students in the experimental module biology program and 375 students in one of the structure-oriented biology programs.

Experimental Design

The research design used was that of Campbell and Stanley's (1963) Design 6, the Posttest-Only model, which controls for testing as main effect and interaction. Design 6, or Posttest-Only, was chosen to avoid an experimenter-induced pretest session, and to avoid what Campbell and Stanley (1963, p. 26) describe as the "give-away" repetition of highly similar unusual content, as in attitude change studies.

The ATES (Steele, 1969a) was used to assess specific outcomes of the treatment groups in six sub-scales: (1) Future Orientation, (2) Learning How to Learn, (3) Self Responsibility, (4) Learning as Process, (5) Learning as Knowing Facts, and (6) Relevance of School.
The CCTT, Level X (Ennis and Millman, 1971) was used to compare results of treatment groups in cognitive operations which involve: (1) Induction, (2) Reliability, (3) Deduction, and (4) Assumption Finding.

The BSBI, Form C (Steiner and Lee, 1970a) was used to compare outcomes of treatment groups in the affective domain in the areas of: (1) Curiosity, (2) Openness, (3) Satisfaction, and (4) Responsibility.

The CTBS, Form Q, was used for covariance analysis to compare equivalency of treatment groups in the areas of: (1) Reading, (2) Language, (3) Arithmetic, and (4) Composite Ratings.

The 16 cooperating teachers all taught two or more biology classes per day, with one of each teacher's classes randomly selected for piloting the IYE experimental module. Intact classes of the treatment groups were non-tracked.

General ability of the treatment groups in reading, language, and arithmetic was obtained for covariance analysis from class means on the CTBS.

Data were analyzed by computing group means of the intact classes after obtaining individual scores in each of the criterion tests.

**Procedures**

The cooperating teachers in the research study were volunteers from among those in the August 1974 briefing session in Boulder, and
volunteer teachers from among those participating in the IYE in-service training program in Fresno, California, in 1974.

The random assignment of treatments to class periods was determined by utilizing Snedecor's (1956) Table of Random Numbers, and by informing cooperating teachers by postcard announcement prior to the implementation of the experimental module. Teachers detached and returned a self-addressed postcard to the investigator providing information on the number of students in each treatment group, and approximate dates when they would be ready to administer the test instruments. Packages of testing materials sufficient for a class set, directions for administering, answer sheets for the total number of students involved in each treatment group, and stamped return mailers specifically identified for the appropriate answer sheets of each treatment group per teacher, were then sent by first class mail to the cooperating teachers.

Criterion tests were administered by the teachers to their own classes near the end of the spring term, 1975. Directions for administering tests were clearly explained in the manuals accompanying each set of tests. At the conclusion of each testing session, the sets of answer sheets were stapled, an ID sheet attached providing vital statistics such as treatment group, class period, teacher name, etc.; and they were returned to the investigator for processing.
Statistical Analysis

The data were computed by two-factor analysis of variance using *Anova 12 at Oregon State University Computer Center to statistically test the null hypotheses. The F-test was used to compare treatment results.

Three criterion tests having a total of 14 sub-scales were used to compare performances of the two treatment groups. Seventeen variables were used to test the three major and 14 minor hypotheses.

Discussion of Hypotheses Test Results

Seventeen null hypotheses were tested in this study. Seven hypotheses related to attitudes toward education, and five hypotheses related to critical thinking ability. The remaining five hypotheses related to specific affective behaviors, including curiosity, openness, satisfaction and responsibility.

Outcomes Related to the Major Hypotheses

The two major hypotheses, which stated there was no significant difference in the two modes of instruction upon student attitudes toward education or upon specific student affective behaviors among classes in the treatment groups, were tested and not rejected.

The F-test for the null hypothesis relating to critical thinking
ability showed that the hypothesis was rejected in the comparison of $T_1$ and $T_2$ at the .05 level of significance, with the results of the BSCS Biological Science classes showing higher performance ratings in overall critical thinking ability as compared to the experimental module classes. The $F$-value obtained for $T_1 \times T_2$ was 7.13. Since an $F$-value $< 4.96$ and $>10.04$ is significant at the .05 probability level, the null hypothesis:

There is no significant difference between the two modes of instruction in stimulating critical thinking in students as measured by the CCTT

was rejected at the .05 level of significance.

The $F$-test also showed the same hypothesis was rejected in the comparison of $T_1$ and $T_2 \times T_3$ combined, at the .10 level of significance, with the results of the combined, structure-oriented biology programs showing higher performance ratings in overall critical thinking ability as compared to the experimental module ratings. The $F$-value obtained for $T_1 \times T_2 \times T_3$ was 3.09. Since an $F$-value $< 3.07$ and $>4.54$ is significant at the .10 probability level, the same null hypothesis relating to these treatment comparisons was likewise rejected at the .10 level of significance.

**Outcomes Related to the Minor Hypotheses**

**Attitudes Toward Education Survey.** No significant $F$-values were found in the class means of the treatment groups for Self
Responsibility, Learning as Process, Learning as Knowing Facts, and Relevance of School: four of the six sub-scales in the ATES. Therefore, the null hypotheses relating to these four aspects of the attitude survey were not rejected.

The F-test for the null hypothesis relating to Future Orientation showed that the hypothesis was rejected in the comparison of $T_1$ and $T_3$ at the .10 level of significance with the results of the experimental module classes showing they were less inclined to view education as mainly a preparation for college as compared to the Modern Biology classes. This outcome is consistent with the program philosophy. The F-value obtained for $T_1 \times T_3$ was 6.80. Since an F-value $< 4.54$ and $> 7.71$ is significant at the .10 probability level, the minor null hypothesis:

There is no significant difference between the two modes of instruction in influencing students' views of secondary education as a preparation for college

was rejected at the .10 level of significance.

The F-test also showed the same hypothesis was rejected in the comparison of $T_1$ and $T_2T_3$ combined, at the .05 level of significance, with the results of the experimental module classes showing they were less inclined than the structure-oriented biology classes to view education as mainly a preparation for college. The F-value obtained for $T_1 \times T_2T_3$ was 7.30. Since an F-value $< 4.50$ and $> 8.68$ is significant at the .05 probability level, the same null hypothesis relating to
these treatment comparisons was likewise rejected at the .05 level of significance. This outcome is highly supportive of the IYE program philosophy.

The F-test for the null hypothesis relating to Learning How to Learn showed that the hypothesis was rejected in the comparison of T₁ and T₃ at the .10 level of significance, with the results of the experimental module classes showing greater tendency to view the purpose of education as preparing for learning on one's own than the Modern Biology classes. This outcome is consistent with the program philosophy. The F-value obtained for T₁ x T₃ was 5.04. Since an F-value < 4.54 and > 7.71 is significant at the .10 probability level, the minor null hypothesis:

There is no significant difference between the two modes of instruction in influencing students' views of secondary education as a preparation for self-learning

was rejected at the .10 level of significance.

Cornell Critical Thinking Test. No significant F-values were found in the class means of the treatment groups for Inductive Reasoning, Deductive Reasoning, and Ability to Identify Plausible Assumptions: three of the four sub-scales in the CCTT. Therefore, the null hypotheses relating to these three aspects of the critical thinking test were not rejected.

The F-test for the null hypothesis relating to Evaluating
Reliability of Information showed that the hypothesis was rejected in the comparison of $T_1$ and $T_2$ at the .10 level of significance, with the results of the combined BSCS Biological Science classes showing higher ability to evaluate the reliability of information as compared to the combined experimental module classes. The F-value obtained for $T_1 \times T_2$ was 3.82. Since an F-value $< 3.28$ and $> 4.96$ is significant at the .10 probability level, the minor null hypothesis:

There is no significant difference in the two modes of instruction in the ability of students to evaluate reliability of information

was rejected at the .10 level of significance.

**Biology Students Behavioral Inventory.** No significant F-values were found in the class means of the treatment groups for Curiosity, Satisfaction and Responsibility: three of the four sub-scales in the BSBI. Therefore, the null hypotheses relating to those three aspects of the behavioral inventory were not rejected.

The F-test for the null hypothesis relating to Openness showed that the hypothesis was rejected in the comparison of $T_1$ and $T_3$ at the .05 level of significance, with the results of the Modern Biology classes showing more openness as compared to the experimental module classes. The F-value obtained for $T_1 \times T_3$ was 8.21. Since an F-value $< 7.71$ and $> 21.19$ is significant at the .05 probability level, the minor null hypothesis:

There is no significant difference in the two modes of instruction in students demonstrating openness
was rejected at the .05 level of significance.

The F-test also showed the same hypothesis was rejected in the comparison of \( T_1 \) and \( T_2T_3 \) combined, at the .10 level of significance, with the results of the combined, structure-oriented classes showing greater openness than the experimental module classes. The F-value obtained for \( T_1 \times T_2T_3 \) was 4.28. Since an F-value < 3.07 and > 4.54 is significant at the .10 probability level, the same null hypothesis relating to these treatment comparisons was likewise rejected at the .10 level of significance.

**Conclusions**

Within the framework of this study, students who participated in the IYE module, which allows maximum latitude for each student to select and pursue independently an investigation of his own choosing, did not appear to differ significantly in the achievement of the overall outcomes examined from students in more structure-oriented biology programs. The results of this study indicate that students in more structure-oriented programs actually demonstrated greater facility in the cognitive processes examined than did those in the experimental program. Likewise, students in the more structure-oriented classes in general showed more positive responses in the affective behaviors examined.

Several factors may have contributed to the inverse relationship
in the performance of classes in the experimental program. Considerations which may have had a bearing include the following.

1) Classes selected to pilot the IYE module in the last 9-11 weeks of the school year had previously been participating in more structure-oriented biology programs the greater part of the school year.

2) Students may have found difficulty adapting to the change of instructional methodology.

3) Students may have found coping with greater freedom, being personally responsible for time utilization, and for collecting and manipulating data too difficult to handle all at once.

4) The 9-11 week term may not have provided sufficient time for psychological and mental adjustments among students to take place.

More research is needed on the competencies that are necessary for students to succeed in self-directed learning. It may very well be that only learners exhibiting specific aptitudes ought to be given the latitude within a school setting to pursue self-directed learning. It may also very well be that educators are remiss in developing and utilizing effectively the instructional methodologies that motivate students to become more personally responsible for self-learning. The whole problem of pedagogy raises a hydra-headed issue. If the raison d'être for methodology is to facilitate learning, much research is yet to be done to discover what constitutes an effectual learning
environment to accommodate a wide variety of aptitudes and capabilities in human beings.

Recommendations for Further Study

On the basis of this investigation, the following recommendations are presented for further consideration.

1. Significant differences in achievement of program goals may not occur over a nine-week experimental period. Therefore, it is recommended that a comparable study comparing the effects of the two programs researched in this investigation be conducted with classes that have become familiarized with the IYE environmental module for a minimum of one school year.

2. It is recommended that a comparable study be done to compare the effects of the two programs researched in this investigation utilizing a greater number of teachers, thereby a large student population.

3. It is suggested that a comparable study comparing the effects of the two programs researched in this investigation be conducted using different teachers as opposed to the same teachers for each of the treatment groups.

4. It is further suggested that a study be undertaken which will attempt to measure the effects attributable to individual teacher attitudes, critical thinking, and creative ability toward class
achievement of science program goals.

5. It is proposed that a study be conducted to identify the appropriate student population for participating in self-directed, individualized science programs at the secondary level.

6. It is further proposed that a study be undertaken to discover what specific competencies are needed for students to succeed in self-directed learning.

7. It is suggested that a study be undertaken to identify teacher competencies needed to adequately supervise independent, self-directed science programs at the secondary level.

8. It is proposed that a study be undertaken to identify appropriate evaluative instruments for self-directed science courses in which students pursue independent research investigations.

9. It is further proposed that a comparable study be conducted in which biology is an elective as opposed to a required course for the secondary students involved in the study.

10. It is recommended that a study be done to determine the relationship of critical thinking ability and success in biology as a subject.

11. It is suggested that a study be done to determine the relationship of critical thinking ability and achievement of the goals in the new IYE environmental module.

12. It is proposed that a study be done to determine the relationship
of creativity and success in biology as a subject.

13. It is suggested that a study be done to determine the relationship of creativity to achievement of the goals in the new IYE environmental module.

14. One of the advantages cited for self-directed, individualized science program methodology is that it will motivate positive student behaviors through the student's active involvement in scientific pursuits of personal choosing. It is recommended that a study be undertaken to research this claim.

15. Presently it is not known whether negative psychological effects, if any, may be attributable to compulsory, self-directed science programs for untracked students. It is proposed that the emotional effects of compulsory, self-directed science course programs upon individual personalities be investigated.
BIBLIOGRAPHY


BSCS Biological Science Versions.


APPENDICES
# APPENDIX A

## COOPERATING TEACHERS

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ATTITUDES TOWARD EDUCATION SURVEY

Below are a number of statements about schools and education. Consider each statement as a statement of opinion. If you agree at least a little bit with the statement, circle the letter A. If you disagree even a little bit with the statement, circle the letter D. If you both agree and disagree, or if you have no opinion, leave the letters uncircled.

A = AGREE  D = DISAGREE  Blank = Neither

1. A  D  A major purpose of school is to teach the student the facts that he or she will need to get into college.

2. A  D  Schools should help people get ready to learn more after they leave school.

3. A  D  Learning about what I think is important would waste a lot of time in school.

4. A  D  Schools are concerned with real things that I think are important.

5. A  D  I usually don’t see a use for most things that I learn in school.

6. A  D  I can learn a lot of things that are important to me outside of school.

7. A  D  It is important that everyone in a class learn the same thing.

8. A  D  Knowing how to find facts is more important than knowing facts.

9. A  D  Answering my questions is more important than answering the book’s questions.

10. A  D  If I learn everything in the book, I shouldn’t have any questions about this subject.

11. A  D  Students should sometimes decide what they want to study.

12. A  D  The only way one can learn very much is by being in class almost every day.

13. A  D  Learning how to find answers to my questions is more important than learning what is in textbooks.

14. A  D  Students should be able to arrange to leave the school building if that will help them learn something.

15. A  D  The only way you can really learn something is to memorize it.

16. A  D  School won’t help me get where I want to go in life.

17. A  D  Learning is mostly knowing facts.

18. A  D  Being able to follow directions for doing an experiment is more important than trying to figure out how to do an experiment.

19. A  D  Memorizing right answers is more important than trying to find out if an answer is right.

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<tbody>
<tr>
<td>20. A</td>
<td>D</td>
<td>One can learn more by reading about an experiment than by doing an experiment.</td>
<td></td>
</tr>
<tr>
<td>21. A</td>
<td>D</td>
<td>Most things in my life that are important to me involve the classes I take in school.</td>
<td></td>
</tr>
<tr>
<td>22. A</td>
<td>D</td>
<td>Students should be given the reasons for learning the things they are asked to learn in school.</td>
<td></td>
</tr>
<tr>
<td>23. A</td>
<td>D</td>
<td>Teachers should not be very concerned with what students think is important to learn.</td>
<td></td>
</tr>
<tr>
<td>24. A</td>
<td>D</td>
<td>Learning how to judge if information is correct is at least as important as learning information.</td>
<td></td>
</tr>
<tr>
<td>25. A</td>
<td>D</td>
<td>Learning what I will need to know to get into college is the most important reason for going to school.</td>
<td></td>
</tr>
<tr>
<td>26. A</td>
<td>D</td>
<td>I doubt that what I learn in school this year will be needed in the classes I'll take next year.</td>
<td></td>
</tr>
<tr>
<td>27. A</td>
<td>D</td>
<td>It's not important that students see a use for the things they have to learn in school.</td>
<td></td>
</tr>
<tr>
<td>28. A</td>
<td>D</td>
<td>There is always one best way to solve a problem.</td>
<td></td>
</tr>
<tr>
<td>29. A</td>
<td>D</td>
<td>One can learn a lot by participating in a class discussion.</td>
<td></td>
</tr>
<tr>
<td>30. A</td>
<td>D</td>
<td>Students seldom learn anything very important on their own.</td>
<td></td>
</tr>
<tr>
<td>31. A</td>
<td>D</td>
<td>Being able to answer questions is more important than deciding which questions should be asked.</td>
<td></td>
</tr>
<tr>
<td>32. A</td>
<td>D</td>
<td>Learning is mostly finding out what the right answer is.</td>
<td></td>
</tr>
<tr>
<td>33. A</td>
<td>D</td>
<td>Students can learn a lot by listening to other students.</td>
<td></td>
</tr>
<tr>
<td>34. A</td>
<td>D</td>
<td>Students often have good ideas of what they should learn.</td>
<td></td>
</tr>
<tr>
<td>35. A</td>
<td>D</td>
<td>Learning how to solve immediate real-world problems is a major purpose for going to school.</td>
<td></td>
</tr>
<tr>
<td>36. A</td>
<td>D</td>
<td>The things I learn in most high school classes will probably help me to be a success in college.</td>
<td></td>
</tr>
<tr>
<td>37. A</td>
<td>D</td>
<td>I use a lot of things outside of school that I learn in school.</td>
<td></td>
</tr>
<tr>
<td>38. A</td>
<td>D</td>
<td>Knowing facts is less important than knowing which facts are needed.</td>
<td></td>
</tr>
<tr>
<td>39. A</td>
<td>D</td>
<td>Knowing how to learn is more important than knowing what to learn.</td>
<td></td>
</tr>
<tr>
<td>40. A</td>
<td>D</td>
<td>I probably will learn more after I get out of school than I learned in school.</td>
<td></td>
</tr>
<tr>
<td>41. A</td>
<td>D</td>
<td>I should have the opportunity at school to find answers to questions that I think are important.</td>
<td></td>
</tr>
<tr>
<td>42. A</td>
<td>D</td>
<td>Students' own evaluation of what they have done should help determine their grade.</td>
<td></td>
</tr>
<tr>
<td>43. A</td>
<td>D</td>
<td>Students usually need to be told exactly what to do.</td>
<td></td>
</tr>
</tbody>
</table>
APPENDIX C

ATTITUDES TOWARD EDUCATION SURVEY

Responses to the items on the ATTITUDES TOWARD EDUCATION SURVEY provide six scale scores. When plotted on the PROFILE below, the responses will indicate some aspects of your attitudes toward education.

HOW TO SCORE YOUR RESPONSES: For each scale, check your sheet to see how you responded to each of the eight items. If you marked the item as indicated for the scale, put a check in the parentheses. For example, on Scale 1 if you circled "A" for Item No. 1, put a check in the parentheses.

Put the total number of checks for each scale in the appropriate box. Then for each horizontal scale under PROFILE, circle the number corresponding to the box score for that scale. Draw your profile by connecting the scores on the six scales.

<table>
<thead>
<tr>
<th>SCALE 1. Future Orientation</th>
</tr>
</thead>
<tbody>
<tr>
<td>A person high on this scale appears to view the purpose of education as primarily preparing for future classes or college.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>SCALE 2. Learning How to Learn</th>
</tr>
</thead>
<tbody>
<tr>
<td>A person high on this scale appears to view the purpose of education as preparing for learning on one's own.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>SCALE 3. Self Responsibility</th>
</tr>
</thead>
<tbody>
<tr>
<td>A person high on this scale appears to think that the student should be responsible for making decisions about his or her own learning.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>SCALE 4. Learning as a Process</th>
</tr>
</thead>
<tbody>
<tr>
<td>A person high on this scale appears to view learning as processes such as asking questions, seeking answers, finding information, designing and doing investigations.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>SCALE 5. Learning as Knowing Facts</th>
</tr>
</thead>
<tbody>
<tr>
<td>A person high on this scale appears to view learning primarily as memorizing or knowing facts and information.</td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th>SCALE 6. Relevance of School</th>
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</thead>
<tbody>
<tr>
<td>A person high on this scale tends to think that his schooling deals with things that are relevant and important to his real life problems.</td>
</tr>
<tr>
<td>Scale</td>
</tr>
<tr>
<td>---------</td>
</tr>
<tr>
<td>Scale 1</td>
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### APPENDIX E

**CLASS ATTITUDES TOWARD EDUCATION SURVEY TALLY**

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<thead>
<tr>
<th>No.</th>
<th>Agree</th>
<th>Disagree</th>
<th>No Response</th>
<th>No.</th>
<th>Agree</th>
<th>Disagree</th>
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</tbody>
</table>
Dear Sister Corinne:

It was good to hear from you again and of your progress toward completing your Ph.D. program. Your study sounds very worthwhile and you certainly have my permission to use the Biology Student Behavior Inventory in your research. Some data on validity and reliability are provided on the enclosed pages which are from reference #2 below. You may want to obtain more information about the BSBI through referring to a microfilm of my dissertation if one is available.

The BSBI has been used by the Mid-continent Regional Educational laboratory in Kansas City, Missouri on several occasions the last four or five years in their evaluation of their Inquiry Role Approach Project. Reports of their evaluation include results obtained through use of the BSBI. References to the BSBI may be found in:


The BSBI was designed to obtain class scores for the four subscales and total score as described. Therefore, you may want to check your research design as to whether or not ten classes will provide sufficient data.
I hope this information will help you in deciding whether or not to use the BSBI. I wish you the very best for success with your research. Please let me know if I can provide you with any additional information.

Sincerely,

H.E. Steiner, Jr.
Associate Professor

enclosure

HES/dm
APPENDIX G

VITAL STATISTICS ID

NAME OF SCHOOL

ADDRESS

Street or Box   City   State   ZIP

Place an X in the appropriate categories below which best identify your school.

Public _____ Private _____ Rural _____ Urban _____ Inner City _____

Approximate total school enrollment _____

Approximate ethnic distribution in %:

Black _____ Brown _____ Red _____ White _____ Other _____

Class period designated for IYE _____ Number of students _____

Class period designated for GB _____ Number of students _____

Biology program used in addition to IYE:

BSCS _____ Version or level _____

Other Biology (name) ______________________

INSTRUCTOR ______________________________

ATTACH THIS SHEET WITH YOUR STUDENT ANSWER SHEETS AND PROFILE SHEETS AND RETURN IT IN ONE OF THE SELF ADDRESSED, STAMPED MAILERS PROVIDED. BE SURE THAT ALL IYE ANSWER SHEETS ARE LABELED IYE, AND RETURNED IN THE MAILER DESIGNATED IYE. LIKewise, BE SURE THAT ALL GB ANSWER SHEETS ARE LABELED APPROPRIATELY ACCORDING TO THE PROGRAM, AND RETURNED IN THE MAILER PROVIDED FOR THE GB TREATMENT GROUP.

THANK YOU!