6-1-1969

The uses of behavioral objectives in teaching biology

Larry R. Shannon
Atlanta University

Follow this and additional works at: http://digitalcommons.auctr.edu/dissertations

Recommended Citation

This Thesis is brought to you for free and open access by DigitalCommons@Robert W. Woodruff Library, Atlanta University Center. It has been accepted for inclusion in ETD Collection for AUC Robert W. Woodruff Library by an authorized administrator of DigitalCommons@Robert W. Woodruff Library, Atlanta University Center. For more information, please contact cwiseman@auctr.edu.
THE USES OF BEHAVIORAL OBJECTIVES IN TEACHING BIOLOGY

A THESIS
SUBMITTED TO THE FACULTY OF THE SCHOOL OF EDUCATION, ATLANTA UNIVERSITY, IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE DEGREE OF MASTER OF ARTS

BY
LARRY R. SHANNON

SCHOOL OF EDUCATION

ATLANTA UNIVERSITY
ATLANTA, GEORGIA
JUNE, 1969
# TABLE OF CONTENTS

<table>
<thead>
<tr>
<th>LIST OF TABLES</th>
<th>iii</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chapter</td>
<td></td>
</tr>
<tr>
<td>I. HISTORY, PHILOSOPHY AND RATIONALE OF BSCS BIOLOGY</td>
<td></td>
</tr>
<tr>
<td>Rationale</td>
<td>1</td>
</tr>
<tr>
<td>The Beginning of Biological Science Curriculum Study</td>
<td>1</td>
</tr>
<tr>
<td>BSCS Special Materials</td>
<td>3</td>
</tr>
<tr>
<td>Evolution of the Problem</td>
<td>5</td>
</tr>
<tr>
<td>Contribution to Education</td>
<td>8</td>
</tr>
<tr>
<td>Statement and Definition of the Problem</td>
<td>9</td>
</tr>
<tr>
<td>Purposes of the Study</td>
<td>10</td>
</tr>
<tr>
<td>Limitations of the Study</td>
<td>10</td>
</tr>
<tr>
<td>Research Procedures</td>
<td>10</td>
</tr>
<tr>
<td>Survey of Related Literature</td>
<td>11</td>
</tr>
<tr>
<td>II. ANALYSIS AND PRESENTATION OF DATA</td>
<td></td>
</tr>
<tr>
<td>Results of Performance on the Otis Quick Scoring Test of Intelligence (Beta Form)</td>
<td>20</td>
</tr>
<tr>
<td>Results of Performances on the BSCS Impact Pre-Test</td>
<td>24</td>
</tr>
<tr>
<td>Results of the Performances of the Tenth Grade Pupils on the BSCS Impact Post-Test</td>
<td>27</td>
</tr>
<tr>
<td>III. SUMMARY AND CONCLUSIONS</td>
<td></td>
</tr>
<tr>
<td>Recapitulation of Research Design</td>
<td>31</td>
</tr>
<tr>
<td>Summary of Pertinent Literature</td>
<td>32</td>
</tr>
<tr>
<td>Summary of Findings</td>
<td>34</td>
</tr>
<tr>
<td>Conclusions</td>
<td>34</td>
</tr>
<tr>
<td>Implications</td>
<td>35</td>
</tr>
<tr>
<td>Recommendations</td>
<td>35</td>
</tr>
<tr>
<td>BIBLIOGRAPHY</td>
<td>36</td>
</tr>
<tr>
<td>VITA</td>
<td>38</td>
</tr>
</tbody>
</table>
# LIST OF TABLES

<table>
<thead>
<tr>
<th>Table</th>
<th>Description</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Distribution of Intelligence Quotients on the Otis Quick Scoring Test of Mental Maturity (Form Beta)</td>
<td>21</td>
</tr>
<tr>
<td>2.</td>
<td>Significant Differences of Intelligence Quotients on the Otis Quick Scoring Test of Mental Maturity (Form Beta)</td>
<td>23</td>
</tr>
<tr>
<td>3.</td>
<td>Distribution of Raw Scores on the BSCS Impact Test for the Pre-Test Period</td>
<td>25</td>
</tr>
<tr>
<td>4.</td>
<td>Significant Differences of Raw Scores on the BSCS Impact Test for the Pre-Test Period</td>
<td>26</td>
</tr>
<tr>
<td>5.</td>
<td>Distribution of Raw Scores on the BSCS Impact Test for the Post-Test Period</td>
<td>28</td>
</tr>
<tr>
<td>6.</td>
<td>Significant Differences of Raw Scores on the BSCS Impact Test for the Post-Test Period</td>
<td>29</td>
</tr>
</tbody>
</table>
CHAPTER I

HISTORY, PHILOSOPHY AND RATIONALE OF BSCS BIOLOGY

Rationale

There are two major aims in studying any natural science. One is to become acquainted with the significant scientific facts upon which rest the major concepts and theories of science. These are the ideas that have so profoundly altered our views of man's place in nature. In biology, this objective also includes a firsthand acquaintance with living organisms and the outstanding features of their lives.

The other aim is indispensable to the young scientist and non-scientist alike and to everyone who hopes to participate intelligently in the life of a scientific age which so constantly demands difficult decisions and real wisdom. This second objective is to know what science really is and to recognize its spirit and to appreciate its method. Science is not magic, and a scientific civilization surely will not endure if most people of intelligence regard science as such. It is a way, or a composite of many ways, of securing reliable, confirmed knowledge about all natural phenomena. It is compounded of the observations of the human senses and the inferences and deductions that can be derived from such experiences.

To achieve these aims requires an understanding of the develop-
ment of biology as a science, not so much because of its historical value or its value in understanding the current status of biology, although these are important, but primarily because this can lead to an understanding of how biology is developing and will continue to develop. Schwab noted that biology is changing from a "literal-minded empiricism to a complex in which conceptual invention plays a vast role, determining the facts we seek and conditioning the meaning we confer upon them."¹

Those research biologists who examined the traditional high school course in biology in the early 1960's found: (1) it represented little of the SCIENCE of biology; (2) it was out-of-date in terms of today's theories and knowledge; (3) it was fragmented and it lacked logical coherence; (4) it did not present biology as a discipline; (5) it forced memorization instead of requiring understanding; (6) its laboratory work failed to portray the investigation natures of biology and (7) it was taught more as a dogma than as an ongoing science.²

The growing demand for a reform in biology teaching was the result of a complex of factors. The growth of knowledge in biology during recent years has been exponential. The amount of knowledge in biology that now exists in almost any sub-field of biology is more than can be mastered in a lifetime. What, then, can be taught to a secondary school student in the approximately 150 hours per year usually available for the study of biology?

²Ibid., p. 2.
The sophistication of biology as a science has advanced greatly within recent years. Biology needs no longer be simply a grouping of phenomena for the sake of descriptions, classification and correlation. Recent advances should be reflected in the teaching of biology at the secondary school level. How should young people be taught to appreciate and to understand progress in biology? What should we teach and to what ends? It is implied that an education in biology today must be DIFFERENT IN KIND from that offered before, and that a new conceptual basis is primarily needed for the development and organization of courses.

The Beginning of Biological Science Curriculum Study

In 1959, the American Institute of Biological Sciences, with the financial support of the National Science Foundation, established the Biological Sciences Curriculum Study (BSCS) to conduct an intensive investigation of biological education in the secondary schools of the United States. The function of the BSCS, as stated by the National Science Foundation, was to evaluate the content of present biology course offerings, to determine what biological knowledge can and should be learned at each level, and to recommend how this latter goal could be achieved. Research biologists, educators, both high school and university biology teachers, and some others who comprised the BSCS, recommended that a different approach to the teaching of biology...
biology was necessary, one that was more suited to modern concepts of biology. During the summer of 1960, 69 writers -- research biologists, and educators -- were convened to produce three versions of a textbook with coordinated student laboratory manuals and teachers' guides.

The BSCS writers were of the opinion that a secondary school course in biology should: (1) present modern knowledge and concepts; (2) focus on the nature of scientific inquiry; and (3) provide students with a coherent picture of contemporary biology.

To present biology in a logical and unified manner, nine themes which offered promise of conveying the content and structure of the discipline were identified. These themes are: (1) science as inquiry; (2) the intellectual history of biological concepts; (3) the change of living things through time -- evolution; (4) diversity of type and unity of pattern in living things; (5) the genetic continuing of life; (6) complementarity of organisms and environment; (7) biological roots of behavior; (8) complementarity of structure and function; and (9) regulation and homeostasis -- preservation of life in the face of change. The first two themes convey the logical structure of the course; the other seven define the content.  

The BSCS recognized that there was no single best way to organize a course in high school biology. Biology is a relatively diffuse science and a wide variety of good course designs could be organized. Three patterns were selected, each different in approach from the others but within the general framework of the BSCS objectives, in-

---

cluding the unifying biological themes. For use in identification, these courses were referred to as the Blue, Green, and Yellow Versions. The Blue Version (Biological Science: Molecules to Man) approaches the study of biology from a molecular level with emphasis upon recent advances in physiology and biochemical evolution. In the Green Version (High School Biology), the approach is through a study of the ecological and behavioral aspects of biology. A major emphasis is placed upon the biological community and the world biome. The Yellow Version (Biological Science: An inquiry Into Life) is organized around the concepts of biological unity, diversity and continuity, and stresses the cellular level of organization.

Although differing in many ways, each of the three versions of biology is a balanced presentation of biological science for secondary school students and is designed for use at the 10th grade level. Dissimilarity among the courses reflects different approaches to the study of biology and not the characteristics of potential groups of students. Each version is built around the same basic themes and the majority of the core content is common to the three versions.

The BSCS courses differ from traditional biology courses. In the BSCS programs, more emphasis is placed upon molecular and cellular biology, the world biome, the biological community and the study of populations, and less on the organ and tissue levels which have been stressed in the other recent high school texts.

BSCS Special Materials

The BSCS evaluation program indicated that about two-thirds of
the 10th grade biology students in American High schools can successfully use the three basic versions. At the same time, many teachers reported the BSCS approach to biology, with its emphasis on laboratory experience and on understanding of inquiry, seemed to be appropriate for the student who was considered academically less able. Many of these students showed abilities, formerly not evidenced, to think and deal with biological problems in the laboratory. Hence it appeared a presentation of materials which capitalized on these abilities might make BSCS Biology potentially accessible to an increased number of students.

The researchers' opinion is that laboratory experiments are better called "experiencing" or "messing around" techniques. These techniques are considered as the new concept of science teaching. According to the new concept, the teacher should use a process approach. In using such an approach, certain behavioral objectives are met. These behavioral objectives or acquired skills are:

1. Identifying. Selecting (by pointing to, touching or picking up) the correct object of a class name. This would include identifying object properties (such as rough, smooth, straight, curved) and, in addition, kinds of changes such as an increase or decrease in size and/or number. An example of this behavior would be an interpretation of graphs on population.

2. Distinguishing. Identifying objects or events which are potentially confusabie, or when two contrasting identifications are involved. An example of this behavior would be the separation of two similar but different objects or events.

1Ibid., p. 6

3. Classifying. Arranging two or more objects, events or organisms in proper order in accordance with their characteristics.

4. Describing. Describing and naming biomes all of the necessary categories of objects, object properties, even properties or organisms relevant to the description of a designated situation. The description is considered complete when there is little or no likelihood that the description will conflict with any other object or organism.

5. Stating a Rule. Making a verbal statement (not necessarily in technical terms) which conveys a rule or a principle, including the names of the proper classes of objects or events in their correct order.

6. Applying a Rule. Using a learned principle or rule to derive an answer to a question. The answer may be correct identification, the supplying of a name, or an imperative response question may be stated in such a manner that the student must employ a rational process to arrive at the answer. Such a process may be simple, as: all Aves have feathers, ducks have feathers, therefore ducks are Aves.

7. Demonstrating. Performing the operations necessary to the application of a rule or principle. Example: "Show how you would pith a frog." The answer requires that the individual hold the frog and perform the manipulation in a particular manner.

8. Interpreting. Identifying objects and/or events in terms of their consequences. There will be a set of rules or principles always connected with this behavior. Graph interpretation and analysis are examples.

9. Observing. Critically analyzing those things that are viewed or studied in laboratory and field work.

The writers of the BSCS materials are of the opinion that behavioral skills are not necessary for successful comprehension of laboratory techniques and materials. This investigator is of a different opinion. He feels that a better understanding of the behavioral skills and more opportunities to actually become involved with these techniques provide a student with a better position in relation to
other students lacking these behavioral skills.

The writers of BSCS do not think it absolutely necessary for the students to meet certain behavioral objectives before enrolling in BSCS biology. The investigator will argue that these behavioral objectives or skills are necessary if total BSCS work is done successfully. Without these skills, it is not good practice to begin laboratory work. To fully implement the BSCS program, laboratory work must be required of each student. When a student is unprepared to do laboratory work, he must be taught to remediate his inadequacies. On the other hand, students who have met all or most of the behavioral objectives are able to start right into laboratory work.

Since the BSCS approach to biology is laboratory oriented, students should know the procedures and skills involved in doing lab work. Therefore, the investigator feels that students who have had at least some exposure to the basic behavioral objectives do perform better.

The Evolution of the Problem

The problem with which the investigator is concerned stems from the average and above average student's inability to perform laboratory tasks with satisfaction. The fact that the majority of these students are lacking in many behavioral skills, which they should have developed prior to enrolling in the BSCS course, causes the major problem. Pre-tests given to these students should indicate whether the students possess the basic behavioral skills that are essential to a good start in the BSCS course.

After studying the situation for a while, the investigator wrote to Dr. Maner H. Kennedy, a consultant of BSCS, to request a list of
basic skills essential for performing the laboratory work. Dr. Kennedy, in his reply, states: "The writers of the BSCS materials did not assume that students would need to bring any fund of knowledge with them to the tenth grade. However, in school systems with strong junior high school science and mathematics programs, biology teachers are able to move their classes along more rapidly and to provide more indepth treatment of many topics. The same is true for the inquiry processes associated with BSCS biology. Where students have had prior experience in making careful and critical observations comparing, grouping and classifying materials; formulating problems and asking relevant questions; developing hypotheses and designing experimental tests for them; synthesizing findings and interpretations from several sources; and so forth, BSCS biology teachers are able to promote these skills to higher levels of sophistication."

Contribution to Education

It is felt that the findings of this investigation may indicate whether or not there are weaknesses in our science education programs. It is further hoped that teachers of science may be helped to recognize the need to strengthen the program by altering objectives to promote a better program in the elementary and secondary school without needless repetition.

Finally, it is desired that this investigation encourage science coordinators to develop a coordinated science program in grades one through twelve.

---

1Maner H. Kennedy, personal letter.
Statement and Definition of the Problem

This study investigated the effects of concentrated attention to the development of behavioral skills in biology on the scientific achievement of students in tenth grade biology.

Purposes of the Study

The purpose of this study was to test the null hypothesis that there is no significant difference in the scientific achievement of biology students who have or have not had concentrated exposure to the behavioral objectives of the BSCS materials.

Limitations of the Study

The experimental phase of this study was restricted by the school calendar to eight weeks. It is probable that this short period of time is inadequate for a true test of the experimental effects.

Research Procedures

The procedural steps were:

1. Permission to conduct the study was requested from the proper authorities of the Atlanta Public School System.

2. The students included in this research project were those in a selected secondary school taking biology for the first time. All repeaters in biology were omitted. The experimental group was composed of three biology classes with a total of 67 students. Three other biology classes, with 70 students, made up the control group. Analysis of I.Q. scores for each group indicated that the ability levels of all subjects were comparable.

3. A pre-test designed by the BSCS writers was given to every student in both groups in September.

4. During the eight-week experimental period, laboratory experiments designed by the BSCS writers were conducted by all students in the experimental group. Laboratory experiments, though not totally omitted, were given little attention in the control group.
5. All students were re-tested with the initial test in November, 1968.

6. Fisher's "t" was used to test the significance of difference after a decision was made to accept or reject the null hypothesis at the .05 level of confidence.

7. The findings and conclusions are presented in terms of the null hypothesis. Implications and recommendations stem directly from the findings and conclusions of the study.

Survey of Related Literature

Metzner stated that we should be aware of the time element involved in the teaching of BSCS biology.¹ With the many necessary laboratory exercises provided, there is limited time to teach many of the behavioral skills essential for successful laboratory work. The BSCS biology teacher will be able to teach the course without having to take time to teach these skills if these skills are possessed by the students at least to a moderate degree. Unfortunately, the majority of students have had insufficient opportunities to become familiar with the behavioral skills necessary for BSCS biology.

Education is concerned with changing the behavior of students. Knowledge about behavior then should be useful to the educator in understanding and improving the teaching process.² The research worker who wishes to understand teaching and teachers must understand not only the teaching and educational process as it takes place, but also the outcomes or effects of the process — the changes that take place in the learners.³ While it may be true that the most important changes


in the learner are those which may be described as cognitive, i.e., knowledge, problem-solving, higher mental processes, etc., it is true that these are the type of changes in students which most teachers do seek to bring about.\footnote{Ibid.}

Research on teaching must, in most cases, make use of measures of cognitive achievement to determine whether the teaching method, instructional procedure, or the teacher does produce changes in the learners. Research on teaching makes use of tests of cognitive ability (and achievement) to identify the samples of students being studied and to determine whether there are differential effects of the teaching on the various subgroups.

Research on teaching also uses tests of cognitive ability and cognitive achievement to determine how changes in the cognitive domain are related to changes in other areas.\footnote{Ibid., pp. 379-380.}

In Tyler's discussion of the relationships between educational research and the behavioral sciences, he stressed three main points: (2) the behavioral sciences are not going to provide direct answers to basic questions posed for educational research; (b) the behavioral sciences do not ask questions concerning either what should be done or how tasks are to be accomplished, but look at behavioral phenomena as natural processes. In the behavioral sciences, efforts are put forth to explain what takes place, what characteristics are involved, what the nature of the relationships among these attributes is, and, insofar as possible, what circumstances customarily lead to what occurrences. On the other hand, much educational research is addressed to
questions pertaining directly to school operations; (c) although the behavioral sciences and educational research ask different questions, the behavioral sciences do contribute to educational research, not only through the formulation of conceptualizations that are helpful in planning studies and in interpreting them, but also through the development of new techniques from the fields of anthropology, social psychology, personality studies and sociology.¹

Cooley identified two main reasons why greater utilization of the behavioral sciences is necessary in planning and conducting basic educational research. First, since science advances by successive approximations, the most recently developed principles of human behavior are generally the most reliable. Second, is the need for open-mindedness. It becomes increasingly apparent that the scientist must have a working knowledge in other fields as well as in his own specialty.²

Henderson called attention to the fact that a student's knowledge is not an observed entity. It is inferred from sampling a student's behavior by observation or through the use of instruments which sample student behavior.³ Bloom argued, persuasively, that the ultimate criterion of all educational endeavors is change in student be-


behavior. Watson stressed that if learning outcomes are stated in terms of behavior the task of evaluation is greatly facilitated, but if the expected outcomes are stated in grandiose terms evaluation is extremely difficult.

Both Henderson and Watson suggested that the model is most useful when the domains of Z and X are regarded as sequences of verbal and non-verbal behavior. The teacher could then be considered a classroom, a television, a book, or a program sequence. Since the behavior of X is not random, the sequences of behavior can be classified into sets in terms of the common properties that characterize the set. The relation $S(Y, Z)$ which represents the relation between methods and student behavior, or teacher behavior and student behavior, is the usual basic model of methods research. In the model, X could represent the teacher in terms of teacher personality or teacher characteristics. Henderson also called attention to the fact that a student's knowledge about a subject fits the triadic mode. This indicates that "X" infers "Y" from "z'x" behavior.

The triadic model review above is obviously applicable to research in both mathematics and science education by the specification of Y in terms of science and mathematics content and Z as student behavior appropriate to science and mathematics learning.

---

3 Kenneth B. Henderson, op. cit., p. 1007.
4 Ibid.
The development of an articulated twelve-year program of science education is a continuing problem. Frequently, there is much non-essential content and too much repetition of some types of materials. Scientific ideas are sometimes presented at inappropriate grade levels. Some courses in general science have been developed without considering the earlier elementary-science program. High-school curriculum committees are likely to look to the college for guidance rather than to build upon the science background levels of pupils enrolled in different high school grades. Thus, the problems of scope and sequence may need to be more realistically dealt with in such situations.¹

The problem of balancing the program is that of providing science in the proper amount at each grade level and of distributing the physical, the biological, and the earth sciences in appropriate assignments with reference to the age-grade distribution of the students assigned. It is obvious that the objective of such balancing of the science curriculum cannot be achieved by allowing each student an unrestricted choice of science subjects or by permitting the student to choose between science and some other field of study.²

The rapid growth of elementary-school science, accompanied at times by erratic offerings of seventh- and eighth-grade science, has made ninth-grade general science a curriculum problem. Originally an introductory course to high-school science, general science is frequently


²Ibid., p. 332.
too repetitive of the content of elementary-school science.¹

Much of the content in science courses that has commonly been considered fundamental is, in reality, merely traditional. Much weeding of this content must precede the modernizing of the science courses. Furthermore, the continuing increase in the amount of new knowledge and theory suggests that an appropriate modernizing of science courses will prove to be a continuing problem. The current trend toward teaching fewer concepts, but with increased emphasis on depth of understanding, accentuates the need for increased care in the selection of learning experiences. Curriculum workers would like to see the scientific societies take more interest in the problem of identifying content for science courses.²

There is much concern about the way science is taught. Many commonly used teaching procedures offer little promise of realizing such objectives of science-teaching as the development of problem-solving ability, critical attitudes, and an appreciation of science. The difficulty may be that science teachers have been taught by methods that did not achieve for them the results expected of pupils.

Educators realize that the improvement of instruction involves (a) the better selection and use of means to develop concepts and ideas, (b) improved use of research-study procedures in learning science, (c) the organization of instruction to provide practice in the application of science theory, and (d) the use of methods and procedures that

¹Ibid.
²Ibid., pp. 332-333.
will develop more pupil responsibility for learning. Teachers' opinions vary widely with respect to the nature of the learning process and its meaning for science teaching.¹

Changing conceptions of the values and purposes of science-teaching have tended toward an increasing emphasis upon laboratory work. The nature of the scientific enterprise is found in the methods by which problems are attacked. Therefore, more attention should be directed to the processes or methods of seeking answers in the laboratory rather than putting so much stress on finding exact answers. More time should be spent by students in developing insights as to how data may be processed and predictions made for them.²

¹Ibid., pp. 333-334.
²Ibid., p. 334.
CHAPTER II

ANALYSIS AND PRESENTATION OF DATA

The data obtained in this research project was secured by using the standardized Biological Science Curriculum Study Impact Test and the Otis Quick-Scoring Test of Mental Maturity (Form Beta). During September, 1968, the experimental and control groups were given both tests. The Otis-Quick Scoring Test of Mental Maturity was used to determine whether there was any significant difference between the intelligence levels of the two groups. The BSCS Impact Test was given to determine whether any significant difference existed between the two groups in their scientific achievement levels.

After testing the one hundred thirty-seven subjects, the scores were subjected to statistical analysis. From the scores, the researcher computed the mean, median, standard deviation and Fisher's "t" for comparison of the experimental and control groups. The .05 level of confidence had been previously selected as the acceptable level of significance.

During the eight-week treatment period, the experimental group performed eleven laboratory exercises. An analysis of the laboratory exercises and tests suggested that nine basic operations are necessary for successful performance by biology students. More emphasis was placed on demonstration, observation, application, and interpretation than on the other five performances because of the number of times they
must be manifested.

The experimental students represented in this study are those previously described, who performed all of the laboratory exercises during the eight-week period of experimentation. The control group performed a total of four laboratory exercises. A record of each pupil's performance was kept, and those that missed assignments made them up.

Described below are the performance objectives that were emphasized:

1. Identifying: Identification was performed by:
   (a) having students to pick out certain structures in cells.
   (b) having students to point out certain types of leaves.
   (c) having students to identify a biome by viewing the flora, fauna, and precipitation.
   (d) having students to determine if organisms are either single or a population.

2. Distinguishing: Students were given several opportunities to demonstrate their ability to distinguish between similar objects and events. These revealed the student's ability to distinguish between:
   (a) two different genera.
   (b) two or more different biomes.
   (c) similar cell structures.
   (d) plants and animals.

3. Classifying: The students had opportunities to demonstrate their ability to classify organisms and places in accordance with their characteristics. Laboratory exercises were provided to enhance this ability of the students.

4. Describing: This performance was demonstrated by the students' ability to describe:
   (a) plant and animal cells.
   (b) certain species of plants and animals.
   (c) characteristics of certain species.

5. Stating a Rule: In that more emphasis is placed on performance than memory of a rule, the activities were infrequent, and this objective was applied through written exercises.
6. Applying A Rule: Application of rules was exemplified through laboratory exercises. Examples included use of the microscope, cutting and bending glassware, etc.

7. Demonstrating: This performance objective was displayed by the students showing how to:
   (a) properly use a microscope.
   (b) correctly cultivate living cultures without contamination.
   (c) properly pith a frog.

8. Interpreting: Laboratory exercises, in addition to the problems at the end of each chapter, were used to check the students' ability to interpret data.

9. Observing: Observation was emphasized through laboratory exercises performed by the students.

The experimental and control groups were tested within a two-day period at the end of the treatment period. The tests were scored by the teachers of the two groups, and the researcher made a comparison of the scores. Comparisons were made of the two groups by obtaining the mean and median scores. Fisher's "t" was used to test the significance of difference and a decision was made to accept or reject the null hypothesis at the .05 level of confidence.

The following tables represent the performances of the control and experimental groups. After each table is a summary of the performances of each group, which indicates the relationship of the two sets of scores.

Results of Performance on the Otis Quick Scoring Test of Intelligence (Form Beta)

The results of the performance of 137 tenth grade pupils enrolled at Brown High School on the Otis Quick Scoring Test of Mental Maturity are presented in Table 1, page 21, and discussed in the paragraphs which follow.
TABLE 1
DISTRIBUTION OF INTELLIGENCE QUOTIENTS ON THE OTIS QUICK SCORING TEST OF MENTAL MATURITY (FORM BETA)

<table>
<thead>
<tr>
<th>Intelligence Quotients</th>
<th>Experimental Number</th>
<th>Experimental Per Cent</th>
<th>Control Number</th>
<th>Control Per Cent</th>
</tr>
</thead>
<tbody>
<tr>
<td>109 - 111</td>
<td>2</td>
<td>3.0</td>
<td>2</td>
<td>2.9</td>
</tr>
<tr>
<td>106 - 108</td>
<td>4</td>
<td>6.0</td>
<td>2</td>
<td>2.9</td>
</tr>
<tr>
<td>103 - 105</td>
<td>7</td>
<td>10.8</td>
<td>1</td>
<td>1.4</td>
</tr>
<tr>
<td>100 - 102</td>
<td>9</td>
<td>13.4</td>
<td>6</td>
<td>8.7</td>
</tr>
<tr>
<td>97 - 99</td>
<td>12</td>
<td>17.9</td>
<td>20</td>
<td>28.2</td>
</tr>
<tr>
<td>94 - 96</td>
<td>9</td>
<td>13.4</td>
<td>16</td>
<td>23.5</td>
</tr>
<tr>
<td>91 - 93</td>
<td>8</td>
<td>11.7</td>
<td>8</td>
<td>11.5</td>
</tr>
<tr>
<td>88 - 90</td>
<td>9</td>
<td>13.4</td>
<td>9</td>
<td>12.4</td>
</tr>
<tr>
<td>85 - 87</td>
<td>5</td>
<td>7.4</td>
<td>3</td>
<td>4.3</td>
</tr>
<tr>
<td>82 - 84</td>
<td>2</td>
<td>3.0</td>
<td>3</td>
<td>4.3</td>
</tr>
</tbody>
</table>

| Total                  | 67                  | 100.0                 | 70             | 100.1            |

|                      | Mean            | 96.40                | 95.30          |
|                      | Median          | 96.26                | 94.70          |
|                      | Sigma           | 6.69                 | 5.94           |
|                      | SEm             | .82                  | .71            |

Experimental

For the sixty-seven tenth grade biology students in the experimental group, the intelligence quotients ranged from 82 to 110 with a mean of 96.40, a median of 96.26, a standard deviation of 6.69, and a standard error of the mean of .82.
The data in Table 1 reveal that twenty-two, or 33.2 per cent of the pupils scored above the mean; thirty-three, or 48.9 per cent, scored below the mean, and twelve, or 17.9 per cent, scored within the mean interval.

Control

For the seventy tenth grade biology students in the control group, the intelligence quotients ranged from 82 to 109, with a mean of 95.3, a median of 94.70, a standard deviation of 5.94, and a standard error of the mean of .71. The data in Table 1 reveal that thirty-one, or 44.1 per cent, of the pupils scored above the mean; twenty-three, or 32.5 per cent, scored below the mean, and sixteen, or 23.5 per cent, scored within the mean interval.

Comparative Data for Intelligence Test Performance of Experimental and Control Groups

Table 2, page 23, presents comparative measures of intelligence for the two groups. The means were 96.40 and 95.30 for the experimental and control groups, respectively, with a difference of 1.10 in favor of the experimental group; the medians were 96.26 and 94.70 for the experimental and control groups, respectively, with a difference of 1.56 in favor of the experimental group; the standard deviations of the mean were 6.69 and 5.94, respectively, with a difference of .75 in favor of the experimental group; the standard errors of the mean were .82 and .71 for the experimental and the control groups, respectively, with a difference of .11 in favor of the experimental group. The standard error of the difference between the two means was 1.08.

The "t" ratio of 1.01 was not statistically significant, since
## TABLE 2

**SIGNIFICANT DIFFERENCES OF INTELLIGENCE QUOTIENTS ON THE OTIS-QUICK SCORING TEST OF MENTAL MATURITY (FORM BETA)**

<table>
<thead>
<tr>
<th>Group</th>
<th>Mean</th>
<th>Median</th>
<th>Sigma</th>
<th>SEM</th>
<th>$M_1 - M_2$</th>
<th>SEM$_1 - m_2$</th>
<th>&quot;t&quot;</th>
</tr>
</thead>
<tbody>
<tr>
<td>Experimental</td>
<td>96.40</td>
<td>96.26</td>
<td>6.69</td>
<td>.82</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Control</td>
<td>95.30</td>
<td>94.70</td>
<td>5.94</td>
<td>.71</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
it was less than the 1.96 required for significance at the .05 level of confidence with 135 degrees of freedom. Therefore, the difference in intelligence quotients was not significant for these two groups of tenth grade biology students.

Results of Performances on the BSCS Impact Pre-Test

The results of the performance of the 137 subjects on the BSCS Impact Pre-test are presented in Table 3, page 25, and discussed in the paragraphs which follow.

Experimental

For the sixty-seven biology pupils enrolled in the experimental group, the Impact test scores ranged from 7 to 33, with a mean of 16.76, a median of 16.64, a standard deviation of 5.40, and a standard error of the mean of .67. The data in Table 3 reveal that twenty-five, or 37 per cent, of the pupils scored above the mean; twenty-three or 34 per cent, scored below the mean; and nineteen or 28 per cent, scored within the mean interval.

Control

For the seventy biology pupils enrolled in the control group, the scores ranged from 8 to 35, with a mean of 18.08, a median of 19.61, a standard deviation of 5.52, and a standard error of the mean of .67. The data in Table 3 reveal that twenty-three, or 32.6 per cent, of the pupils scored above the mean; thirty-one, or 44.3 per cent, scored below the mean; and sixteen, or 22.4 per cent, scored within the mean interval.
### TABLE 3

**DISTRIBUTION OF RAW SCORES ON THE BSCS IMPACT TEST FOR THE PRE-TEST PERIOD**

<table>
<thead>
<tr>
<th>Raw Scores</th>
<th>Experimental</th>
<th>Control</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Number</td>
<td>Per Cent</td>
</tr>
<tr>
<td>33 - 35</td>
<td>1</td>
<td>1.5</td>
</tr>
<tr>
<td>30 - 32</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>27 - 29</td>
<td>4</td>
<td>6.0</td>
</tr>
<tr>
<td>24 - 26</td>
<td>5</td>
<td>7.5</td>
</tr>
<tr>
<td>21 - 23</td>
<td>8</td>
<td>11.9</td>
</tr>
<tr>
<td>18 - 20</td>
<td>7</td>
<td>10.4</td>
</tr>
<tr>
<td>15 - 17</td>
<td>19</td>
<td>28.4</td>
</tr>
<tr>
<td>12 - 14</td>
<td>9</td>
<td>13.5</td>
</tr>
<tr>
<td>9 - 11</td>
<td>10</td>
<td>15.0</td>
</tr>
<tr>
<td>6 - 8</td>
<td>4</td>
<td>6.0</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>67</td>
<td>100.2</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th></th>
<th>Experimental</th>
<th>Control</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean</td>
<td>16.76</td>
<td>18.08</td>
</tr>
<tr>
<td>Median</td>
<td>16.64</td>
<td>19.61</td>
</tr>
<tr>
<td>Sigma</td>
<td>5.40</td>
<td>5.52</td>
</tr>
<tr>
<td>SEm</td>
<td>.67</td>
<td>.67</td>
</tr>
</tbody>
</table>

Comparative Data for the Experimental and the Control Group Performances on the Impact Pre-test

Table 4, page 26, shows that the comparative measures on the BSCS Impact Pre-test for the two groups were: the means were 16.76 and 18.08 for the experimental and control groups, respectively, with
TABLE 4
SIGNIFICANT DIFFERENCES OF RAW SCORES ON THE BSCS IMPACT TEST FOR THE PRE-TEST PERIOD

<table>
<thead>
<tr>
<th>Group</th>
<th>Mean</th>
<th>Median</th>
<th>Sigma</th>
<th>SEM</th>
<th>$M_1 - M_2$</th>
<th>SEM$_1 - m_2$</th>
<th>&quot;t&quot;</th>
</tr>
</thead>
<tbody>
<tr>
<td>Experimental</td>
<td>16.76</td>
<td>16.64</td>
<td>5.40</td>
<td>.67</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>1.32</td>
<td>.95</td>
<td>1.39</td>
</tr>
<tr>
<td>Control</td>
<td>18.08</td>
<td>19.61</td>
<td>5.52</td>
<td>.67</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
a difference of 1.02 in favor of the control group; the medians were 16.64 and 19.61 for the experimental and control groups, respectively, with a difference of 2.97 in favor of the control group; the standard deviations were 5.40 and 5.52 for the experimental and control groups, respectively, with a difference of .12 in favor of the control group; the standard errors of the means were .67 and .67 for the experimental and control groups, respectively, with no difference between the two groups. The standard error of the difference between the two means was .95.

The "t" ratio for the data was 1.39, which was not statistically significant at the .05 level of confidence with 135 degrees of freedom. Therefore, the pre-test revealed no significant difference in scientific comprehension for these two groups of tenth grade pupils prior to the experimental period.

Results of the Performances of the Tenth Grade Pupils on the BSCS Impact Post-Test

The results of the performances of the 137 subjects on the BSCS Impact post-test are presented in Table 5, page 28, and discussed in the paragraphs which follow.

Experimental

For the sixty-seven biology pupils in the experimental group, the BSCS Impact post-test scores ranged from 7 to 34, with a mean of 19.1, a median of 18.82, a standard deviation of 4.86, and a standard error of the mean of .73. The data in Table 5 reveal that ten, or 16 percent, of the pupils scored above the mean; thirty-nine, or 58.2 percent, scored below the mean; and eighteen, or 26 percent, scored
TABLE 5
DISTRIBUTION OF RAW SCORES ON THE BSCS IMPACT TEST FOR THE POST-TEST PERIOD

<table>
<thead>
<tr>
<th>Score Distribution</th>
<th>Experimental</th>
<th>Control</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Number</td>
<td>Per Cent</td>
</tr>
<tr>
<td>33 - 35</td>
<td>1</td>
<td>1.5</td>
</tr>
<tr>
<td>30 - 32</td>
<td>1</td>
<td>1.5</td>
</tr>
<tr>
<td>27 - 29</td>
<td>1</td>
<td>1.5</td>
</tr>
<tr>
<td>24 - 26</td>
<td>7</td>
<td>11.5</td>
</tr>
<tr>
<td>21 - 23</td>
<td>18</td>
<td>26.0</td>
</tr>
<tr>
<td>18 - 20</td>
<td>16</td>
<td>23.8</td>
</tr>
<tr>
<td>15 - 17</td>
<td>12</td>
<td>17.9</td>
</tr>
<tr>
<td>12 - 14</td>
<td>5</td>
<td>7.5</td>
</tr>
<tr>
<td>9 - 11</td>
<td>4</td>
<td>6.0</td>
</tr>
<tr>
<td>6 - 8</td>
<td>2</td>
<td>3.0</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>67</td>
<td>100.2</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th></th>
<th>Experimental</th>
<th>Control</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Mean</strong></td>
<td>19.10</td>
<td>19.80</td>
</tr>
<tr>
<td><strong>Median</strong></td>
<td>18.82</td>
<td>19.67</td>
</tr>
<tr>
<td><strong>Sigma</strong></td>
<td>4.86</td>
<td>5.79</td>
</tr>
<tr>
<td><strong>SEm</strong></td>
<td>.60</td>
<td>.71</td>
</tr>
</tbody>
</table>

within the mean interval.

Comparative Data for the BSCS Impact Post-test Performance

Table 6, page 29, provides comparative data from the BSCS Impact post-test. The means were 19.10 and 19.80 for the experimental and
### TABLE 6

**SIGNIFICANT DIFFERENCES OF RAW SCORES ON THE BSCS IMPACT TEST FOR THE POST-TEST PERIOD**

<table>
<thead>
<tr>
<th>Group</th>
<th>Mean</th>
<th>Median</th>
<th>Sigma</th>
<th>SEM</th>
<th>M₁ - M₂</th>
<th>SEM₁ - m₂</th>
<th>&quot;t&quot;</th>
</tr>
</thead>
<tbody>
<tr>
<td>Experimental</td>
<td>19.10</td>
<td>18.82</td>
<td>4.86</td>
<td>.60</td>
<td>.70</td>
<td>.93</td>
<td>.75</td>
</tr>
<tr>
<td>Control</td>
<td>19.80</td>
<td>19.67</td>
<td>5.79</td>
<td>.71</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
control groups, respectively, with a difference of .70 in favor of the control group. The medians were 18.82 and 19.67 for the experimental and control groups, respectively, with a difference of .85 in favor of the control group. The standard deviations were 4.86 and 5.79 for the experimental and control groups, respectively, with a difference of .93 in favor of the control group. The standard errors of the mean were .60 and .71 for the experimental and control groups, respectively, with a difference of .11 in favor of the control group. The standard error of the difference between the two means was .93.

The "t" ratio for these data was .75, which was not statistically significant at the .05 level of confidence with 135 degrees of freedom. Therefore, the post-test revealed no significant difference in scientific achievement for these two groups of tenth grade biology pupils at the end of the experimental period.
CHAPTER III

SUMMARY AND CONCLUSIONS

Recapitulation of Research Design

The major purpose of this study was to test the null hypothesis that there is no significant difference in the scientific achievement of biology students who have, or have not, had concentrated exposure to the behavioral objectives of the BSCS materials.

The groups used in this study were composed of students comparable in grade level and intelligence.

The experimental group was exposed to nine basic BSCS behavioral objectives. The control group had little or no exposure to these objectives.

The students were given a pre-test during the second week of September and a replication of this test eight weeks later. During the eight-week experimental period, subjects in the experimental group were given opportunities to develop skills in identifying, stating a rule, demonstrating, interpreting, observing, applying a rule, distinguishing and classifying.

The pupils were tested at the end of the experimental period with a replication of the pre-test.
Summary of Pertinent Literature

Education is concerned with changing the behavior of students. Knowledge about behavior is essential to the educator in understanding and improving teaching processes. ¹ The researcher who wishes to understand teaching and teachers must understand not only the teaching and educational process as it takes place, but also the outcomes or effects of the process -- the changes that take place in the learners.²

Henderson calls attention to the fact that a student's knowledge is not an observed entity. It is inferred from sampling a student's behavior by observation or through the use of instruments which sample student behavior.³

The development of an articulated twelve year program of science education is a continuing problem. Frequently, there is much non-essential content and too much repetition of some types of materials. Scientific ideas are sometimes presented at inappropriate grade levels. Some courses in general science have been developed without regard to the earlier, elementary science program.⁴

High school curriculum committees are likely to look to the college for guidance in the background level of pupils enrolled in different high school grades.

The rapid growth of elementary-school science, accompanied at times by erratic offerings of seventh and eighth grade science, has

¹Hively, Implications for the Classroom, p. 37.
²Bloom, Testing Cognitive Ability and Achievement, p. 379.
³Henderson, Research on Teaching, p. 1007.
made ninth-grade general science a curriculum problem. Originally an introductory course to high-school science, general science is frequently too repetitive of the content of elementary-school science.¹

The BSCS writers had the function of evaluating the content of the biology course offerings to determine what biological knowledge should be learned at each level.

The BSCS writers were of the opinion that a secondary school course in biology should: (1) present modern knowledge and concepts; (2) focus on the nature of scientific inquiry; and (3) provide students with a coherent picture of contemporary biology.²

The problem lies in the training that students should acquire before being confronted with the three above-mentioned ideas. The significant point is that a stronger and better-organized junior high program could be developed to bridge the gap between the developing elementary science program and the high school biology courses. There are skills that students should develop prior to the BSCS courses. With an organized junior high science program, these performance objectives could be met by the end of the ninth-grade.

The accomplishment of these prerequisites could be met with exposure to laboratory exercises. These exercises should include identification, distinguishing, classifying, describing, stating a rule, applying a rule, demonstrating, interpreting and observing.

Changing conceptions of the values and purposes of science-teaching have tended toward increasing emphasis upon laboratory work.

¹Ibid.
²Ibid.
The nature of the scientific enterprise is found in the methods by which problems are attacked.

Thus, more attention should be directed to the processes or methods of seeking answers in the laboratory rather than putting so much stress on finding exact answers. More student time should be spent in developing insights as to how data can be processed and predictions made from them.

Summary of Findings

The findings of this study are presented in accordance with the purpose. Quantitative measures and Summary Tables are found in Chapter II, Tables 1 through 6.

1. The scientific achievement of students who were exposed to BSCS behavioral objectives in this study was not significantly higher than the scientific achievement of students who were not exposed to the BSCS behavioral objectives. After the experimental period, the difference between the scientific achievement levels of the two groups was .75 which was not statistically significant at the .05 level of confidence.

Conclusion

From the findings of the study the following conclusion was drawn: Students achieve at essentially the same level whether taught by the traditional method or by emphasis on the laboratory oriented BSCS course. The null hypothesis was accepted.
Implications

From the findings and conclusions of this study, the following implications can be drawn:

1. New methods must be devised to increase students' scientific achievement.
2. An articulated science program must be developed to allow more time for students to acquire basic skills.

Recommendations

Based on the findings and conclusions of this study, the following recommendations are made:

1. Students should begin development of behavioral objectives in science while enrolled in the elementary grades.
2. An inquiry approach to elementary and junior high science should be developed without needless repetition.
3. There should be developed an approach to biology that will involve both the traditional and BSCS materials.
4. The school program should allow more student time for carrying out the meaningful laboratory exercises designed by the BSCS writers.
5. This study should be replicated, allowing a longer period of time for the experimental phase.
BIBLIOGRAPHY

Books


Articles and Periodicals


36


**Unpublished Materials**


VITA

SHANNON, LARRY R.

Education

B.S. Florida A. and M. University, Biology.

Summer Studies (3) through National Science Foundation at Southern University, Baton Rouge, Louisiana.

NSF Fellowship, Atlanta University, 1965-66.

Experience


U. S. Army (2 years)

Field of Concentration

Science education with major emphasis in biology.

Personal Information

Member of Church of The Master United Presbyterian Church, Atlanta Teachers Association, Georgia Education Association, National Education Association, and American Biology Teachers. Past president of Manatee County (Florida) Teachers Association.