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THE EFFECTS OF CLASS PERIOD LENGTH AND FREQUENCY OF MEETINGS ON BIOLOGY STUDENTS' UNDERSTANDING OF THE PROCESSES OF SCIENCE AND THEIR ACHIEVEMENT IN BSCS BIOLOGY

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JERRY LEROY SMYTHE

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THE EFFECTS OF CLASS PERIOD LENGTH AND FREQUENCY OF MEETINGS ON BIOLOGY STUDENTS' UNDERSTANDING OF THE PROCESSES OF SCIENCE AND THEIR ACHIEVEMENT IN BSCS BIOLOGY

APPROVED BY

DISSERTATION COMMITTEE

Dedicated to:

My Wife and Children

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THE EFFECTS OF CLASS PERIOD LENGTH AND FREQUENCY OF MEETINGS ON BIOLOBY STUDENTS' UNDERSTANDING OF THE PROCESSES OF SCIENCE AND THEIR ACHIEVEMENT IN BSCS BIOLOGY

CHAPTER I

INTRODUCTION

An increased emphasis upon student participation and interaction with their physical environment through inquiry in the laboratory characterizes a significant trend in science education. The central position of the laboratory reflects the conviction that students understand science through participation in laboratory experiences that involve actual student investigations rather than through the vicarious position of reading about science or watching teacher demonstrations. The increased emphasis on student participation and interaction in the laboratory requires flexible and variable patterns of time.

Students need adequate time to read journal articles, to search for ideas and details in books, to identify problems, to pose relevant questions, to perform efficient and effective experiments, to make judgments on alternate hypotheses, and to interpret data. Since the 1930's a steady decline in the use of extended laboratory periods in science has been observed. Science courses are being taught largely within the framework of a traditional time schedule of fifty-five minute periods, five times per week. Many laboratory activities that emphasize the important feature of student self-discovery and direct experience with their physical environment require one hour or more. Metzner (1962) supported this point of view when he wrote that "it is difficult to compress into a single or double period laboratory the many experiences that emphasize the important features of an experimental approach. Continuity of time and effort in pursuit of a problem is required until the desired outcomes are obtained. In many instances the traditional schedule ends the lesson presentation and study before students have had adequate time to master the subject at hand" (p. 34).

Professional educators are beginning to question the traditional schedule in light of the knowledge explosion, recent information on individual student differences and the renewed emphasis upon the science laboratory as the focal point for teaching science as inquiry. The term "flexible scheduling" has received much attention in the professional literature in recent years, particularly in secondary schools. In rationale, flexible scheduling assumes that the nature of the subject dictates the length of the scheduled period. Therefore, educators realize that various subjects, by their very nature, do not require the same amounts of daily class time. No apparent logic exists today in the time honored assumption that all methods of learning are most effective within the framework of hour long periods that meet every day.

The questioning by educators of the traditional schedule and the current experiments with shorter periods, longer periods, and variable periods are healthy signs. The current professional literature reveals the startling fact that these flexible and variable patterns of time allotments appear to be based upon opinions of leading educators, social pressures, and administrative expediency.

Scientific inquiry in the area of time allocations is extremely meager. Otto (1950) concluded that "experimental evidence as to how much time per day per week is needed to teach a given subject in accordance with accepted standards is so inadequate that it may be ignored" (p. 379).

Smith, Stanley and Shores (1957) supported Otto when they stated that "the research bearing upon the distribution of time is both meager and inconclusive. The length and distribution of class periods usually have been determined with little regard to psychological realities. The distribution of the time alloted to various subjects has been determined more often by rule of thumb and by convenience" (p. 214-215). They went on to pose some very interesting questions, "how often should a class meet - three times, only once? Should it be thirty minutes, forty minutes, ninety minutes? Would it be more effective, other things being equal, to distribute the time over a longer period by offering the class only two or three times each week rather than daily? (p. 218). They supplied the answer to these queries by concluding that "there are as yet no answers to these questions. Nor is there adequate research bearing upon them... ... the entire secondary school system is operating on the basis of a mere convention with respect to the distribution of time" (p. 218). The amounts of time necessary for formal class situations is still not known, according to Heller (1971).

Today the Carnegie Unit faces a resistance that is encouraged by marked change in content of instruction, teaching methods, flexible scheduling, advanced placement honor courses, and early admissions to college. However, an absence of adequate research on which to base decisions regarding time allotments to replace the Carnegie Unit exists as Smith, Stanley and Shores (1957) pointed out "that no one knows the length of class period, nor the frequency of periods, most conducive to learning in any given content course" (p. 218).

Background of the Study

In 1963-64, the Oklahoma City Public School System adopted the Biological Science Curriculum Study, hereinafter referred to as BSCS and its related materials. The primary emphasis of the BSCS materials is on the importance of laboratory experiences that involve students in actual biology investigations. Much of the success in the teaching of BSCS materials is predicated on the students' involvement in laboratory activities.

Two versions of the BSCS biology program, the blue version, and the green version, were implemented in all high schools as the first year course in biology. Teachers were free to select the version they felt most qualified to teach.

During the 1970-71 school year the Oklahoma City Public School System developed and implemented a "time block" schedule in all but two of its member high schools. The concept of "time blocks" referred to blocks of time which differed in length according to the amount of time each block contained. Thus, classes met for various time durations and varying numbers of sessions per week. Some biology classes were meeting for two hours and twenty-five minutes twice a week, others met for seventy minutes four times per week, while still other biology classes met for fifty-five minutes five times per week. These blocks of time are hereinafter referred to as treatment A, treatment B, and treatment C, respectively. Further clarification of these treatment groups will be given in Chapter III.

Assuming that some subjects demand more time while others, by their very nature need less time daily, then research data should be gathered on the length of period and the frequency of meetings that are more conducive to learning in BSCS biology.

Implementation of the "time block" schedules brought to mind the following questions concerning BSCS biology:

1. what is the effect of an extended class period that meets less frequently on tenth grade students' achievement in biology?

2. is there a class period length and frequency of meeting more conducive than the traditional schedule for teaching and learning biology by inquiry?

3. will tenth grade BSCS biology students develop a better understanding of the processes of science if they are provided a longer class period?

4. is there a class period length and a frequency of meeting more conducive than the traditional schedule for high, medium and low ability level students' achievement in BSCS biology?

Statement of the Problem

The problem of this investigation was to determine if length of class period and frequency of class meetings significantly effected students' understanding of the processes of science and achievement in BSCS biology.

The first part of this study was concerned with the possible significant differences of tenth grade students with high, medium or low ability levels in their understanding of the processes of science and their achievement in BSCS biology classes that met during treatment A, treatment B, and treatment C.

The second part of the study compared tenth grade students' achievement in BSCS biology and their understanding of the processes of science in treatment A and treatment B with students enrolled in treatment C.

An investigation was also made of two secondary problems that related to the major problem under consideration.

1. Is there a significant difference in BSCS blue version and BSCS green version biology students' understanding of the processes of science and their achievement in BSCS biology classes that met for different lengths of time and frequency?

2. Is there a significant difference between biology teachers' classroom and laboratory practices?

Hypotheses

The following null hypotheses were proposed with regard to the major problem of this study:

Hypothesis 1. There is no significant difference in biology achievement as measured by the Comprehensive Final Examination, Form J, between high, medium and low ability tenth grade students in treatment A, treatment B, and treatment C.

Hypothesis 2. There is no significant difference in understanding of the processes of science, as measured by the Processes of Science Test, Form A, between high, medium and low ability tenth grade students in treatment A, treatment B, and treatment C.

Hypothesis 3. The academic ability level (DAT VR+NA) has no significant effect on tenth grade students' achievement in BSCS biology and their understanding of the processes of science.

Hypothesis 4. There is no significant interaction among academic ability, treatment, and the dependent variables, achievement in BSCS biology and understanding of the processes of science.

Hypothesis 5. After statistically adjusting for initial differences in academic ability, there is no significant difference in biology achievement, as measured by the Comprehensive Final Examination, Form J, between classes of tenth grade students taught in treatment A, treatment B, and treatment C.

Hypothesis 6. After statistically adjusting for initial differences in academic ability, there is no significant difference in the understanding of the processes of science as measured by the Processes of Science Test, Form A, between classes of tenth grade biology students taught in treatment A, treatment B, and treatment C.

Hypothesis 7. After statistically adjusting for initial differences in academic ability, there is no significant difference in the teachers' effect on classes of tenth grade biology students' understanding of the processes of science and achievement in BSCS biology.

Hypothesis 8. After statistically adjusting for initial differences in academic ability, there is no significant interaction among teachers, treatments, and the dependent variables, understanding of the processes of science and achievement in BSCS biology.

The following null hypotheses were proposed with regard to the secondary problems of this study:

Hypothesis 9. After statistically adjusting for initial differences in academic ability, there is no significant difference in biology achievement, as measured by the Comprehensive Final Examination, Form J, between BSCS blue version and BSCS green version biology classes taught in treatment A, treatment B, and treatment C.

Hypothesis 10. After statistically adjusting for initial differences in academic ability, there is no significant difference in understanding of the processes of science, as measured by the Processes of Science Test, Form A, between BSCS blue version and BSCS green version biology classes taught in treatment A, treatment B, and treatment C.

Hypothesis 11. After statistically adjusting for initial differences in academic ability, there is no significant difference in biology achievement and understanding of the processes of science between BSCS blue version and BSCS green version biology classes.

Hypothesis 12. After statistically adjusting for initial differences in academic ability, there is no significant interaction among version studied, treatments, and the dependent variables, understanding of the processes of science and achievement in BSCS biology.

Hypothesis 13. There is no significant difference in the classroom practices of biology teachers (section A through D combined) as measured by the Biology Classroom Activity Checklist, in treatment A, treatment B, and treatment C.

Hypothesis 14. There is no significant difference in the laboratory practices of biology teachers (section E through G combined) as measured by the Biology Classroom Activity Checklist, in treatment A, treatment B, and treatment C.

Hypothesis 15. There is no significant difference in the classroom practices (section A through D combined) and laboratory practices (section E through G combined) as measured by the Biology Classroom Activity Checklist, between teachers.

Hypothesis 16. There is no significant interaction among the teachers, treatments, and the dependent variables, classroom and laboratory practices of teachers, as measured by the Biology Classroom Activity Checklist.

Significance of the Study

Several aspects of this study had significant implications for future basic use. First, this study was designed to provide information in an area where very little information based on research data existed. Second, this study should have provided research data on which future decisions may be based in regard to time allocations that facilitate learning and teaching of an inquiry laboratory oriented biology course. Third, the results of this study should provide information in regard to length and distribution of class periods most conducive for high, medium, and low ability students to achieve in an inquiry oriented biology course. Fourth, the results of this study were designed to provide information concerning the reorganization of time for other science course offering in area schools. Fifth, the results of this study should provide data concerning teacher methodology conducive for learning science through the inquiry approach that local systems could use in designing in-service programs to improve science teaching, and finally this study should provide an investigation on which future studies might be based.

Definition of Terms

Achievement in BSCS biology is a students' knowledge and understanding of biology concepts and relationships studied in BSCS blue and green version biology as measured by the *Comprehensive Final Examination*, Form J.

Understanding of the processes of science is the ability of a student to interpret qualitative data; to recognize adequate criteria for accepting or rejecting hypotheses; and to evaluate the general structure of the experimental designs in science as measured by the *Processes of Science Test* (POST), Form A.

Time blocks refer to the amount of time and frequency of meetings alloted to specific classes.

BSCS blue and green version biology are two biology courses developed for average and above average tenth grade students. Each course consisted of a textbook with coordinated student laboratory manuals and teacher guides. Each course represented a different approach to the study of the same nine basic biological themes.

The basic content of both courses was seventy percent alike. The level of difficulty of the two versions was the same.

Inquiry occurred when students were provided opportunity to observe, hypothesize, experiment, gather data, analyze and draw conclusions from their data in finding their own answers. Emphasis was placed on employment of logical processes in solution of problem.

Delimitations

The study was limited to a single science subject, biology, as taught at a single grade level, the tenth.

The study involved only tenth graders enrolled in a BSCS blue or green version biology class in five Oklahoma City high schools.

The study involved only teachers who had taught a BSCS biology course one or more years, and were teaching either a BSCS blue or green version biology class in treatment A, treatment B, and treatment C.

Assumptions

That students were randomly placed in the participating biology classes prior to the initiation of this study;

That the sample selected from each school represented the population of that particular school which enrolled in BSCS blue and green version biology;

That achievement in BSCS biology could be measured effectively by the BSCS Comprehensive Final Examination, Form J;

The students' understanding of the processes of science could be measured effectively by the BSCS Processes of Science Test, Form A; and

That students' perception as to whether the teacher was conducting the BSCS biology classroom and laboratory according to the objectives and philosophy of the BSCS course could be measured effectively by the Biology Classroom Activity Checklist, (BCAC).

Organization of the Study

This study was divided into five chapters. Chapter I contains the introduction, background of the study, need and justification for the study, definition of the problem, and terms to be used. A review of selected and related literature is found in Chapter II. Chapter III deals with the design, procedures, instrumentation, test administration and scoring, and statistical treatment and Chapter IV presents the analysis and interpretation of data. The last chapter consists of the summary, major findings, conclusions, and recommendations.

CHAPTER II

REVIEW OF SELECTED AND RELATED LITERATURE

Science teachers and those responsible for the education of science teachers have been increasingly beset by claims concerning the values to be derived from the laboratory centered approach to science teaching. Investigations (Cox, 1963; Glass, 1962; Grobman, 1963; Hurd and Palmer, 1964; Klickman, 1962) supported the belief that the laboratory should be the very center of learning activities in a modern science course. Weaver (1963) summarized the feelings of most science educators and teachers concerning the use of the individual laboratory when he stated:

> It seems to me that it is absolutely essential that students do something more than listen to lectures, look at demonstration experiments, study a textbook, and recite a lesson. All of these things are good, but they are not enough. In addition, the students simply must do something on their own with their own minds and with their own hands (p. 342).

The problem of time in the use of the laboratory was discussed by Haney (1966) when he stated that "laboratory work takes time, especially work which is largely exploratory and unstructered. . . . for pupils to invent their own experiments . . . more time is generally required" (p. 31). Carleton (1960) supported Haney when he pointed out that "in order to provide for problem solving laboratory work in science. . . . within the time limits presently available it will not be possible to cover the large number of topics or problems generally included" (p. 165).

Students participating in the 1969 International Youth Science Fortnight were asked to evaluate the experimental approach to the teaching of science. Their evaluations were in agreement with Haney (1966) and Carleton (1960) when they considered the experimental approach was more interesting and beneficial than the traditional approach, but that the new sciences' materials had the disadvantage of being inefficient. These students felt that, while being freed in the physics laboratory to discover the properties of waves or pendulums was a creative challenge, it would also take time. The self-discover method provided them with a thorough understanding of fundamental concepts, but the study of more advanced topics was frequently precluded by the lack of time.

Hurd (1961) found that "it is becoming increasingly apparent that the present organization of teaching schedules . . . may not be the most efficient. A redeployment of time to allow for some periods that are longer . . . is needed" (p. 242). Hurd explained further that ". . . the investigatory side of the study of science [requires] the active participation of the learner in some real scientific investigation . . ." (p. 146), and also, that "we therefore need a block of uninterrupted, consecutive time of considerable magnitude . . ." (p. 148).

Berry (1964) advised:

> Teachers and class schedules should provide for substantial blocks of time so that learning tasks are not continually interrupted, and . . . an individual or a group has time to follow through with an alternate response relative to a topic or problem of particular interest. Discovery is seldom compatible with rigid time limits (p. 108).

The experimental approach that is being emphasized today has never been entirely neglected in laboratory teaching. The best teachers and planners have always done what they could to include a valid experimental approach to the sciences in their laboratory teaching. Hurd (1961) reviewed that:

> Such efforts have floundered on the practical difficulty of compressing an experimental approach to a problem into the confines of single laboratory period, or, at best, a short sequence. For the very essence of the experimental approach is that it continues to press toward a solution of a problem until results are obtained (p. 148).

Voss and Brown (1968) emphasized that:

> Laboratory work is too often rushed to completion because of time schedules. Much of the value of the laboratory in teaching reflective thinking is lost by this rush because thinking takes time. A few well-chosen, properly motivated laboratories, with large time allowances are probably preferable (p. 88).

The need for adequate time was expressed by Combs and Snygg (1959) as "the discovery of personal meaning is a process which seems to proceed best in an unhurried, unharried atmosphere. . . . Perceiving takes time and . . . the pressures of speed may destroy the processes of exploration entirely" (p. 394).

Martin (1960) point out that ". . . an increasing emphasis on pupil planning and performance of experiments to determine the principles which are actually inherent in a problem under investigation . . . teachers will need more time . . ." (p. 252).

Trump and Baynham (1961) felt that "different purposes in instruction require different class organization, procedures and skills" (p. 9). Trump and Baynham went on to stat that ". . . a complete break from the rigid organization of time [is needed] . . ." (p. 11).

Trump further indicated that in the future, schools will do less scheduling of students into forty to fifty-five minute class periods, and that experiences will determine the class period length. This suggestion of Trumps' must be based on pertinent research if it is to be useful.

Abel and Gill (1960) suggested the following:

> The length of the class period should be long enough to facilitate the gathering of pertinent information, studying such information, and then discussing it or rejecting it under the supervision of a competent teacher who can direct the process of recognizing the problem, gathering the information, sorting, interpreting, arriving at conclusions, and testing the conclusion in an orderly, challenging and effective manner (p. 8).

Saylor (1962) recommended that "high schools, rather than trying out plans that break the school day into little fifteen to twenty minute modules, try out plans of extended periods of ninety to one hundred twenty minutes" (p. 109).

Studies Pertaining to Class Period Length in Science

Although science educators and science teachers have written about the need for more class period time to conduct laboratory work, scientific research on time allocations was not abundant. A review of the literature did not yield a single study dealing with the same time block arrangements and frequency of meetings. A few selected studies were reviewed as a background to stimulate further investigation.

Olstad (1961) investigated the effect of length of class period on biology achievement in three randomly assigned groups of students. He reviewed the literature on the relationship of class period length to student achievement from 1918 through 1961. Because of the limited number of studies pertaining to class period length and achievement, Olstad's review of the literature is repeated in this study.

Sugar (1928) and Apolegarth (1935) studied the value of a single and double laboratory class in high school chemistry. They found that there was no significant advantage in favor of either.

Denman and Kirby (1933) attempted to determine subject matter achievement in long periods (fifty-five - sixty minutes) versus short periods (forty - forty-five minutes) in a number of high school courses which included physics and general science. They found no significant difference in favor of either the long or short periods in science, but did find a significant difference in American literature and geometry which did favor long periods. Kambly (1938) compared a one hour, two semester course in biology with a two hour, one semester course. He failed to find conclusive evidence that either plan or presentation was superior to the other, but found that teachers and students generally favored the two hour period per day. McElhinney (1961) investigated the relationship between classes that were scheduled for long periods (fifty-five or more minutes) and short periods (forty-five or less minutes) and the academic achievement in several areas of the high school curriculum, including science (biology and general science). Through use of the analysis of covariance, he found no significant difference in growth in achievement in the various academic areas (English, mathematics, science and social studies) between the long and short periods. He found that teachers and students favored the long periods.

Olstad (1961) criticized this early research on the relationship of class-period length to student achievement as not meeting the criteria of good research. He stated that:

> What little existed suffered from faulty design and

> analysis in ways such as the lack of randomization in sampling, the use of inadequate statistical techniques, the lack of control of all the variable factors, and the failure to measure the attainment of outcomes other than the mean gain in factual information (p. 24).

It was on the basis of the inconclusiveness and incompleteness of the early research that led Olstad to conduct his study. Olstad investigated the effect of class period length on biology achievement in three randomly assigned groups of students. Two groups met on alternate days for a double period of time (110 minutes), while the third group met daily for a single hour period (55 minutes). One of the two double period groups capitalized on the time allotment, while the second group treated the double period as if it were simply two single periods placed together. Olstad found that the two hour method, when utilized to the maximum produced a significantly greater attainment of problem-solving skills and was more effective in increasing variabilities in students' achievement in biology, than did the single hour method. Students in the longer class periods also tended to react more positively to their biology instructions. The above findings were made in light of the following limitations listed by Olstad:

1. A single school with a large majority of high ability students (mean intelligence for the entire school was 124);
2. A small sample size (three biology classes);
3. A single subject and grade level (ninth grade biology)

The above limitations and the following recommendations made by Olstad provided the major emphasis for the present investigation:

> 1. Research on the relationship of class period length to student achievement should be broadened to include other patterns of organization of class hours. Perhaps a longer

class period than that employed in this investigation would yield even greater dividends.

2. Research should be conducted in other schools on the relationship of class period length to student attainment of objectives of biology instruction. This would, in itself, provide a broader base for generalization (p. 142).

Welch and Budgham (1968) investigated the pacing of instruction in physics and the relationship of student achievement to the length of time spent on a particular unit. Here again, no significant correlation was found between achievement gain and elapsed time.

Grobman (1963) and Wallace (1963) reported on the results of large scale evaluation studies of the BSCS biology program. The BSCS biology program was tested by 65,000 tenth grade students over a two year period. Analysis of the data yielded the following conclusions:

1. Students' performance on the BSCS Comprehensive Final Examination and the Processes of Science Test correlated highly with general ability as measured by the DAT VR+NA.

2. On the BSCS Comprehensive Final Examination, students beginning the biology course knew little of the test content.

3. That one version of the BSCS biology was not more suitable for use with certain types of students or in certain types of school situations.

4. A positive relationship was found between the variables-teacher salary, adequacy of laboratory, small class size, and proportion of schools' graduates going to college - with students' performance on the Comprehensive Final Examination.

5. The variables of student ability, sex of student, teachers' salary, adequacy of laboratory, class size, and proportion of schools' graduates going on to college accounted for about three quarters of the variance in student scores on the BSCS Comprehensive Final Examination. One fourth of the variance in student achievement is unaccounted for.

6. The variables of size of school, length of class period, number of periods per week, per pupil expenditure, teacher's age, years of teaching experience, number of undergraduate

> and graduate hours in biology and the location of school (rural-urban-suburban) had little or no demonstrable relationship to students' performance on the BSCS Comprehensive Final Examination.

Information on the class period length and on the number of class meetings per week was obtained by use of a questionnaire completed by each teacher who participated in the evaluation. A summary of the responses dealing with length of class period and number of meetings per week yielded the following information:

1. Ninety-five percent of the teachers met in class periods of forty to fifty minutes in length.

2. Ninety-nine percent of the teachers reported meeting classes from four to seven times per week.

There was not a noticeable amount of variation in the experimental sample which would account for the failure of the length of class periods and number of meetings per week to be discriminatory.

Studies Related to Class Period Length in Other Areas

The studies reviewed investigated the relationship of time allotments to achievement of elementary students. Deady (1969) conducted an investigation to determine if increased time allotments and a teachers' preference for a particular time allotment would increase fourth grade students' achievement in science. He also investigated the relationship between the teachers' preference for a particular time allotment and the fourth grade students' attitude toward science. The experimental groups reported a mean of thirty minutes of science instruction per day, while the control groups reported a mean of twenty minutes of science instruction per day. Deady found no significant difference that could be attributed to the treatment variable of increased time allotment or the variable of teacher preference when examined across experimental groups, sexes, IQ, or reading groups. Infrequent interactions were attributed to random effects.

Jarvis (1962) conducted a study on the relationship between variables of time allotments and intermediate elementary pupils' achievement in reading, arithmetic, and language. Analysis was made of the achievement of 329 pupils who were studying reading on an average of sixty - seventy minutes daily, and language forty - fifty minutes daily. The results of these pupils were compared with the 384 pupils studying in class period length of forty - fifty minutes daily for reading, thirty-four - forty-five minutes daily for arithmetic, and twenty-five - thirty minutes daily for language. Pupils were further studied by isolating pupils with intelligence quotients of 95 or less, and 115 or more from both the maximum time allotment and minimum time allotment groups for comparing achievement. A t-test was used to determine that the maximum and minimum time allotment pupils did not differ significantly in ability. Jarvis concluded that:

> In reading vocabularly there was no significant difference between mean achievement levels of maximum and minimum time allotment pupils when all of the children were considered or when those of 95 or less intelligence quotients were analyzed. Mean achievement levels of 115 or more IQ pupils in maximum time allotments was significant at the .01 level of confidence.
>
> In the area of arithmetic reasoning and fundamentals, the students in the maximum time allotment groups achieved higher than those in the minimum time allotment groups. These findings were significant at the .01 level of confidence.
>
> The longer time allotments were also favorable to student achievement in language mechanics. These findings were significant at the .01 level of confidence.

Jarvis' study was also designed to answer the following question: Is there a relationship between time allotments and pupil achievement in elementary school reading, English, and spelling? He collected data on 723 sixth-grade pupils in reading, 616 pupils in English, and 253 children in spelling. These students had been studying under varying time allotments in grades four, five and six. In reading, the maximum time allotment children spent 60-70 minutes daily and the minimum time allotment pupils spent 40-50 minutes daily. In English, the maximum time allotments spent 40-50 minutes daily compared to 25-30 minutes daily for the minimum time allotment pupils. In spelling, the maximum time allotment was 40-50 minutes daily, while the minimum time allotment was 20 minutes daily. The maximum and minimum time allotment pupils did not differ significantly in intelligence when subjected to a t-test for statistical significance.

Jarvis' conclusions were:

> In English mechanics which included the areas of capitalization, punctuation, and word usage, the evidence is unmistakably clear that to effect the greatest pupil achievement the daily class period length should not be less than forty minutes.
>
> The most significant findings of all was the relationship between time allotments and pupil achievement in spelling. Spelling periods which are in excess of twenty minutes daily are unwarranted, pupil achievement was found to be greater in the short time allotments.
>
> Formalized reading classes which are longer than fifty minutes daily do not yield enough additional significant pupil achievement to warrant them.

Loveless and Holmes (1968) sent out an opinionnaire to 478 business and office practice teachers, counselors, principals, vocational directors and superintendents in Utah high schools to obtain their opinions concerning the advantages and disadvantages of two-period block classes compared to two one-hour period classes not taught consecutively. A total of 259 or 58 percent, usable opinionnaires were returned and tabulated. A majority of those responding agreed that the following were the advantages of using the two-period blocks; more material could be taught, related subjects correlation would be greater, more flexibility is permitted, student achievement is higher, opportunity for individualized instruction is increased, vocational counseling is improved, and more usable working time is provided. Loveless and Holmes concluded that the two-hour period was more desirable than the two one-period block for the teaching of vocational business classes.

Steagall (1968) conducted a study to determine whether students enrolled in a stenographic block of time program achieved higher competencies in the knowledge and skills of stenography than students enrolled in the conventional stenographic program. A questionnaire was used to obtain comments from students and teachers on the value of the block program. Two sets of the National Business Entrance Tests, stenographic skills and business fundamentals, were administered. Analysis of covariance was used to adjust for student difference in ability. Steagall reported that:

> 1. No significant differences were found between the achievement of the block students and conventional students as measured by the National Business Entrance Tests.
>
> 2. No significant differences were found between the low, average, and high ability students in the block program and the conventional program.
>
> 3. Urban students in the block program scored significantly higher on the stenographic test than the conventional urban students.

4. Suburban students in the conventional program scored significantly higher on the business fundamentals test than the block suburban students.

5. No significant differences were found between the achievement of the block and conventional students in the rural and urban schools as measured by the business fundamentals test and the stenographic skills test.

Those practices identified in the students' questionnaire as occurring more frequently in the block-of-time program were:

1. The block program provides the time for instruction in depth and for intensive training.

2. The teacher is able to become better acquainted with the needs, interests, and abilities of students and to plan learning experiences to meet students needs.

3. The teacher is better able to vary instructions to meet individual needs.

4. Greater opportunity is provided to explore and utilize the knowledge and skills of more than one subject in solving problems.

5. The class is able to complete a project or discussion without interruption at the end of a regular period.

6. More flexibility is provided because of the longer period of time with one group of students.

A Chi-square test indicated a significant difference at the .05 level.

Georgiades and Bjelke (1966) compared English achievement of ninth grade pupils enrolled in a three period block, team-teaching (experimental) class with English achievement of ninth grade pupils enrolled in a conventional (control) class. Comparison of achievement was effected on the basis of a 100 item teacher-made test and two sections of a standardized achievement test. In this investigation, English achievement of 74 ninth grade pupils enrolled in a three period, team-teaching class (including algebra, English, and social studies) was compared with English achievement of 149 ninth grade pupils enrolled in a conventionally taught class. An analysis of variance revealed the following:

> 1. A significant difference in means for the experimental versus the control group on the teacher-made test and the two sections of a standardized achievement test.
>
> 2. A significant difference in means for the high level of intelligence group versus the low level of intelligence group on each of the three measures of achievement.
>
> 3. A significant difference in the means for the girls versus boys on the teacher-made test.
>
> 4. No significant difference effects; i.e., interaction between the three main effects (methods of instruction by level of intellectual ability by sex).

Georgiades and Bjelke concluded that the findings were sufficiently positive to warrant further implementation and evaluation of the three period block, team-teaching class.

Carroll (1963) proposed a model of the influence of time variations on learning and achievement. Carroll states that:

> The model involves five elements - three residing in the individual and two stemming from external conditions. Factors in the individual are (1) aptitude - the amount of time needed to learn the task under optimal instructional conditions, (2) ability to understand instruction, and (3) perseverance - the amount of time the learner is willing to engage actively in learning. Factors in external conditions are (4) opportunity - time allowed for learning, and (5) the quality of instruction - a measure of the degree to which instruction is presented so that it will not require additional time for mastery beyond that required in view of aptitude (p. 729).

The degree of learning was considered to be a function of the ratio of time actually spent in learning to the time needed to learn. Time spent in learning was defined by a combination of the smallest value of the following: (a) opportunity - the time allowed for learning; (b) aptitude - the amount of time needed to learn; and (c) the length of time the learner was willing to spend in learning (perseverence). The time needed to learn a task is determined by the quality of instruction and the ability to understand instruction. The values representing the time spent and the time needed were the numerators and the demoninators, respectively, in the ratio mentioned earlier. The time needed to learn might be extended by poor quality of instruction and by the inability of the learner to understand instruction.

A variety of research studies regarding the influence of time variations upon effective learning of school related tasks have been patterned after or are congruent with the model proposed by Carroll.

Sjogren (1967) in a study constructed to test the Carroll model concluded that the results supported the model in that a measure of the degree of learning from the study of a program one time was significantly related to the ratio of time taken to time needed for the study of the program. Sjogren concluded that the data provided evidence that time ratio has a significant linear relationship with measures of learning, with two achievement tests, and with an aptitude measure, thus providing additional evidence to support the credibility of the Carroll model.

Bugelski (1962) studied item presentation time per trial in relation to total learning time. He tested the hypotheses that, in at least some areas of memorization and under some conditions of presentation, the degree of learning would be a function of total time, regardless of the duration of the individual's trial-interitem times. Bugelski reported that the findings suggested that the total learning time was a significant variable to be considered in at least some kinds of learning.

Murdock (1960) employed free recall of work in lists of varying lengths. He found that time was a determining factor in the amount of number learned, regardless of presentation time.

Jester and Travers (1967) studied the effects of various presentation patterns on the comprehension of speeded speech by tracing the two conditions of increasing and decreasing speed. They concluded that when the rate at which material is presented is increased, there was no gain in comprehension after the second display of the material. A fast presentation after a slow presentation did not add to the material retained. Conversely, by decreasing the rate of presentation on successive trials, the learning curve continued to rise throughout the different rates of presentation and reached a higher level of learning than either of the other rates of presentation conditions. The level of learning achieved fell roughly between increasing and decreasing modes of presentation. From the results, Jester and Travers concluded that maximum learning occurs when the rate of presentation nears the optimum of level required by the learner for mastery.

In a study which assessed two possible strategies for accommodating individual difference in pacing requirements when the pace must be controlled externally, Kress and Gropper (1966) concluded that achievement scores tend to decline as the tempo increases (a finding similar to that reported by Jester and Travers, 1967). They also observed a general pattern which revealed that the mean performance was highest when characteristically fast students worked under a fast fixed tempo, and when characteristically slow students worked under a slow fixed tempo. Kress and Gropper concluded that the lowest mean achievement scores resulted when there was a failure to match characteristic work rates and externally controlled tempos.

Research conducted by Rogers (1968), concerned with programmed and flexible modes of presentation, revealed the following:

> 1. The method of presentation affects the rate variation of pupils when they are asked to perform related tasks.
>
> 2. Pupils with different operative rate patterns will show different achievement outcomes when exposed to different modes of presentation.
>
> 3. The rate of work is the best predicator or gain of achievement if the method of presentation is flexible (fast worker will be superior achiever).
>
> 4. The rate with which learners complete the criterion test can be predictive of performance when the modes of presentation becomes a variable.

In general, Rogers' findings supported Carroll's model which stated that the degree of learning was a function of the ratio of time spent to time needed.

Summary

A review of the literature disclosed many references to the need for larger blocks of time to conduct the inquiry laboratory oriented science course. However, research bearing on the relationship of time allocation to achievement in science was meager and inconclusive. Studies on time allocation and achievement in other disciplines of the school curriculum would indicate that time needed may depend somewhat on the structure or nature of the subject. Several studies reviewed seem to support the assumption that there is a linear relationship between time and learning.

An examination of the research failed to produce a study utilizing the same time block variables as included in this study, nor did any of the studies reviewed use any of the new science curriculum material emphasizing inquiry teaching techniques.

CHAPTER III

METHODS AND PROCEDURE

Subjects

The subjects for this study were tenth grade students enrolled in biology classes in five of the senior high schools of the Oklahoma City Public School System. All five schools offered either the BSCS blue version text, Biological Science: Molecules to Man, 2nd edition, or the BSCS green version text, High School Biology, 2nd edition, as the first year program in biology. All schools had similar requirements in regard to student eligibility for enrollment in BSCS blue and green version biology. Teachers in each school were free to select the version they felt they were most qualified to teach.

A total of 128 students from six classes taught by two teachers in two high schools were using the BSCS blue version biology program. The other three teachers, in different high schools, were using the BSCS green version with a total of 158 students.

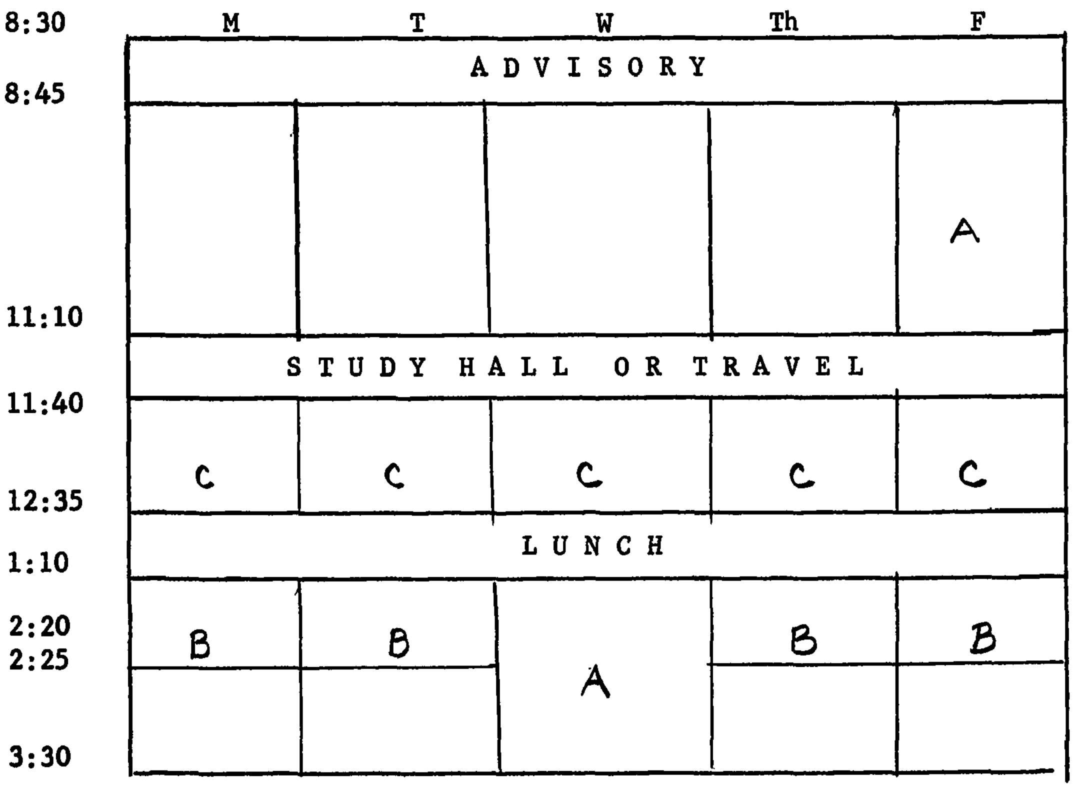
In all of the schools, the subjects were taught by certified teachers in treatment A, treatment B, and treatment C. The total amount of time devoted to biology instruction each week was 280, 280, and 275 minutes respectively. Students enrolled in treatment A were given a five minute break half-way through the period, accounting for the 280 minutes per week instead of the 290 minutes. No attempt was made to equate the amount of material presented to the individual classes. The scheduling of the treatment groups is shown diagrammatically in Figure 1.

Although biology was not specifically required for graduation in the five schools, a majority of the subjects elected biology as the laboratory science to meet graduation requirements.

The subjects were members of fifteen intact biology classes, which were established by the normal enrollment procedures employed by counselors in the five schools. Normal enrollment procedures in the

Figure 1

Sample Weekly Schedule for Treatment Groups



participating schools did not include the division of students into groups according to academic achievement.

The BSCS blue and green version biology classes in this study were taught by five teachers, all of whom had experience in teaching the BSCS biology program. Four of the teachers had received special training in the use of BSCS curriculum materials. The use of five different teachers introduced variables that would not be present if all classes had been taught by the same instructor. The investigator, therefore, elected to include the five teachers as independent variables in the design of the experiment.

Selection and Description of Instruments

All subjects in the five schools were required to take two standardized tests at the end of the study. The investigator selected the Comprehensive Final Examination, Form J, and the Processes of Science Test, Form A, developed by the BSCS evaluation committee to measure specifically students' progress in a BSCS biology course.

In a study by Galleger (1967) of how teachers teach a concept in biology concluded that "there really is no such thing as a BSCS curriculum presentation in the schools. Rather there is a [teacher A] interpretation of the curriculum, and so forth" (p. 17). The Biology Classroom Activity Checklist was used to obtain students' perception of whether the teachers' classroom and laboratory practices were in agreement with the objectives and philosophy of the BSCS course. The technique of having students report on the practices that take place in their classroom is supported by (Cogan, 1958; Cornel, 1952; Kochendorfer, 1967; Leeds and Cook, 1947;

Lewin, 1943) who believed that students could accurately report what they had observed.

Additional standardized multifactor test scores were secured for each school from the research department of the participating school system. The descriptive information which follows in this chapter was found in the respective test manuals.

Comprehensive Final Examination, Form J, (Biological Science Curriculum Study, 1965) was designed to measure a students' knowledge and understanding of basic concepts, principles, and relationships contained in a BSCS biology course. The test consisted of 50 multiple choice items that measured specific knowledge of the course materials in both the BSCS blue and green versions biology. The test allowed forty-five minutes of testing time for completion of the 50 items. The test manual contained distribution scales which listed percentile ranks and standard scores based on data obtained by testing 11,092 students. The published norms, reliability, and validity of the standardized test, provided sufficient evidence that the test was a valid instrument for use in this study.

Processes of Science Test, Form A, (Biological Science Curriculum Study, 1965) consisted of forty multiple choice items designed by the BSCS evaluation committee to appraise a students' understanding of general scientific principles and scientific reasoning ability. More specifically, the test was an instrument for measuring the following:

1. the ability to interpret qualitative and quantitative data;
2. ability to screen and judge the design of experiments;
3. ability of students to recognize adequate criteria for accepting or rejecting hypotheses;

4. to evaluate the general structure of experimental design in science, including the need for controls; and

5. the extent to which students have developed standards for judging or appraising data.

The test allowed thirty-five minutes of testing time for completion of the 40 items. The test manual contained norms, reliability, and validity coefficients based on data obtained from administering the test to more than 28,000 students enrolled in BSCS biology courses. This data provided sufficient evidence that the test was a valid instrument for use in this study.

Biology Classroom Activity Checklist (Kochendorfer and Lee, 1966) was designed to measure a students' perception of actual classroom practices as they related to the philosophy and rationale of the BSCS program. The checklist consists of 53 specific items that described some classroom activity (Appendix B). Each of the items was written from the viewpoint of the student. Kochendorfer obtained a reliability and validity coefficient of .96 and .84 respectively for the instrument.

The BCAC is organized into seven sections. The nature of each section was identified as:

1. role of the teacher
2. student participation
3. use of curriculum materials
4. tests
5. pre-laboratory
6. laboratory
7. post-laboratory

The BCAC had 26 items which were considered true and 27 items which were considered false. The student responds depending upon the situation in his classroom. The instrument was scored by considering a positive item marked true or a negative item marked false as a correct response. A score for each checklist was computed, using the following formula:

$$\text{Score} = \frac{\text{Number of Correct Responses}}{\text{Total Number of Responses}} \times 100$$

Scores on the BCAC had a potential range of 0 to 100, with the highest scores indicating a greater degree of agreement with practices recommended by the BSCS.

Written permission to use the BCAC was obtained from Dr. Leonard Kochendorfer and Dr. Addison Lee.

Laboratory Facilities Checklist (BSCS, 1962 revised, 1966) was designed to facilitate comparative evaluation of biology laboratory facilities in schools (Appendix B). The laboratory facilities were grouped into three categories:

1. fixed laboratory installations, budget considerations, microscopes, and laboratory assistance
2. small equipment and demonstration of aids
3. major equipment

The checklist permitted a general comparison of a schools' facilities with optimal facilities indicated on the checklist. A point value was assigned to each category and the school received points for having items listed on the checklist. A grand total for all categories was computed and the school laboratory was rated from A to F, based on the total number of points received.

Differential Aptitude Test (DAT) was administered annually to every ninth grade student enrolled in the school system of which the five schools participating in the research were part. The DAT contained eight sub-tests, which are: (a) verbal reasoning, (b) numerical ability, (c) abstract reasoning, (d) space relations, (e) mechanical reasoning, (f) clerical ability, (g) spelling ability, and (h) sentence usage.

The test was divided into easily administered parts, answer sheets were provided for machine scoring, and directions were clear on the two available forms. Three hours and six minutes of actual testing time was needed to administer the test.

The students' scores on the combined verbal reasoning and numerical ability components of the DAT measured that which was equivalent to academic aptitude or ability.

Selection of Samples

The Oklahoma City Public School System employed 23 teachers to teach 4,759 BSCS biology students in seven high schools. The samples of subjects were selected by identifying those teachers who were teaching a BSCS blue or green version biology class during all three time block variations. All teachers who had not received special training or who had not taught the BSCS biology program for one or more years were excluded. A biology class that met for fifty-five minutes, five times per week; seventy minutes, four times per week; and two hours and twenty-five minutes, two times per week were selected from the program of each teacher who met the above criteria. Classes were selected that met approximately the same time of the day, i.e., the afternoon.

The final sample of subjects selected consisted of five teachers and 286 tenth grade students (BSCS biology) enrolled in fifteen intact biology classes in five senior high schools. The sample distribution is recorded in Table 1.

Table 1

Sample Distribution

School	Teacher	Version Studied	Treatment A	Treatment B	Treatment C	Total
A	1	Blue	15	23	22	60
B	2	Blue	15	26	27	68
C	3	Green	22	20	24	66
D	4	Green	22	18	13	53
E	5	Green	11	14	14	39

Since the samples were non-random, generalizations about the population from which the samples were drawn was made with some caution. However, no effort was made by the investigator to choose particular teachers or classes for this study, other than to apply the criteria of:

1. training and experience of the teacher with the BSCS program;

2. teachers who were teaching a BSCS blue or green version biology class during all three time variations;

3. selection of classes that met during one of the different time block variations; and

4. selection of classes that met in the afternoon.

Any variable that may have appeared to effect the selection procedure should not, in general, have had more effect on the selection of the teachers and/or classes in one group than another. There was no evidence that students were not randomly assigned to the different classes by normal enrollment procedures.

Procedure

The procedure of this study was the testing of the hypotheses by use of three treatment groups in each of the participating high schools. The major difference between the treatment groups was the length of time and the number of times the classes met per week. The three treatment groups were thus defined:

1. Treatment A (experimental, time and frequency of meetings): This group consisted of biology classes that met for two hours and twenty-five minutes, two times per week. Teachers received no special training in the employment of procedures to take advantage of the extended class period.

2. Treatment B (experimental, time and frequency of meetings): These groups consisted of biology classes that met for seventy minutes, four times per week. Teachers received no special training in the employment of procedures to take advantage of the extended class periods.

3. Treatment C (control): This group consisted of biology classes that met for fifty-five minutes, five times per week.

The biology course content utilized here, as with all treatment groups, was the BSCS blue and green version biology texts and related laboratory materials. These two versions of BSCS biology were inquiry laboratory oriented materials designed to help students develop a workable understanding of the principles and generalizations of biology. They were also designed to aid students in the development of an operational understanding of the nature of science and its' underlying methods and attitudes.

Standardized tests were administered to all students in order to gather data on the variables, students' understanding of the processes of science, and their achievement in BSCS biology. Each students' score on the DAT VR+NA was obtained from the central testing office for the computation of a mean ability score for each class. This data was used to compute multiple-classification analysis of covariance F test to determine the relationship and significant difference of treatments and teachers on the dependent variables. Students' DAT VR+NA scores were also used to classify students into high, medium and low ability groups. The interaction of ability level and treatments with the dependent variables, achievement and understanding of the processes of science, were tested by computing multiple-classification analysis of variance F tests.

The secondary problem, version of BSCS biology studied and how it related to students' achievement in biology and their understanding of the processes of science, was studied by classifying students according to version studied. Multiple-classification analysis of covariance F tests, using the DAT VR+NA scores as the covariate, were computed to determine the relationship and significant difference of treatment and version studied on the dependent variables.

The Biology Classroom Activity Checklist was used to collect data on teachers' classroom and laboratory practices. This data was used to compute multiple-classification analysis of variance F tests to determine the relationship and significant differences between teachers and treatments.

Testing Procedure

Each year in October the guidance counselors administered the Differential Aptitude Test to all ninth-grade students in the Oklahoma City Public School System. Classroom teachers acted as proctors and assistants to the guidance counselors during the testing procedure. The answer cards were processed in the research department on an IBM 1401 computer. A copy of the test results was sent to the central testing office.

The participating school system did not permit reproduction of test data identifiable by student name. Therefore, the test results of the DAT VR+NA were recorded for subjects according to an assigned number.

In February, 1972, the five teachers participating in this study completed the Laboratory Facilities Checklist to provide a comparison of laboratory facilities available to each teacher.

Also during February, the Biology Classroom Activity Checklist (BCAC) was administered by the classroom teachers to all students participating in this study. The answer sheets were all hand scored. A classroom practice mean score (section A through D combined), and a laboratory practice mean score (section E through G combined) were computed for each class.

During the last week in February, 1972, all student participants were given sample tests to familarize them with the type of questions asked, and the general format of the BSCS standardized tests (Appendix B).

The answers to the questions were listed on the sample test and the students were allowed to keep the tests. Between March 1 and 10, 1972, the Comprehensive Final Examination, Form J, was given to 282 students to measure their achievement in BSCS blue and green version biology, and 286 students were given the Processes of Science Test, Form A, to measure their understanding of the processes of science. These tests were administered by the classroom teachers. Four student participants were absent the day the Comprehensive Final Examination, Form J, was given. All answer sheets were scored by hand. An achievement mean test score and an understanding of the processes of science mean test score were computed for each class.

The data collected in this investigation was recorded, and is included in Appendix A. This data was recorded according to an assigned teacher and student number.

Design

The design selected for this study was patterned after the posttest-only, control group design as described by Campbell and Stanley (1963). Concerning the posttest design, Campbell and Stanley agreed that proper application of analysis of covariance and blocking on subject variables, such as previous grades, IQ, and parents' employment could provide an increase in the power of significance test similar to that provided by a pretest.

The analysis of covariance was employed because of the need to use intact BSCS biology classes. The use of this statistical technique enabled this investigator to study the performance of several biology classes which were unequal in academic ability as though they were equal in this respect.

Analysis of covariance procedures adjusted the treatment groups means on the dependent variable for initial between group differences on the covariate. The correct error term was used to test for the significance of difference among adjusted means.

Scores on the DAT VR+NA were used for establishing group equivalence and as a concomitant observation in the analysis of covariance. The DAT VR+NA scores were selected as the control or covariate because of the high correlation of these tests with scores on the Comprehensive Final Examination, Form J, and the Processes of Science Test, Form A. The DAT VR+NA correlated r = .71 with the Comprehensive Final Examination, Form J, and r = .66 with the Processes of Science Test, Form A, (Bennett, Seashore, and Wesman, 1966).

As advocated by both Roth (1967) and Wardrop (1969), the unit of analysis was the entire class of students, and not the individual student.

Significance of difference between the mean scores of classes were tested with multiple-classification analysis of covariance F tests. In addition, two-way analysis of variance F tests were used to test the significance of difference between mean scores of other selected variables.

The .05 level of significance was adopted for acceptance or rejection of the stated hypotheses.

CHAPTER IV

RESULTS

Introduction

The primary purpose of this investigation was to determine the effects of class period length and frequency of meeting on tenth grade biology students' understanding of the processes of science and their achievement in BSCS biology. Two main effect variables of the problem were time allocation and frequency of class meetings, and the effects of these two factors on students of different levels of ability in their study of BSCS biology was of primary concern. A secondary purpose was to analyze data collected to determine the effect of the version studied and difference in teachers' classroom and laboratory practices on tenth grade students' achievement in biology and their understanding of the processes of science.

Data included in this chapter were obtained by administering two standardized tests, the BSCS Comprehensive Final Examination, Form J, and the BSCS Processes of Science Test, Form A. The Biology Classroom Activity Checklist was used to gather data on students' perception of actual classroom and laboratory practices of their teachers as they related to the philosophy and rationale of the BSCS program.

The statistical treatments, employed for testing the hypotheses stated in Chapter I, were the multiple-classification analysis of variance and the analysis of covariance which adjusts for initial inequalities Popham's (1967, p. 204-255) computation procedures were used for computing these statistical tests.

All calculations were performed on a Marchant 1016 PR electronic calculator. The .05 level of confidence was selected to test for significant differences between means.

Testing the Hypotheses and Analysis of the Data

The results of this study are presented in five sections. The first section records the results of two multiple-classification analysis of variance tests. These tests were used to determine if students of varied ability performed significantly different on the processes of science test and the biology achievement test in the three treatment groups.

The second section is a presentation and discussion of the results of two multiple-classification analysis of covariance tests used to determine the relationship and significant difference in students' achievement and understanding of the processes of science, with teachers and treatment groups as the independent variables.

The third section is concerned with results of two multiple-classification analysis of covariance tests used to determine the relationship and significant difference in students' achievement and understanding of the processes of science, with version studied and treatment groups as the independent variables.

The fourth section of this chapter is a presentation and discussion of two multiple-classification analysis of variance test used to determine if a significant difference existed between the teachers' classroom and laboratory practices, with teacher and treatment as the independent variables.

The fifth section is a supplementary analysis of data relevant to individual teacher differences in their laboratory and classroom practices.

The general format of each section consists of a statement of the hypothesis to be tested, followed by a table describing the appropriate sample data. This is followed by the results of the primary statistical treatment used and an interpretation of the applied statistical method with reference to the hypotheses tested.

Findings Pertaining to Biology Students of Varied Ability

Hypotheses one, two, three and four were tested in this section.

Hypothesis one stated that there is no significant difference in biology achievement between high, medium and low ability tenth grade students in three treatment groups.

Hypothesis two stated that there is no significant difference in understanding of the processes of science between high, medium and low ability tenth grade biology students in three treatment groups.

Hypothesis three stated that the academic ability level has no significant effect on tenth grade students' achievement in BSCS biology and their understanding of the processes of science.

Hypothesis four stated that there is no significant interaction among academic ability, treatments and the dependent variables, achievement in BSCS biology and understanding of the processes of science.

The raw scores on the combined verbal reasoning (VR) and numerical ability (NA) of the Differential Aptitude Test (DAT), were used to classify students into high ability (raw scores 41-99), medium ability (raw scores 27-40), and low ability (raw scores 0-26) groups. Two multiple-classification analysis of variance F tests were used to test the hypotheses.

Hypothesis one. Table 2 contains a summary of the means and standard deviation scores for 282 high, medium and low ability tenth grade biology students' achievement in three treatment groups.

Table 2

Achievement Means and Standard Deviation Scores of High, Medium and Low Ability Biology Students

	Time Blocks								
	Treatment A			Treatment B			Treatment C		
Groups	N	$\bar{X}$	SD	N	$\bar{X}$	SD	N	$\bar{X}$	SD
High	25	22.48	7.33	34	23.00	8.06	30	23.50	6.79
Medium	30	16.00	4.87	29	17.17	5.65	37	17.75	5.09
Low	33	14.79	5.47	34	13.91	3.74	30	14.60	4.56
Total	88	17.75		97	18.02		97	18.61	

The results of a multiple-classification analysis of variance test of 282 high, medium and low ability tenth grade biology students' achievement difference in three treatment groups is contained in Table 3. The obtained F value must be equal to or greater than 1 to be significant, therefore, the .942 value for treatments was not significant. Hypothesis one was accepted because high, medium and low ability tenth grade biology students achieved as well in treatment A and treatment B as they did in treatment C. The computed F value of 52.54 for ability was substantially larger than the 4.66 required for significance at the .01 level with 2 and 271 degrees of freedom. The F value of .093 for interaction was not significant at the .05 level.

Table 3

Analysis of Variance Test of Achievement Differences in Three Treatment Groups

Source of Variation	Degrees of Freedom	Sum Squares	Mean Squares	F
Treatments	2	63.5	31.75	.942
Ability	2	3540.5	1770.30	52.54**
Interaction	4	12.5	13.13	.093
Within	273	9200.0	33.69	
Total	281	12,816.5		

** Significant at the .01 level.

Hypothesis two. The means and standard deviation scores for 286 high, medium and low ability tenth grade biology students' understanding of the processes of science in three treatment groups are presented in Table 4. The results of a multiple-classification analysis of variance test of 286 high, medium and low ability tenth grade biology students' understanding of the processes of science differences in three treatment groups is summarized in Table 5. The computed F value of 3.49 (Table 5). for treatments was larger than the 3.02 necessary for significance at the .05 level with 2 and 276 degrees of freedom. Hypothesis two was rejected, which indicated that students' understanding of the processes of science was significantly different in treatment A, treatment B and treatment C. The total processes of science means in treatment A, treatment B and treatment C (Table 4) were compared by the Newman-Keuls method of multiple-comparisons (Weiner, 1962). The results of the comparisons indicated that students' understanding of the processes of science was not only higher in treatment C than in treatment B, but that the difference was significant at the .05 level. There was no significant difference between treatment A and treatment C, nor was there any significant

Table 4

Processes of Science Means and Standard Deviation Scores of High, Medium and Low Ability Biology Students

	Time Blocks								
	Treatment A			Treatment B			Treatment C		
Groups	N	$\bar{X}$	SD	N	$\bar{X}$	SD	N	$\bar{X}$	SD
High	22	25.68	4.47	36	23.33	4.02	32	24.22	5.84
Medium	32	17.50	6.24	29	17.38	5.09	34	19.06	6.54
Low	31	11.39	3.46	36	13.50	4.48	33	14.76	4.91
Total	85	18.19		101	18.07		100	19.35	

difference between treatments A and B. A comparison of high, medium and low ability students' processes of science means across treatment A, treatment B and treatment C (Table 4) indicated that medium and low ability students scored significantly higher in treatment C, while high ability students performed significantly higher in treatment A.

The *F* value of 116.49 for the students' ability, another source of variation, was substantially larger than the 4.66 necessary for significance at the .01 level. The F value of 1.49 computed for interaction was not significant at the .05 level.

Table 5

Analysis of Variance of Processes of Science Differences in Three Treatment Groups

Source of Variation	Degrees of Freedom	Sum of Squares	Mean Squares	F
Treatments	2	171.1	85.60	3.49*
Ability	2	5703.6	2851.80	116.49**
Interaction	4	146.3	36.57	1.49
Within	276	6761.8	24.48	
Total	285	12,782.6		

* Significant at the .05 level.
** Significant at the .01 level.

Hypotheses three and four. Based on the significant F values for ability and the non-significant F values for interaction (Table 3 and Table 5), hypothesis three was rejected and hypothesis four was accepted. Rejection of hypothesis three indicated that students' achievement in BSCS biology and their understanding of the processes of science was highly dependent on general academic ability. Acceptance of hypothesis four indicated that there was no significant interaction among ability level and the dependent variables.

The highly significant F tests for academic ability (Table 3 and Table 5) further supported the use of students' DAT VR+NA scores as a covariate to statistically control for initial difference in academic ability between classes in sections two and three.

Effects of Treatments and Teachers on Tenth Grade Biology Students

The use of intact biology classes and students absenteeism on the days that tests were given resulted in unequal class size necessitating the use of Ferguson's (1966, p. 120) formulae for computing the components of variance in the case of unequal classes. The use of these formulae depended upon whether the chi square departed significantly from equality at the .01 level. The formulae used to determine chi square or expected equal frequencies was:

$$x^2 = \sum_{r=1}^{R} \sum_{c=1}^{C} \frac{(n_{rc} - \bar{n})}{\bar{n}}; \; df \; RC-1$$

x^2 = Chi square

Nrc = Cell size

$\bar{n}$ = Average cell size of total sample

If the chi square value did not depart significantly from equality at the .01 level, the sum and sum of squares for each cell were adjusted by multiplying the values by $\bar{n}$/Nrc. Thus: the adjusted cell sum was:

$$\frac{\bar{n}}{n_{rc}} \sum_{r=1}^{n_{rc}} X_{rci}$$

and the adjusted cell sum of squares was:

$$\frac{\bar{n}}{n_{rc}} \sum_{i=1}^{n_{rc}} X_{rci}^2$$

The adjusted cell sums and sum of squares were used to obtain the row and column totals and the total sum of squares. This adjustment estimated what the cell sum and sum of squares would be if there was an equal number of subjects in each cell. The adjustment did not change the cell means or the row and column means. The analysis of covariance statistical test was computed in the usual way using these adjustments.

Hypotheses five, six, seven and eight were concerned with the variables, treatments and teachers, as they related to tenth grade students' achievement in BSCS biology, and their understanding of the processes of science.

Hypothesis five stated that after statistically adjusting for initial difference in academic ability, there is no significant difference in biology achievement between biology classes taught in treatment A, treatment B and treatment C.

Hypothesis six stated that, after statistically adjusting for initial difference in academic ability, there is no significant difference in the understanding of the processes of science, between biology classes taught in treatment A, treatment B and treatment C.

Hypothesis seven stated that, after statistically adjusting for initial difference in academic ability, there is no significant difference in teachers effect on students' understanding of the processes of science and their achievement in BSCS biology.

Hypothesis eight stated that after statistically adjusting for initial difference in academic ability, there is no significant interaction among treatments, teachers and the two independent variables.

Hypothesis five. Table 6 contains a summary of the unadjusted and adjusted achievement means, standard deviations and control variable means for 282 tenth grade biology students.

Table 6

Unadjusted and Adjusted Achievement Means, Standard Deviation and Control Variable Means

	Criterion Achievement				Control DAT VR+NA
	Unadjusted			Adjusted	
Groups	N	$\bar{X}$	SD	$\bar{X}$	$\bar{X}$
Treatment A					
Teacher 1	16	24.64	6.58	23.14	41.81
Teacher 2	15	18.80	5.62	18.03	38.20
Teacher 3	22	18.68	4.39	18.21	36.68
Teacher 4	23	11.78	3.21	13.40	26.26
Teacher 5	12	14.33	2.90	15.51	28.42
Subtotal	88	16.57		17.75	34.27
Treatment B					
Teacher 1	24	25.54	8.17	22.91	47.54
Teacher 2	23	17.04	5.37	16.54	36.83
Teacher 3	21	17.09	4.08	17.25	33.62
Teacher 4	17	13.70	4.16	14.56	30.08
Teacher 5	12	13.00	3.86	13.85	30.08
Subtotal	97	17.28		17.02	35.63
Treatment C					
Teacher 1	20	23.25	5.48	21.46	43.30
Teacher 2	28	19.10	7.76	18.56	37.11
Teacher 3	24	19.54	4.17	19.07	36.71
Teacher 4	12	12.16	3.06	14.85	20.91
Teacher 5	13	14.23	4.14	15.51	27.92
Subtotal	97	17.66		17.89	33.19
Total	282	17.52		17.70	34.36

Table 7 contains the results of a multiple-classification analysis of covariance test of the achievement difference between three treatment groups, controlling for academic ability. The computed F value of 3.25 for treatment was larger than the necessary 3.02 for significance at the .05 level. Hypothesis five was rejected. This

Table 7

Analysis of Covariance of Achievement Difference Between Three Treatment Groups, Controlling for Ability

Source of Variation	Degrees of Freedom	Residual Sum of Squares	Residual Mean Squares	F
Treatments	2	99.6	49.80	3.25*
Teachers	4	1387.8	346.95	22.67**
Interaction	8	1045.2	130.65	8.53**
Within	267	4085.1	15.30	
Total	281	6617.0		

* Significant at the .05 level.
** Significant at the .01 level.

suggested that after adjusting for initial difference in ability, there was a significant difference in students' achievement in treatment A, treatment B and treatment C. A comparison of the adjusted achievement means in Table 6 indicated that the overall mean (17.89) in treatment C was significantly higher than in treatment B (17.02); however, there was no significant difference in achievement between treatment A and treatment B, or treatment A and treatment C, at the .05 level. The obtained

F value of 22.67 for teachers was substantially larger than the 3.36 necessary for significance at the .01 level. Teachers did have a significant effect on students' achievement in BSCS biology. The F value of 8.53 obtained for the interaction source of variation was also significant at the .01 level, which indicated a significant interaction among teachers, treatments and achievement in BSCS biology.

Hypothesis six. Table 8 contains the unadjusted and adjusted processes of science means, standard deviations and control variable means for 286 tenth grade biology students. The results of a multiple-classification analysis of covariance test for the processes of science difference between three treatment groups, controlling for academic ability, is summarized in Table 9.

The F value of 2.61 for treatments (Table 9) was smaller than the 3.02 necessary for significance at the .05 level, therefore, hypothesis six was accepted. There was no significant difference in students' understanding of the processes of science in treatment A, treatment B or treatment C, after adjusting for initial differences in academic ability. The teacher's source of variation F value of 17.89 was greater than the 3.36 necessary for significance at the .01 level of confidence. The obtained F value of 3.37 for interaction was also significant at the .01 level.

Hypotheses seven and eight. Based on the significant F values obtained for ability and interaction (Table 7 and Table 9), hypotheses seven and eight were rejected. This indicated that after statistically adjusting for initial differences in academic ability, students' understanding of the processes of science and achievement in BSCS biology

Table 8

Unadjusted and Adjusted Processes of Science Means
Standard Deviation and Control Variable Means

		Criterion Achievement			Control DAT VR+NA
	Unadjusted			Adjusted	
Groups	N	$\bar{X}$	SD	$\bar{X}$	$\bar{X}$
Treatment A					
Teacher 1	15	23.06	7.44	20.46	44.40
Teacher 2	15	14.06	7.80	13.12	38.20
Teacher 3	22	21.90	5.95	21.39	36.59
Teacher 4	22	12.59	5.43	14.77	26.41
Teacher 5	11	14.81	7.16	16.61	28.00
Subtotal	88	16.57		17.65	34.27
Treatment B					
Teacher 1	23	23.69	5.45	20.23	47.52
Teacher 2	26	18.03	6.15	17.26	37.58
Teacher 3	20	17.10	6.21	17.10	34.65
Teacher 4	18	14.77	6.40	16.75	27.33
Teacher 5	14	14.86	4.80	16.57	28.29
Subtotal	101	17.70		17.58	35.07
Treatment C					
Teacher 1	22	23.31	5.08	20.52	45.05
Teacher 2	27	17.74	6.35	17.24	36.52
Teacher 3	24	22.58	5.16	21.66	38.08
Teacher 4	13	11.15	4.46	13.69	25.23
Teacher 5	14	17.00	4.47	19.28	26.21
Subtotal	100	18.36		18.48	34.22
Total	286	17.78		17.77	34.66

were effected by the classroom teacher. A significant interaction indicated that teachers and treatments interact with students' understanding of the processes of science and their achievement in BSCS biology.

Table 9

Analysis of Covariance of Processes of Science Differences Between Three Treatment Groups, Controlling for Academic Ability

Source of Variation	Degrees of Freedom	Residual Sum of Squares	Residual Mean Squares	*F*
Treatments	2	97.0	48.50	2.61
Teachers	4	1332.0	333.00	17.89**
Interaction	8	501.8	62.73	3.37**
Within	271	5043.7	18.61	
Total	285	6974.5		

** Significant at the .01 level.

Figure 2 presents a two dimensional analysis of the interaction among teachers, treatments and tenth grade students' achievement in BSCS biology. A significant interaction indicated that the performance of students on the achievement test was related to a particular combination of teacher and length of class period. The graph in figure 2 was made from the adjusted class achievement means in treatment A, treatment B and treatment C, for each teacher from Table 6.

An examination of figure 2 reveals that the significant interaction was among teachers and the difference in students' performance on the achievement test in the longer time blocks, treatment A and treatment B. For example, students taught by teacher 1 achieved higher in treatment A and treatment B, while students' performance on the achievement test for teachers 2, 3 and 5, was lowest in treatment B.

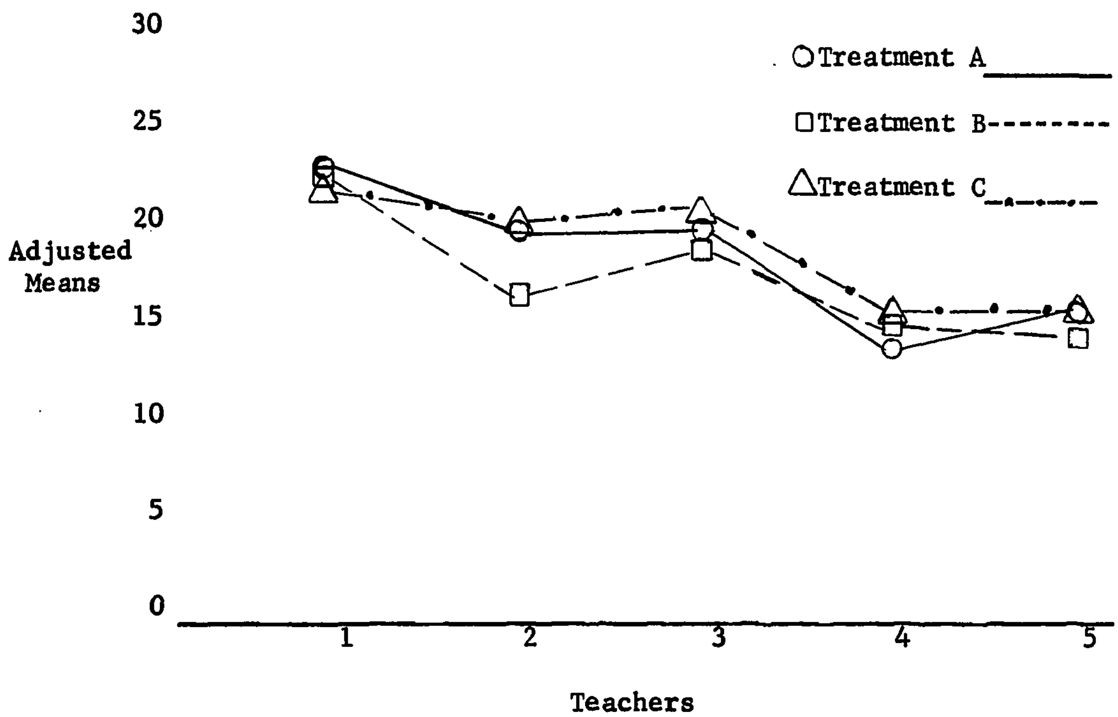


Fig. 2. Interaction among teachers, treatments and adjusted achievement means.

The parallel lines between teacher 2 and 3 illustrates no interaction; their students' performance on the achievement test was about the same in treatment A, treatment B and treatment C. With the exception of teacher 1, the overall performance of students on the achievement test was highest in treatment C.

Figure 3 presents a two dimensional analysis of the interaction of teachers, treatments and students' performance on the processes of science test. The significant interaction was among teachers and students'

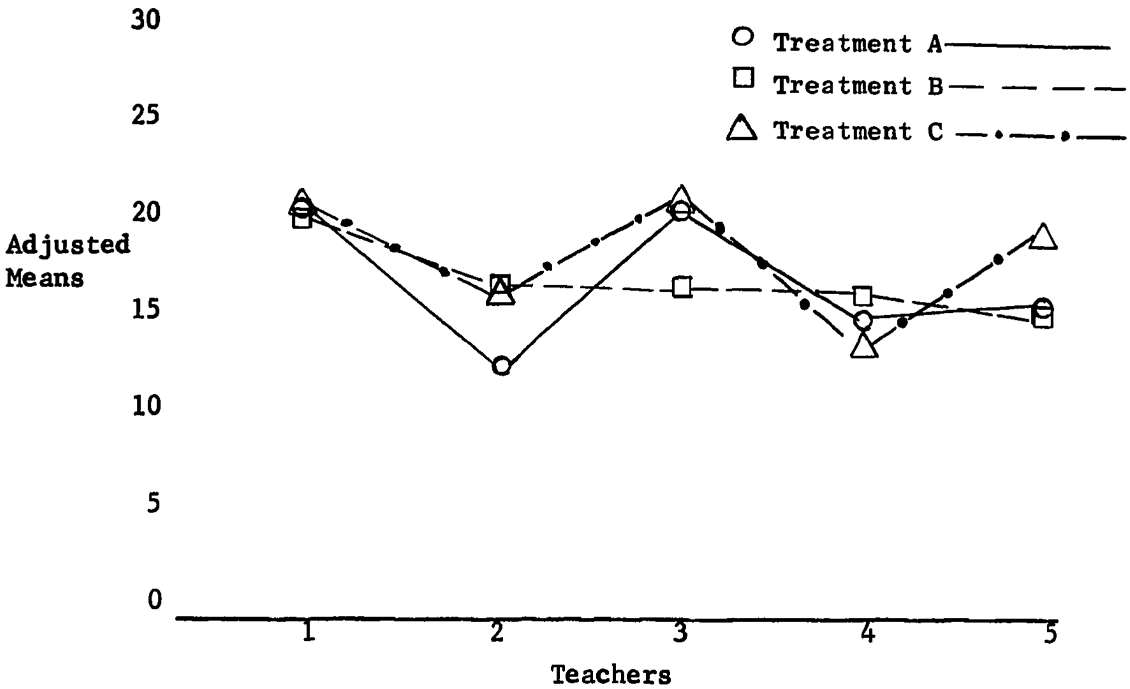


Fig. 3. Interaction of treatments, teachers and students' adjusted means on the processes of science test.

performance on the processes of science test in the shortest and longest time blocks, treatment C and treatment A, respectively. Students' performance on the processes of science test was not significantly different in treatment B under teachers 2, 3, 4 and 5.

The Newman-Keuls method employed to compare the adjusted means (Table 8) of students on the processes of science test in treatment A, B and C of each teacher indicated that, after statistically adjusting for initial differences in ability, students of teacher 1 did not perform significantly different on the processes of science test, in the three treatment groups. Teacher 2's students performed significantly higher in treatments C and B, when compared to treatment A. There was no significant difference between treatment C and treatment B. Teacher 3's students performance was significantly higher in treatments A and C, when compared to treatment B, with no significant difference between treatments C and A. The students of teacher 4 performed significantly higher in treatment B, when compared to the other two treatments. There was no significant difference found between treatment A and treatment C. Students taught by teacher 5 performed significantly higher in treatment C, when compared to treatments A and B. There was no significant difference between treatments A and B.

Effects of Treatments and Version Studied on Tenth Grade Biology Students

Hypotheses nine, ten, eleven and twelve were concerned with the variables of treatments and version studied as they related to students' understanding of the processes of science and their achievement in BSCS biology.

Hypothesis nine stated that after statistically adjusting for initial differences in academic ability, there is no significant difference in biology achievement between BSCS blue version and BSCS green version classes taught in treatment A, treatment B and treatment C.

Hypothesis ten stated that after statistically adjusting for initial differences in academic ability, there is no significant difference in understanding the processes of science between BSCS blue and BSCS green version biology classes taught in treatment A, treatment B and treatment C.

Hypothesis eleven stated that after statistically adjusting for initial differences in academic ability, there is no significant difference in biology achievement and understanding of the processes of science between BSCS blue and BSCS green version biology classes.

Hypothesis twelve stated that after statistically adjusting for initial differences in academic ability, there is no significant interaction among version studied, treatments and the dependent variables.

Students in the three treatment groups were classified into two groups, BSCS blue version and BSCS green version. The multiple-classification analysis of covariance test, with academic ability as the covariate was used to test the hypotheses in this section.

Hypothesis nine. Table 10 contains a summary of the unadjusted and adjusted achievement means, standard deviation and control variable means for 282 tenth grade biology students, classified according to version studied and treatment. An examination of Table 10 indicated that the number of students in each subclass was not equal. A preliminary test for homogeneity of variance resulted in an *F* value of 1.02, which was smaller than the 1.39 required for significance at the .05 level with 97 and 88 degrees of freedom. The assumption of variance homogeneity was accepted; therefore, the researcher continued with the analysis of covariance test.

Table 11 contains the results of a multiple-classification analysis of covariance test of 282 tenth grade biology students' achievement difference between the version studied and treatment groups, controlling for academic ability. In Table 11 the computed *F* value of 1.16 for treatments was smaller than the 3.02 required for significance at the .05 level. Hypothesis nine was accepted. After adjusting statistically for academic ability, there was no significant difference in the achievement of BSCS blue and BSCS green version biology classes in the three treatment groups.

Table 10

Unadjusted and Adjusted Achievement Means, Standard Deviation and Control Variable Mean

	Criterion Achievement				Control DAT VR+NA
	Unadjusted			Adjusted	
Groups	N	$\bar{X}$	SD	$\bar{X}$	$\bar{X}$
Treatment A					
Blue	31	21.81	6.72	20.60	41.62
Green	57	14.98	4.75	16.33	31.02
Subtotal	88	18.39		18.48	36.35
Treatment B					
Blue	47	21.38	8.10	19.74	42.25
Green	50	14.96	4.38	16.35	39.59
Subtotal	97	18.17		18.04	39.59
Treatment C					
Blue	48	20.83	7.14	19.87	39.68
Green	49	16.32	5.04	17.66	31.10
Subtotal	97	18.58		18.76	35.39
Total	282	18.38		18.42	37.11

The $\underline{F}$ value of 27.24 for version was substantially larger than the 6.70 necessary for significance at the .01 level. There was a significant difference in biology achievement between BSCS blue version and BSCS green version classes. The computed $\underline{F}$ value of .784 was not equal to or larger than 1; therefore, after adjusting statistically for academic ability difference, there was no interaction

Table 11

Analysis of Covariance of Achievement Difference Between Version Studied and Treatments, Controlling for Academic Ability

Source of Variation	Degrees of Freedom	Residual Sum of Squares	Residual Mean Squares	F
Treatments	2	53	26.50	1.16
Version	1	625	625.00	27.24**
Interaction	2	36	18.00	.784
Within	276	6332	22.94	
Total	281	7046		

** Significant at the .01 level.

between version studied, treatments and student performance on the achievement test.

Hypothesis ten. Table 12 contains a summary of the unadjusted and adjusted processes of science means, standard deviation, and control variable means for 286 tenth grade biology students. Table 12 did not contain an equal number of students in each subclass. A preliminary test for homogeneity of treatment group variance resulted in an F value of 1.45, which was larger than the 1.39 required for significance at the .05 level with 85 and 100 degrees of freedom. Winer (1962) stated that "there is no need for a high degree of sensitivity in tests for homogeneity of variance because F tests are robust with respect to departure from homogeneity of variance" (p. 93). The assumption of homogeneity of variance was accepted.

Table 12

Unadjusted and Adjusted Processes of Science Means, Standard Deviation and Control Variable Means

		Criterion Achievement			Control DAT VR+NA
	Unadjusted			Adjusted	
Groups	N	$\bar{X}$	SD	$\bar{X}$	$\bar{X}$
Treatment A					
Blue	30	18.23	9.07	16.70	41.30
Green	55	16.75	7.33	18.34	30.80
Subtotal	85	17.49		17.02	36.05
Treatment B					
Blue	49	20.69	6.44	18.88	42.24
Green	52	15.69	5.93	17.34	30.60
Subtotal	101	18.19		18.11	36.42
Treatment C					
Blue	49	20.24	6.41	18.99	40.35
Green	51	18.14	6.70	19.51	31.55
Subtotal	100	19.19		19.25	35.95
Total	286	18.29		18.12	36.14

The results of a multiple-classification analysis of covariance of 286 tenth grade biology students' understanding of the processes of science difference between version studied and treatments, controlling for ability, is contained in Table 13. The computed $\underline{F}$ value of 1.38 was smaller than the 3.02 necessary for significance at the .05 level.

Table 13

Analysis of Covariance of Processes of Science Difference Between Version Studied and Treatments, Controlling for Academic Ability

Source of Variation	Degrees of Freedom	Residual Sum of Squares	Mean Squares	*F*
Treatment	2	67	33.50	1.38
Version	1	78	78.00	3.22
Interaction	2	199	99.50	4.11*
Within	280	6776	24.16	
Total	285	7120		

* Significant at the .05 level.

Hypothesis ten was accepted. After adjusting statistically for ability differences, BSCS blue version and BSCS green version biology students did not perform significantly different on the processes of science test in any of the treatment groups. The *F* value of 3.22 for versions was smaller than the 3.86 necessary for significance at the .05 level. This indicated that after statistically adjusting for ability, BSCS blue version and BSCS green version biology classes did not perform significantly different on the processes of science test. The *F* value of 4.11 for interaction was significant beyond the .05 level of significance. There was a significant interaction among version studied, treatments and students' performance on the processes of science test.

Hypotheses eleven and twelve. Based on the non-significant *F* values obtained for version and interaction (Table 11 and Table 13), hypotheses eleven and twelve were accepted. Acceptance of hypothesis eleven indicated that after adjusting statistically for academic ability, BSCS blue and green version biology students did not perform significantly different on the processes of science test; however, Table 11 indicated that there was a significant difference in BSCS blue version and green version biology students' performance on the achievement test.

Hypothesis twelve was accepted; however, in Table 13 there was a significant interaction between version studied, treatments and students' performance on the processes of science test, but in relation to achievement, there was no significant interaction indicated in Table 11.

Figure 4 presents the significant interaction among version studied, treatments and BSCS blue and BSCS green version biology students' performance on the processes of science test.

A significant interaction indicated whether the performance of students on the processes of science test was related to a particular combination of version studied and treatments. An examination of Figure 4 reveals that the significant interaction was among BSCS blue version and BSCS green version biology classes performance on the processes of science test in treatments A and B. The BSCS blue version classes performed significantly higher in treatment B, when compared to treatment A. The BSCS green version biology classes performed higher in treatment A when compared to treatment B, but the difference was not significant at the .05 level of significance.

Both the BSCS blue and BSCS green version biology classes performed higher on the processes of science test in treatment C, when compared to treatments A and B.

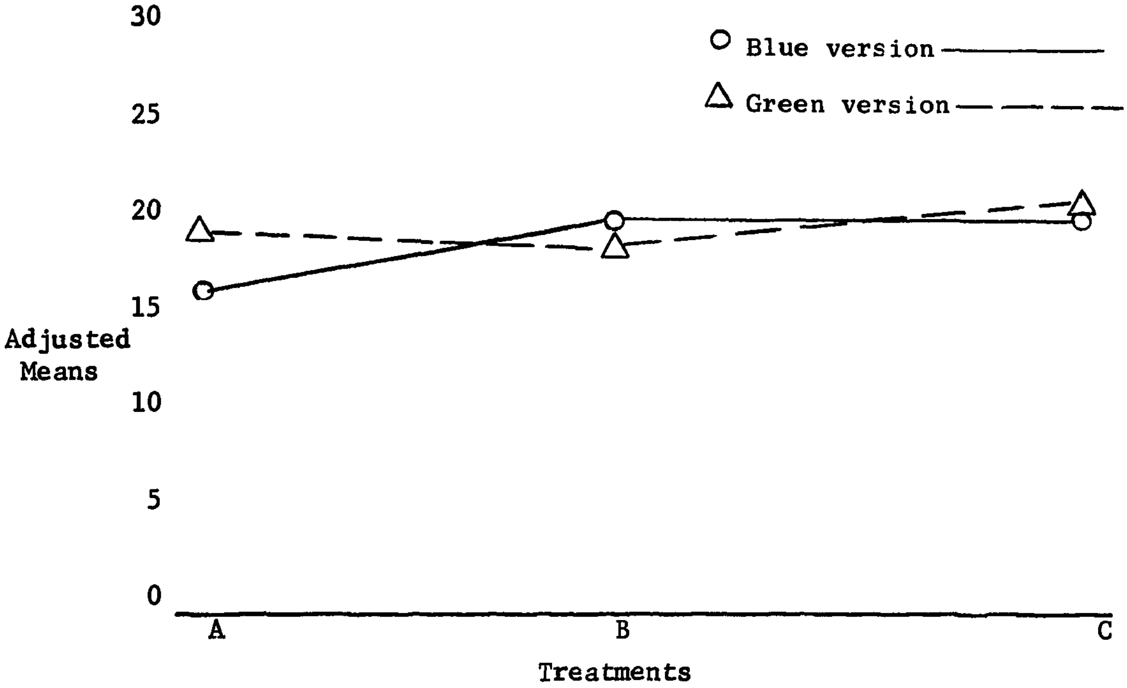


Fig. 4. Interaction among version studied, treatments, and student adjusted processes of science means.

Findings Pertaining to Teachers' Classroom and Laboratory Practices

Hypotheses thirteen, fourteen, fifteen and sixteen were concerned with the extent to which the teaching practice and techniques of the five participating teachers conformed to those advocated by the BSCS course objective and philosphy. The Biology Classroom Activity Checklist was used to gather data for analysis in this section.

Hypothesis thirteen stated that there is no significant difference in the classroom practices of biology teachers (section A through D combined), of the BCAC, in treatment A, treatment B and treatment C.

Hypothesis fourteen stated that there is no significant difference in the laboratory practices of biology teachers (section E through G combined), of the BCAC, in treatment A, treatment B and treatment C.

Hypothesis fifteen stated that there is no significant difference in the classroom practices (section A through D combined), and laboratory practices (section E through G combined), between teachers.

Hypothesis sixteen stated that there is no significant interaction among teachers, treatments and the dependent variables, classroom and laboratory practices of teachers.

The multiple-classification analysis of variance tests were computed to test the hypotheses in this section.

Hypothesis thirteen, Table 14 contains a summary of the means and standard deviation of 282 tenth grade students' scores on the classroom practices (section A through D combined), of the Biology Classroom Activity Checklist.

Table 14

Class Means and Standard Deviation Scores of Teachers' Classroom Practices (Sections A-D combined) on the BCAC

	Time Blocks								
	Treatment A			Treatment B			Treatment C		
Teachers	N	$\bar{X}$	SD	N	$\bar{X}$	SD	N	$\bar{X}$	SD
1	16	68.19	10.62	24	71.29	12.12	20	65.15	9.99
2	15	50.33	10.18	23	43.83	9.23	28	52.29	9.34
3	24	54.21	9.16	21	49.19	6.77	22	60.82	8.97
4	23	52.70	11.86	17	45.71	12.93	12	51.75	11.97
5	12	42.08	8.70	12	47.33	14.66	13	50.92	13.06
Total	90	53.50		97	51.47		95	56.19	

The test for various homogeneity resulted in an F value of 1.59, which was larger than the 1.39 required for significance at the .05 level. Ferguson's (1966) method of computing expected equal frequencies was applied to the data and resulted in bias F tests producing a larger proportion of significant F ratios. Therefore, the investigator decided to use the analysis variance test without adjusting for unequal cell size on the basis that this test was robust to the assumption of homogeneity of variance.

The results of analysis of variance of 282 biology students' scores on the classroom practice (section A through D combined) on the Biology Classroom Activity Checklist is summarized in Table 15. The computed F ratio of 3.83 was larger than the 2.62 necessary for significance at the .05 level. Hypothesis thirteen was rejected. There was a significant difference in the classroom practices of biology teachers in the three treatment groups. A comparison of the total classroom practice means (Table 14) indicated that the mean of 56.19 for treatment C was not only higher than the mean of 51.47 for treatment B and 53.50 for treatment A, but was significantly higher at the .05 level. There was no significant difference in the total classroom practice means for treatment A and treatment B. The F value of 37.65 for teachers was substantially larger than the 3.36 necessary for significance at the .01 level with 4 and 267 degrees of freedom. There was a significant difference between the teachers' classroom practices. The obtained F value of 3.33 was also significant at the .01 level of significance, which indicated that there was a significant interaction among teachers, treatments and students' perception of the classroom practices of teachers.

Table 15

Analysis of Variance of Classroom Practice Difference Between Teachers and Treatments

Source of Variation	Degrees of Freedom	Sum of Squares	Mean Squares	F
Treatments	2	854.1	427.10	3.83*
Teachers	2	16,806.1	4,201.50	37.65**
Interaction	8	2,975.0	371.80	3.33**
Within	267	29,798.0	111.60	
Total	281	50,433.1		

* Significant at the .05 level.
** Significant at the .01 level.

Hypothesis fourteen. Table 16 contains a summary of the means and standard deviation scores of 282 tenth grade biology students' perception of the laboratory practices of teachers (section E through G combined), of the Biology Classroom Activity Checklist. A preliminary test for variance homogeneity yielded an F ratio of 1.27, which was smaller than the 1.29 necessary for significance at the .05 level, therefore, the assumption of variance homogeneity was accepted.

The results of analysis of variance test of teachers' laboratory practices (section E through G combined), on the Biology Classroom Activity Checklist are contained in Table 17. The F value of 1.93 was not significant at the .05 level. Hypothesis fourteen was accepted, indicating that there was no significant difference in the laboratory practices of teachers in the three treatment groups. The computed F value of 31.84 was substantially larger than the 3.36 necessary for

Table 16

Class Means and Standard Deviation Scores of Teachers' Laboratory Practice (Section E - G combined) on the BCAC

	Time Blocks								
	Treatment A			Treatment B			Treatment C		
Teachers	N	$\bar{X}$	SD	N	$\bar{X}$	SD	N	$\bar{X}$	SD
1	16	69.94	8.70	24	68.33	7.82	20	63.80	10.41
2	15	57.67	8.44	23	45.78	7.03	28	50.65	8.13
3	24	57.67	7.70	21	53.29	10.14	22	59.91	8.49
4	23	51.13	13.11	17	50.29	8.28	12	47.91	7.11
5	12	53.67	11.06	12	56.33	13.81	13	52.62	12.65
Total	90	58.01		97	54.80		95	55.17	

Table 17

Analysis of Variance of Laboratory Practice Difference Between Teachers and Treatments

Source of Variation	Degrees of Freedom	Sum of Squares	Mean Squares	$\underline{F}$
Treatments	2	350	175.00	1.93
Teachers	4	11,555	2,888.70	31.84**
Interaction	8	1,973	246.63	2.72**
Within	267	24,226	90.73	
Total	281	38,104		

** Significant at the .01 level.

significance at the .01 level. There was a significant difference in the laboratory practices among teachers. The interaction $\underline{F}$ value of 2.72 was also significant at the .01 level of significance. There was a significant interaction among treatments, teachers and students' perception of the laboratory practices of teachers.

Hypothesis fifteen and sixteen. The significant $\underline{F}$ value, evidenced in Tables 15 and 17, for teachers and interaction, resulted in the rejection of hypotheses fifteen and sixteen. The data recorded in Tables 14 and 16 show the extent to which the teaching approach and techniques advocated by BSCS were being used by the teachers participating in the study. Teacher 1 exhibited the highest degree of conformity, as indicated by the overall mean (68.21) for classroom practice and (67.25) for laboratory practice. It was noted that out of a possible score of 100, only Teacher 1 classes scored in the 65-69 range. It was also noted that although there were differences among the classroom practice and laboratory practice means of teachers 2, 4 and 5, they were not significantly different. Their teaching approaches and techniques were perceived by their students as being very similar.

An illustration of the significant interaction of teachers, treatments and classroom practice means is shown in figure 5. The graph in figure 5 was constructed by plotting the practice means in treatments A, B and C for each teacher (Table 14). An examination of figure 5 indicated that with the exception of teacher 1, students' perceived the classroom practice of teachers to be about the same in treatment B. It was noted that although the means in the treatment groups varied, the classroom practice of teachers 2 and 3 were similar in treatments A, B and C. The teaching approach and techniques of both teachers were perceived by their students as conforming highest to the practice recommended by the BSCS

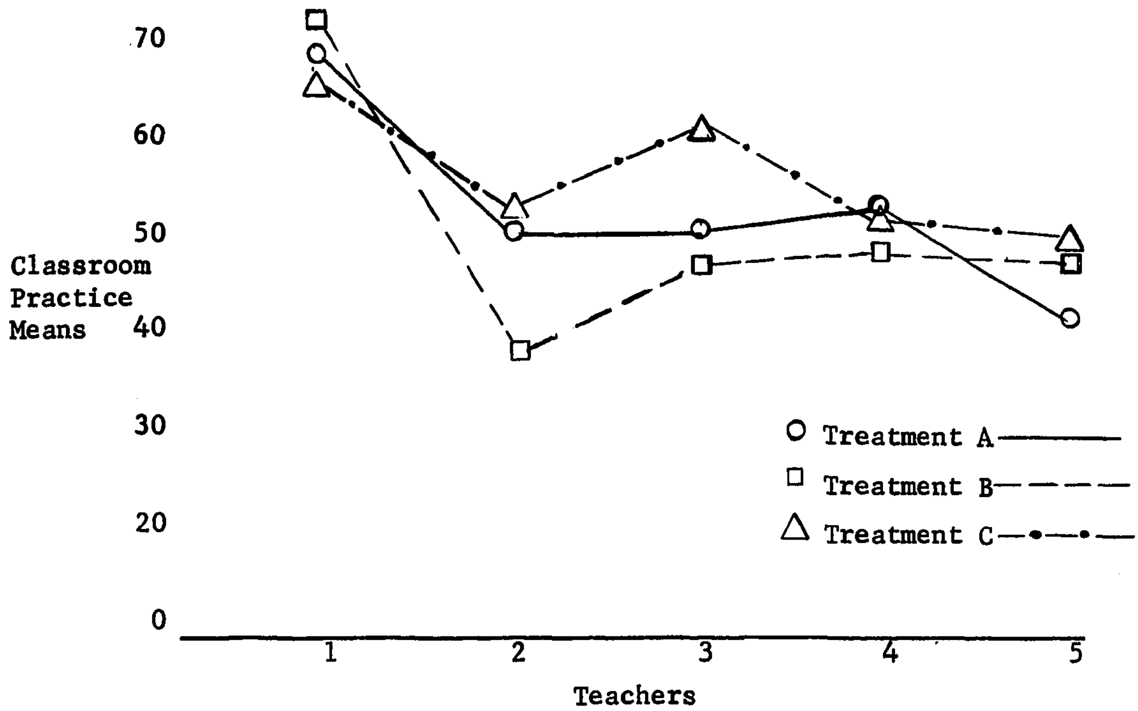


Fig. 5. Interaction of teachers, treatments and classroom practice means.

in treatment C and lowest in treatment B. There was a significant interaction among teachers 1 and 2, and the dependent variable in treatments A, B and C. A significant interaction was also noted among teachers 4 and 5 in treatments A and B.

Figure 6 is a graph of the significant interaction among teachers, treatments and the laboratory practice means of teachers in Table 16. In general, the profile in figure 6 shows that the significant interaction was primarily due to the difference in the students' perception of the laboratory practices of their teachers in treatment B and treatment C. It was noted that although the means varied from teacher to teacher in treatment A, the students perceived the laboratory practices of teachers 2, 3, 4 and 5 to be very similar.

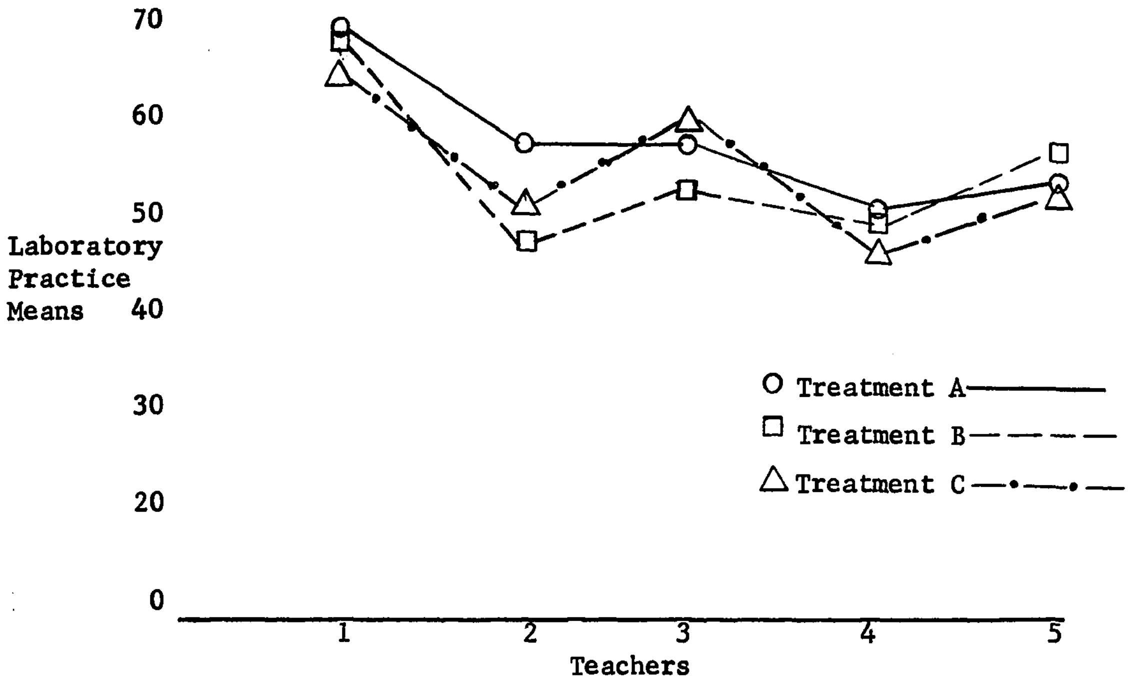


Fig. 6. Interaction among teachers, treatments and laboratory practice.

Supplementary Data Relevant to Teachers Difference

The results obtained in section four indicated a significant difference in the classroom and laboratory practices of teachers (Table 15 and 17). The purpose of this section was to use the data obtained by the Biology Classroom Activity Checklist to identify or bring more sharply into focus specific classroom and laboratory practices of individual teachers.

Table 18 contains a summary of demographical data on teachers 1, 2, 3, 4 and 5. The teachers are classified according to scores on the laboratory facilities checklist, age, number of years teaching biology, years of experience teaching a BSCS course, preparation for teaching BSCS and graduate and undergraduate hours in biology.

In order to identify basic differences, teachers 1, 2, 3 and 5 were selected for comparison. These teachers were selected because teachers 1 and 3's students overall understanding of the processes of science and achievement in BSCS biology were significantly higher than teachers 2 and 5. Teacher 4's students performance on the two dependent variables were very similar to teacher 5, therefore, teacher 4 was not included.

It should be pointed out that teachers 4 and 5 had been teaching BSCS biology the fewest number of years, and had received the least amount of preparation for teaching BSCS biology. It was also noted that teachers 2 and 5 had the lowest laboratory facilities checklist scores, 295 and 246, respectively.

Table 18

Demographical Data on the Five Teachers

Teacher	LFC Score	Age	Years Teaching Biology	Prep-oration Teaching BSCS	Years Teaching BSCS	Under-Graduate Hours Biology	Graduate Hours
1	337	30-39	10-15	Summer Institute	3-5	16-30	16-30
2	295	40-49	16/more	In-service & college course	6-9	31-45	1-15
3	364	20-29	6-9	College course	3-5	31-45	16-30
4	327	20-29	2/less	2-week workshop	2/less	31-45	1-15
5	246	30-39	2/less	None	2/less	Over 45	1-15

As previously reported in Chapter I, the <u>Biology Classroom Activity Checklist</u> was composed of seven sections as follows:

Section A - Role of the teachers in classroom

Section B - Student participation in the classroom

Section C - Use of textbook and reference material

Section D - Design and use of tests

Section E - Preparation for laboratory

Section F - Type of activities

Section G - Laboratory follow-up activities

Sections A through D combined, measure the classroom practice and section E through G combined, the laboratory practice of teachers.

Table 19 contains a summary of mean scores for teachers 1, 2, 3 and 5 on sections A through G of the BCAC. It should be pointed out that the higher the mean score, the more the teaching practices and techniques conform to those advocated by the BSCS course objectives and philosophy. The greatest variation between teacher 1 and teachers 2, 3 and 5 was in section D, design and use of tests; section E, preparation for laboratory; section A, role of the teacher in the classroom; section F, student participation in the classroom; and section G, laboratory follow-up activities. Teacher 3 differed from teachers 2 and 5 in section C, the use of textbook and reference material; section D, use and design of tests; section E, preparation for laboratory; and section G, laboratory follow-up activities.

Figure 7 shows the four select teachers' mean scores on section A through G, on the BCAC. The graph in figure 7 was constructed by combining the scores of all the three classes on each section of the BCAC in the three classes taught by teachers 1, 2, 3 and 5.

Table 19

Teachers' Mean Scores on Section A through G on the BCAC

	Sections							
Teacher	A	B	C	D	E	F	G	Total
1	70.66	61.90	60.00	73.90	74.17	65.03	60.89	67.15
2	49.12	52.93	52.55	32.76	52.85	45.61	51.67	49.34
3	57.23	53.00	61.15	47.33	58.19	51.94	58.43	56.23
5	56.00	41.74	46.77	34.35	53.18	51.68	51.15	49.10

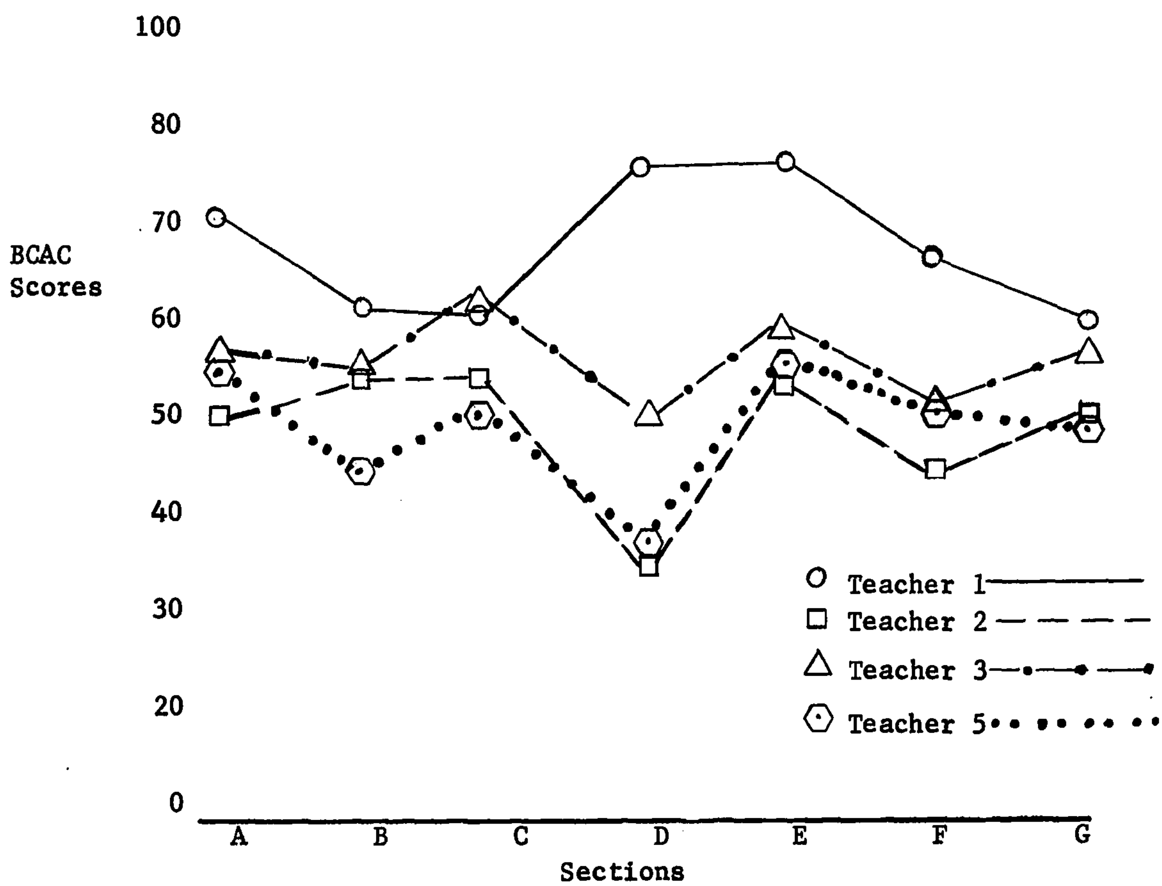


Fig. 7. Teachers mean scores on section A through G of the Biology Classroom Activity Checklist.

Specific items on the laboratory practice (section E through G combined) and the classroom practice (section A through D combined) of BCAC test have been selected for study to identify some basic difference between teachers' classroom and laboratory practice. Specific items on the classroom practice of teachers (section A through D combined) of the BCAC have been selected for study and students' positive responses on these items are given in Table 20.

Table 20

Student Response to Selected Items on Classroom Practice (Section A through D combined) of the BCAC for Four Select Teachers

	Percent of Positive Response			
Section and Item	Teacher 1	Teacher 2	Teacher 3	Teacher 5
A1 Much of our class time is spent listening to our teacher tell us about biology.	45	6	5	35
A3 If there is a discussion among students, the teacher usually tells us who is right.	28	20	22	24
A4 My teacher often repeats almost exactly what the textbook says.	66	32	40	58
A6 My teacher shows us that biology has almost all of the answers to questions about living things.	60	25	46	29
B1 My job is to copy down and memorize what the teacher tells us.	64	42	59	33
B4 Classroom demonstrations are usually done by students rather than by the teacher.	40	24	12	41

Table 20 (continued)

Section and Item	Percent of Positive Response Teacher 1	Teacher 2	Teacher 3	Teacher 5
B7 Most of the questions that we ask in class are to clear up what the teacher or text has told us	15	9	9	22
C1 When reading the text, we are expected to learn most of the details that are stated there	26	29	24	20
C2 We frequently are required to write out definitions to word lists	85	60	76	29
D1 Our tests include many questions based on things that we have learned in the laboratory	85	33	51	40
D2 Our tests often ask us to write out definitions of terms	83	16	75	14
D5 Our tests often give us new data and ask us to draw conclusions from these data	69	22	34	37
D6 Our tests often ask us to put labels on drawings	78	38	37	20

Table 21 shows specific items on the laboratory practice of teachers, section (E through G combined), of the BCAC and students' positive responses on these items. Analysis of the items listed in Table 20 and Table 21 can result in the formation of some statements concerning the difference in the practices employed by these four

Table 21

Student Response to Selected Items on Laboratory Practice (Section E through G combined) of the BCAC for Four Select Teachers

Section and Item	Percent of Positive Response			
	Teacher 1	Teacher 2	Teacher 3	Teacher 5
E1 My teacher usually tells us step-by-step what to do in the laboratory.	85	6	36	32
E5 We often use the laboratory to investigate a problem that comes up in class.	56	9	21	32
E8 We usually know the answer to a laboratory problem that we are investigating before we begin the experiment.	87	68	68	56
F5 We are sometimes asked to design our own experiments to answer a question that puzzles us.	29	17	15	40
F6 We often ask the teacher if we are doing the right thing in our experiment.	11	20	15	17
F8 We spend less than one-fourth of our time in biology doing laboratory work.	83	17	16	51
F9 We never have the chance to try our own ways of doing the laboratory work.	36	32	44	50
G5 We are allowed to go beyond the regular laboratory exercise and to do some experimenting on our own.	15	18	27	27

teachers. Teacher 1 conveyed the impression that biology was not complete (A6). This teacher did not use lecturing as the primary method of teaching (A1), and his students were not expected to learn as much detail (C2). His tests were less textbook-content oriented (D1, D5 and D6), and his labs were more investigative (E8) and less rigid (G5).

Teachers 2, 3 and 5 conducted classes that were more teacher dominated (A3 and B1) with emphasis on lecturing (A1) and the text as the major means of teaching the class (A4, B7 and C1). Their classes had less student participation (B4) with more emphasis on writing out answers to questions (B3) and students' learning more detail (C2). Their tests were textbook-content oriented with emphasis on recall (D1, D2, D5 and D6). Their laboratories were more teacher directed (E1), rigid (G5 and F5) and more illustrative than investigative (E8).

CHAPTER V

SUMMARY, MAJOR FINDINGS, CONCLUSIONS AND RECOMMENDATIONS

Summary

The newer curricular studies, sponsored by the National Science Foundation, have placed more emphasis on the laboratory as a place where the many aspects of "scientific inquiry" are introduced, developed and practiced. In 1963-64, the Oklahoma City Public School System adopted one of the new curricular studies, the Biological Science Curriculum Study (BSCS). The BSCS blue and green version biology courses were implemented in all high schools as the first year course in biology. All biology classes were taught in the traditional schedule of 55 minute periods, five times a week.

In 1971, a "time block" schedule was developed and implemented in all but two of the high schools in Oklahoma City. Under the "time block" schedule, BSCS biology classes were meeting for either 145 minutes, twice a week; 70 minutes, four times a week; or 55 minutes, five times a week. The total amount of time devoted to biology instruction each week was 280, 280 and 275 minutes respectively. Students enrolled in the 145 minute period received a five minute break half-way through the period, accounting for the 280 minutes per week, instead of 290 minutes.

The purpose of this investigation was to determine the effects of class period length and frequency of meetings on biology students' understanding of the processes of science and their achievement in BSCS biology.

The first part of this study was concerned with the possible significant difference of high, medium and low ability tenth grade students' understanding of the processes of science and their achievement in BSCS biology in treatment A, treatment B, and treatment C.

The second part of this study compared tenth grade students' achievement in BSCS biology and their understanding of the processes of science in treatment A and treatment B with students enrolled in treatment C.

An investigation was also made of two secondary problems that related to the major problem under consideration;

1. Is there a significant difference in BSCS blue version and BSCS green version biology students' understanding of the processes of science and their achievement in BSCS biology in classes that met for different lengths of time and frequency?

2. Is there a significant difference between biology teachers' classroom and laboratory practices?

The sample consisted of five teachers and 286 tenth grade students enrolled in fifteen intact biology classes. A total of 128 students and two teachers were using the BSCS blue version course in two schools, and three teachers and 158 students were using the BSCS green version course in the other three high schools.

The sample was selected by identifying teachers who were teaching a BSCS blue or green version biology class during all three time block variations. Only those teachers who had received special training or had taught a BSCS biology course for one year or more were included in this study. Biology classes that met in the afternoon were selected from each of the three time block variations of each teacher. Three treatment groups were used in each of the participating high schools, treatment A, 145 minutes; treatment B, 70 minutes; and treatment C, 55 minutes.

The posttest-only control group design, employing analysis of covariance was selected for this study. The application of analysis of covariance provided an increase in the power of significance test similar to that provided by a pretest.

Standardized tests were administered in March, 1972 to gather data on the students' understanding of the processes of science and their achievement in BSCS biology. The two standardized tests used to gather data were the Comprehensive Final Examination, Form J, to measure students achievement in biology, and the Processes of Science Test, Form A, to measure students' understanding of the processes of science. Achievement scores were obtained for 282 students. Four students were absent on the day the achievement test was administered.

A third instrument, the Biology Classroom Activity Checklist, was administered in February, 1972, to gather data on students' perception of actual classroom and laboratory practices of teachers, as they related to the philosophy and objectives of the BSCS course.

All answer sheets were hand scored. A class mean was computed for each of the standardized tests and the Biology Classroom Activity checklist.

In February, 1972, each teacher completed a laboratory facilities checklist to provide information on the laboratory facilities in each school.

Students' scores on the combined verbal reasoning and numerical ability components of the Differential Aptitude Test were obtained from the central office. The DAT VR+NA scores were used as the control or covariate in computing analysis of covariance tests and to classify students into high, medium and low ability groups.

Data concerning the relationship and significant difference of treatments and teachers on the dependent variables were analyzed by computing multiple-classification analysis of covariance $\underline{F}$ tests. Analysis of covariance tests were also used to determine the effects of version studied and treatments on the two dependent variables.

The effects of the independent variables, student ability level, teachers' classroom and laboratory practices, and treatments, on the two dependent variables were tested by multiple-classification analysis of variance $\underline{F}$ tests. The .05 level of significance was adopted for acceptance or rejection of the stated hypotheses.

Major Findings

1. When the raw scores on the DAT VR+NA were used to classify students into high ability (41-99), medium ability (27-40), and low ability (0-26) groups, the following resulted with regard to the .05 level of significance:

a. High, medium and low ability tenth grade biology students did not achieve significantly different in treatment A (145 minutes), treatment B (70 minutes), and treatment C (55 minutes).

b. High, medium and low ability tenth grade biology students' performance on the processes of science test was significantly higher in treatment C than in treatment B. There was no significant difference in their performance on the processes of science test in treatment A and treatment C, or in treatment A and treatment B. However, when high, medium and low ability students' processes of science means were compared across treatment groups, low and medium ability students' performed significantly higher in treatment C, while high ability students' performance was significantly higher in treatment A.

c. The main effect variable, ability, was significant at the .01 level, indicating that students' performance on the BSCS achievement test and processes of science test was highly dependent on academic ability.

d. There was no significant interaction between the main effect variables, treatment and ability level, and students' performance on the processes of science test and achievement test.

2. When students' DAT VR+NA scores were used as a covariate to control for differences in academic ability, the following resulted with respect to students' performance on the two dependent variables in the three treatment groups:

a. Tenth grade biology students achieved significantly higher in treatment C, than in treatment B, at the .05 level. There was no significant difference in their achievement in treatment A and treatment C, or in treatment A and treatment B.

b. Tenth grade biology students' performance on the processes of science test was not significantly different in any of the three treatment groups.

c. The effect of the classroom teacher on students' performance on the processes of science test and BSCS biology achievement test was highly significant at the .01 level of confidence.

d. A significant interaction was noted between the main effect variables, teachers and treatments, and students' performance on the BSCS achievement test, and the processes of science test. A source of this significant interaction was between teachers and the difference in students' performance on the achievement test in the longer time blocks, treatment A and treatment B. Another source of this significant interaction was between teachers and the differences in students' performance on the processes of science test in the shortest and longest time blocks, treatment C and treatment A, respectively.

3. When academic ability was controlled, the following resulted with respect to BSCS blue and BSCS green version biology students' performance on the two dependent variables in the three treatment groups:

a. BSCS blue and BSCS green version biology classes did not perform significantly different on the achievement test in treatments A, B or C.

b. BSCS blue and BSCS green version biology classes did not perform significantly different on the processes of science test in treatments A, B or C.

c. Biology classes using either the BSCS blue version or the BSCS green version did not perform significantly different on the processes of science test. However, students in the BSCS blue version biology course did perform significantly higher on the BSCS achievement test than did students in the BSCS green version biology course.

d. There was no significant interaction among the main effect variables, version and treatments, and students' performance on the achievement tests; however, there was a significant interaction between version studied, and students' performance on the processes of science test in the two long time blocks, treatment A and treatment B.

4. The students' scores on the BCAC, with respect to their teachers' classroom and laboratory practices in the three treatment groups, resulted in the following:

a. There was a significant difference in the classroom practices of biology teachers in the three treatment groups. The classroom practice mean of 56.19 in treatment C was not only higher than the mean of 51.47 in treatment B, and 54.50 for treatment A, but was significantly higher at the .05 level. There was no significant difference in the total classroom practice means in treatment A and treatment B.

b. There was no significant difference in the total mean laboratory practices of teachers in the three treatment groups; however, teachers did differ significantly in their individual classroom and laboratory practices.

c. There was a significant interaction between the main effect variables, teachers and treatments and students' perception of the classroom and laboratory practices of teachers. One source of interaction was the difference in students' perception of the classroom practices of teachers in the longest and shortest time blocks, treatment A and C, respectively. The source of interaction for laboratory practices was the difference in the students' perception of their teachers' laboratory practices in treatment B and treatment C.

Conclusions

The major findings of this study suggest that:

1. Teacher characteristics were more important in determining outcomes in BSCS biology than any imposed external arrangement of time blocks.

2. The teaching patterns of teachers were independent of the time block length. Teachers did not necessarily change their teaching approach or method just because the time block length was changed.

3. Students' understanding of the processes of science and achievement in a particular time block appeared to depend on whether the teaching methods and techniques used by the classroom teacher were appropriate to the length of the period.

4. The teaching methods and techniques of the teacher were probably more important to students' understanding of the processes of science than a teachers' use of one of the BSCS versions.

5. Tenth grade biology students probably can achieve as well in classes that meet for a longer period and less frequently than traditionally scheduled classes if the teaching approach is appropriate to the length of the class period.

6. Because of the highly significant difference in teachers, this study failed to demonstrate conclusively that a particular period length and frequency of class meeting was more conducive than traditionally scheduled classes for teaching an inquiry laboratory oriented science course, such as BSCS biology.

Recommendations

It was recommended that:

1. This study be duplicated, using the same time block variations, after teachers have received in-service training on the adjustment of course content and teaching methods to longer blocks of time.

2. A study be conducted using one external arrangement of period length, and compare outcomes obtained by using teachers with different characteristics.

3. A study be conducted to find the most effective way of adapting the BSCS course materials to time blocks of different lengths.

4. The use of the time block schedule for the teaching of BSCS biology be continued in the Oklahoma City public schools, with intensive in-service training for teachers in the development of teaching methods that conform to those advocated by BSCS, and the adaptation of the BSCS materials to different blocks of time. In addition, teachers should receive training in the development of a variety of teaching techniques applicable to different lengths of time, and students of different abilities.

5. Administrators, when developing schedules, should give serious consideration to matching teachers with time block lengths, and scheduling low ability students for biology courses other than the BSCS blue and green version biology, preferably in shorter time blocks.

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APPENDIX A

Table 22

Scores on the Comprehensive Final Examination and DAT VR+NA Tests for Teacher No. 1

	Treatment A		Treatment B		Treatment C	
Student No.	CFE	DAT VR+NA	CFE	DAT VR+NA	CFE	DAT VR+NA
1	22	53	25	56	23	54
2	37	62	35	66	25	40
3	14	54	32	68	23	35
4	21	15	15	23	32	62
5	32	55	19	41	27	63
6	20	20	14	26	12	18
7	21	23	26	60	26	56
8	22	19	33	38	23	44
9	19	22	26	61	23	26
10	31	76	38	59	32	52
11	24	36	18	29	28	53
12	30	77	40	63	23	31

Table 22 - Continued

	Treatment A		Treatment B		Treatment C	
Student No.	CFE	DAT VR+NA	CFE	DAT VR+NA	CFE	DAT VR+NA
13	21	59	28	39	20	35
14	32	56	19	42	21	65
15	31	49	27	69	27	58
16	17	35	18	47	20	39
17			31	52	16	44
18			42	70	22	26
19			25	47	25	32
20			20	21	11	33
21			28	46		
22			16	34		
23			22	41		
24			16	43		

Table 23

Scores on the Comprehensive Final Examination and DAT VR+NA Tests for Teacher No. 2

	Treatment A		Treatment B		Treatment C	
Student No.	CFE	DAT VR+NA	CFE	DAT VR+NA	CFE	DAT VR+NA
1	16	25	11	23	40	61
2	32	74	26	68	8	17
3	16	38	14	19	23	59
4	21	51	14	14	18	18
5	17	23	18	52	21	41
6	17	24	12	19	16	27
7	20	25	18	33	16	23
8	20	41	14	35	16	55
9	22	22	27	39	10	52
10	25	68	14	24	10	23
11	13	25	28	74	25	38
12	17	43	15	48	12	22
13	7	36	19	49	35	78
14	17	42	18	34	16	30

Table 23 - Continued

	Treatment A		Treatment B		Treatment C	
Student No.	CFE	DAT VR+NA	CFE	DAT VR+NA	CFE	DAT VR+NA
15	22	36	15	43	26	60
16			10	16	18	49
17			13	28	24	37
18			14	24	16	34
19			20	24	17	16
20			22	65	15	32
21			24	37	32	54
22			9	55	8	28
23			17	24	24	22
24					11	31
25					17	26
26					18	46
27					23	32
28					20	28

Table 24

Scores on the Comprehensive Final Examination and DAT VR+NA Tests for Teacher No.3

	Treatment A		Treatment B		Treatment C	
Student No.	CFE	DAT VR+NA	CFE	DAT VR+NA	CFE	DAT VR+NA
1	13	18	15	37	17	39
2	22	31	13	25	18	23
3	22	18	14	27	16	51
4	25	37	9	35	20	38
5	16	40	15	23	20	46
6	21	32	16	34	17	25
7	20	59	18	19	22	28
8	15	28	19	29	19	46
9	23	32	19	55	17	35
10	27	61	16	34	15	30
11	18	37	16	44	14	45
12	22	49	21	36	25	45
13	15	32	21	23	20	28
14	24	43	27	62	21	47

Table 24 - Continued

	Treatment A		Treatment B		Treatment C	
Student No.	CFE	DAT VR+NA	CFE	DAT VR+NA	CFE	DAT VR+NA
15	21	38	20	33	15	28
16	14	44	14	33	22	33
17	17	47	20	47	32	57
18	12	30	18	33	13	35
19	14	34	15	35	23	37
20	13	34	11	26	19	47
21	21	32	22	16	19	18
22	16	31			18	25
23					25	34
24					22	41

Table 25

Scores on the Comprehensive Final Examination and DAT VR+NA Tests for Teacher No. 4

	Treatment A		Treatment B		Treatment C	
Student No.	CFE	DAT VR+NA	CFE	DAT VR+NA	CFE	DAT VR+NA
1	11	28	15	19	12	28
2	17	59	16	29	14	18
3	10	22	15	42	16	17
4	12	17	8	29	11	36
5	11	20	8	28	18	21
6	9	28	20	23	11	23
7	9	19	23	56	9	18
8	9	39	12	15	6	12
9	10	42	16	18	12	36
10	11	22	13	46	12	24
11	8	26	8	18	12	23
12	10	22	10	13	13	15
13	9	19	13	21		
14	14	25	18	21		

Table 25 - Continued

	Treatment A		Treatment B		Treatment C	
Student No.	CFE	DAT VR+NA	CFE	DAT VR+NA	CFE	DAT VR+NA
15	18	17	13	20		
16	10	29	12	24		
17	13	34	13	56		
18	11	15				
19	19	19				
20	11	19				
21	11	28				
22	18	32				
23	10	23				

Table 26

Scores on the Comprehensive Final Examination and DAT VR+NA Tests for Teacher No. 5

	Treatment A		Treatment B		Treatment C	
Student No.	CFE	DAT VR+NA	CFE	DAT VR+NA	CFE	DAT VR+NA
1	16	19	12	25	7	13
2	15	15	17	37	13	35
3	19	31	10	14	14	23
4	16	31	12	19	9	15
5	16	24	8	24	12	35
6	15	31	14	29	16	24
7	8	23	9	24	15	33
8	11	22	15	58	11	24
9	16	24	22	40	19	36
10	13	29	10	25	14	23
11	15	63	13	34	16	24
12	12	29	14	32	16	33
13					23	45

Table 27

Scores on the Processes of Science Test and DAT VR+NA Tests for Teacher No. 1

	Treatment A		Treatment B		Treatment C	
Student No.	Post	DAT VR+NA	Post	DAT VR+NA	Post	DAT VR+NA
1	31	62	23	56	22	54
2	16	54	36	66	18	40
3	17	15	31	68	21	35
4	34	55	21	23	31	62
5	17	26	21	41	27	63
6	19	23	18	26	14	18
7	14	19	22	60	21	56
8	15	24	25	38	22	44
9	34	76	19	24	22	26
10	16	36	26	61	31	52
11	32	77	31	59	30	53
12	20	59	33	63	17	31
13	28	56	22	39	21	35
14	27	49	17	42	21	65

Table 27 - Continued

	Treatment A		Treatment B		Treatment C	
Student No.	Post	DAT VR+NA	Post	DAT VR+NA	Post	DAT VR+NA
15	26	35	30	69	24	39
16			22	47	23	58
17			25	52	23	39
18			20	70	27	39
19			27	47	25	44
20			19	21	23	32
21			22	46	34	73
22			15	34	16	33
23			20	41		

Table 28

Scores on the Processes of Science Test and DAT VR+NA Tests for Teacher No. 2

	Treatment A		Treatment B		Treatment C	
Student No.	Post	DAT VR+NA	Post	DAT VR+NA	Post	DAT VR+NA
1	12	25	18	23	31	61
2	33	74	31	68	16	17
3	12	38	11	19	23	59
4	18	51	12	14	16	18
5	17	23	15	52	19	41
6	7	24	20	19	10	27
7	8	25	24	33	12	23
8	14	41	11	35	11	52
9	7	22	19	46	10	23
10	28	68	20	39	17	38
11	8	25	14	24	10	22
12	19	43	29	74	33	78
13	8	36	26	48	17	30
14	10	42	23	54	26	60

Table 28 - Continued

	Treatment A		Treatment B		Treatment C	
Student No.	Post	DAT VR+NA	Post	DAT VR+NA	Post	DAT VR+NA
15	10	36	18	49	17	49
16			21	34	23	37
17			18	30	23	34
18			12	43	13	16
19			12	16	16	32
20			15	28	27	54
21			11	24	11	28
22			10	24	14	22
23			14	65	17	31
24			30	37	17	26
25			18	55	11	46
26			17	24	19	30
27					20	32

Table 29

Scores on the Processes of Science Test and DAT VR+NA Tests for Teacher No. 3

	Treatment A		Treatment B		Treatment C	
Student No.	Post	DAT VR+NA	Post	DAT VR+NA	Post	DAT VR+NA
1	9	18	13	37	25	39
2	26	31	17	25	29	74
3	9	18	15	27	12	23
4	27	37	20	34	21	51
5	19	40	8	19	23	38
6	23	40	17	45	26	46
7	26	59	17	29	13	25
8	19	28	23	55	28	22
9	28	32	18	34	20	35
10	29	61	18	44	13	30
11	28	37	21	36	22	45
12	24	49	16	23	27	45
13	20	32	34	62	21	28
14	31	43	13	33	28	47

Table 29 - Continued

	Treatment A		Treatment B		Treatment C	
Student No.	Post	DAT VR+NA	Post	DAT VR+NA	Post	DAT VR+NA
15	20	38	19	33	28	44
16	26	47	25	47	18	28
17	18	30	20	33	32	57
18	20	34	12	35	21	35
19	14	34	8	26	23	37
20	25	42	8	16	22	47
21	19	32			20	18
22	22	31			24	25
23					26	34
24					20	41

Table 30

Scores on the Processes of Science Test and DAT VR+NA Tests for Teacher No. 4

	Treatment A		Treatment B		Treatment C	
Student No.	Post	DAT VR+NA	Post	DAT VR+NA	Post	DAT VR+NA
1	10	28	16	19	14	21
2	10	31	7	29	7	28
3	33	59	15	24	18	18
4	16	22	22	42	12	18
5	13	17	10	23	18	48
6	11	31	10	29	17	17
7	13	20	15	28	8	36
8	13	28	28	23	12	21
9	8	39	22	56	9	23
10	10	22	10	15	10	23
11	9	23	27	46	5	36
12	10	19	11	18	6	24
13	8	17	10	13	9	15
14	17	29	11	21		

Table 30 - Continued

	Treatment A		Treatment B		Treatment C	
Student No.	Post	DAT VR+NA	Post	DAT VR+NA	Post	DAT VR+NA
15	11	26	7	20		
16	15	34	12	22		
17	6	15	14	24		
18	9	19	19	56		
19	14	19				
20	17	28				
21	12	32				
22	12	23				

Table 31

Scores on the Processes of Science Test and DAT VR+NA Tests for Teacher No. 5

	Treatment A		Treatment B		Treatment C	
Student No.	Post	DAT VR+NA	Post	DAT VR+NA	Post	DAT VR+NA
1	8	19	14	25	23	33
2	11	31	13	16	17	35
3	10	19	14	37	18	23
4	28	31	11	14	20	25
5	12	16	10	19	13	15
6	8	24	11	24	12	17
7	12	23	18	29	22	24
8	13	22	8	15	15	14
9	27	63	22	58	19	24
10	13	29	26	40	20	36
11	21	31	16	25	8	20
12			15	34	12	23
13			13	32	22	24
14			17	28	17	45

Table 32

Raw Scores on Classroom Practice (A-D combined) and Laboratory Practice (E-G combined) of the BCAC - Teacher 1

Treatment A		Treatment B		Treatment C	
BCAC Classroom	BCAC Lab	BCAC Classroom	BCAC Lab	BCAC Classroom	BCAC Lab
41	67	52	54	83	50
72	79	76	79	59	67
79	71	83	63	59	54
69	75	83	67	79	63
62	71	55	75	62	50
79	58	76	75	59	75
79	67	69	75	66	58
59	63	55	71	62	67
62	75	62	67	76	79
79	67	41	63	76	75
72	67	79	75	69	58
55	54	83	67	66	63
69	75	83	75	52	71
79	92	90	75	41	71
66	71	79	75	76	83
69	67	83	63	62	67
		69	75	55	50
		66	63	66	71
		69	71	69	54
		83	75	66	50
		69	50		
		62	58		
		72	58		
		72	71		

Table 33

Raw Score on Classroom Practice (A-D combined) and Laboratory Practice (E-G combined) of the BCAC - Teacher 2

Treatment A		Treatment B		Treatment C	
BCAC Classroom	BCAC Lab	BCAC Classroom	BCAC Lab	BCAC Classroom	BCAC Lab
55	58	48	43	54	48
41	67	55	54	50	69
53	43	38	50	50	38
48	50	41	50	63	48
38	46	41	29	46	34
59	71	31	46	54	52
34	63	38	42	50	59
38	46	59	50	33	48
55	58	41	50	54	38
55	58	31	50	63	59
48	63	34	54	54	52
62	67	41	46	46	45
52	54	55	58	33	41
45	58	38	42	54	48
72	63	48	42	50	62
		52	46	46	66
		48	38	46	45
		41	42	63	66
		45	46	58	66
		48	38	50	52
		24	33	54	48
		59	54	63	45
		52	50	42	62
				54	59
				38	52
				42	55
				54	59
				54	48

Table 34

Raw Score on Classroom Practice (A-D combined) and laboratory Practice (E-G combined) of the BCAC - Teacher 3

Treatment A		Treatment B		Treatment C	
BCAC Classroom	BCAC Lab	BCAC Classroom	BCAC Lab	BCAC Classroom	BCAC Lab
38	63	55	58	66	50
52	75	41	71	69	67
48	58	34	46	66	58
48	67	55	42	66	58
59	54	55	50	69	67
66	63	48	46	52	58
41	54	48	71	62	67
66	46	62	54	59	54
48	58	59	58	59	50
48	62	52	50	66	71
55	63	52	63	55	50
62	46	45	67	59	67
55	46	45	38	79	75
45	71	52	46	48	58
62	54	48	54	69	67
69	54	41	58	45	42
52	63	48	38	55	63
66	63	41	46	52	50
55	54	45	46	66	58
41	46	55	67	59	67
66	58	52	50	45	54
52	54			72	67
62	54				
45	58				

Table 35

Raw Score on Classroom Practice (A-D combined) and Laboratory Practice (E-G combined) of the BCAC - Teacher 4

Treatment A		Treatment B		Treatment C	
BCAC Classroom	BCAC Lab	BCAC Classroom	BCAC Lab	BCAC Classroom	BCAC Lab
38	54	44	45	45	54
62	46	55	54	45	46
72	54	76	46	59	54
52	58	34	38	59	38
62	54	41	54	48	46
55	63	45	38	79	54
45	46	41	42	34	46
66	33	41	58	45	33
59	63	31	42	38	50
69	54	45	42	55	50
34	42	24	50	55	46
48	54	41	58	59	58
55	58	55	58		
72	46	66	63		
69	29	38	54		
38	38				
52	42				
41	79				
48	46				
38	42				
48	63				
41	33				
48	79				

Table 36

Raw Score on Classroom Practice (A-D combined) and Laboratory Practice (E-G combined) of the BCAC - Teacher 5

Treatment A		Treatment B		Treatment C	
BCAC Classroom	BCAC Lab	BCAC Classroom	BCAC Lab	BCAC Classroom	BCAC Lab
45	38	31	46	48	38
34	50	21	38	28	33
34	67	59	83	59	75
48	50	45	50	62	46
48	50	59	75	69	50
45	67	66	71	48	67
55	63	55	63	38	58
55	71	52	42	55	50
38	46	38	54	69	71
34	50	28	54	45	46
41	38	52	50	62	42
28	54	62	50	34	58
				45	50

APPENDIX B

BIOLOGY CLASSROOM ACTIVITY CHECKLIST*

The purpose of this checklist is to determine how well you know what is going on in your biology class. Each statement describes some classroom activity. The activities are not judged as either good or bad. Therefore, this checklist is not a test and is not designed to grade either you or your teacher. You are to read each statement and decide if it describes the activities in your class. All answers should be recorded on the answer sheet. NO MARKS should be made in this booklet.

SAMPLE QUESTION

Checklist		Answer sheet T	F
1. My teacher often takes class attendance.	1.	( )	( )

If the statement describes what occurs in your classroom, blacken the space under the letter T (TRUE) on the answer sheet; if it does not, blacken in the space under the letter F (FALSE).

REMEMBER:

1. The purpose of the checklist is to determine how well you know what is going on in your classroom.

2. Make no marks in this booklet.

3. All statements should be answered on the answer sheet by blackening in the space under the chosen response in pencil or ink.

4. Please do not write your name on this booklet or answer sheet.

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*Written permission to use the instrument was granted by Dr. Leonard H. Kochendorfer and Dr. Addison E, Lee.

BIOLOGY CLASSROOM ACTIVITY CHECKLIST

SECTION A

1. Much of our class time is spent listening to our teacher tell us about biology.

2. My teacher doesn't like to admit his mistakes.

3. If there is a discussion among students, the teacher usually tells us who is right.

4. My teacher often repeats almost exactly what the textbook says.

*5. My teacher often asks us to explain the meaning of certain things in the text.

6. My teacher shows us that biology has almost all of the answers to questions about living things.

*7. My teacher asks questions that cause us to think about things that we have learned in other chapters.

*8. My teacher often asks questions that cause us to think about the evidence that is behind statements that are made in the textbook.

SECTION B

1. My job is to copy down and memorize what the teacher tells us.

*2. We students are often allowed time in class to talk among ourselves about ideas in biology.

3. Much of our class time is spent in answering orally or in writing questions that are written in the textbook or on study guides.

*4. Classroom demonstrations are usually done by students rather than by the teacher.

5. We seldom or never discuss the problems faced by scientists in the discovery of a scientific principle.

*6. If I don't agree with what my teacher says, he wants me to say so.

7. Most of the questions that we ask in class are to clear up what the teacher or text has told us.

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*Items considered as those which contribute positively toward the attainment of BSCS objectives.

*8. We often talk about the kind of evidence that is behind a scientist's conclusion.

SECTION C

1. When reading the text, we are expected to learn most of the details that are stated there.

2. We frequently are required to write out definitions to word lists.

*3. When reading the textbook, we are always expected to look for the main problems and for the evidence that supports them.

*4. Our teacher has tried to teach us how to ask questions of the text.

5. The textbook and the teacher's notes are about the only sources of biological knowledge that are discussed in class.

*6. We sometimes read the original writings of scientists.

*7. We are seldom or never required to outline sections of the textbook.

SECTION D

*1. Our tests include many questions based on things that we have learned in the laboratory.

2. Our tests often ask us to write out definitions of terms.

*3. Our tests often ask us to relate things things that we have learned at different times.

*4. Our tests often ask us to figure out answers to new problems.

*5. Our tests often give us new data and ask us to draw conclusions from these data.

6. Our tests often ask us to put labels on drawings.

SECTION E

1. My teacher usually tells us step-by-step what we are to do in the laboratory.

*2. We spend some time before every laboratory in determining the purpose of the experiment.

3. We often cannot finish our experiments because it takes so long to gather equipment and prepare solutions.

4. The laboratory meets on a regularly scheduled basis (such as every Firday).

*5. We often use the laboratory to investigate a problem that comes up in class.

*6. The laboratory usually comes before we talk about the specific topic in class.

7. Often our laboratory work is not related to the topic that we are studying in class.

8. We usually know the answer to a laboratory problem that we are investigating before we begin the experiment.

SECTION F

1. Many of the experiments that are in the laboratory manual are done by the teacher or students while the class watches.

*2. The data that I collect are often different from data that are collected by the other students.

3. Our teacher is often busy grading papers or doing some other personal work while we are working in the laboratory.

*4. During an experiment we record our data at the time we make our observations.

*5. We are sometimes asked to design our own experiment to answer a question that puzzles us.

6. We often ask the teacher if we are doing the right thing in our experiments.

*7. The teacher answers most of our questions about the laboratory work by asking us questions.

8. We spend less than one-fourth of our time in biology doing laboratory work.

9. We never have the chance to try our own ways of doing the laboratory work.

SECTION G

*1. We talk about what we have observed in the laboratory within a day or two after each session.

*2. After every laboratory session, we compare the data that we have collected with the data of other individuals or groups.

3. Our teacher often grades our data books for neatness.

4. We are required to copy the purpose, materials, and procedures used in our experiments from the laboratory manual.

*5. We are allowed to go beyond the regular laboratory exercise and do some experimenting on our own.

*6. We have a chance to analyze the conclusions that we have drawn in the laboratory.

*7. The class is able to explain all unusual data that are collected in the laboratory.

BSCS HIGH SCHOOL BIOLOGY: Blue Version   Sample Test*

Directions: Each of the questions or incomplete statements in this test is followed by five suggested answers or completions. Select the one which is best in each case and then circle the corresponding letter.

Questions 1 - 8 relate to a biologist's experiment in which radioactive tritium(an isotope of hydrogen) is used to find out what happens to fats consumed by an animal.

When natural fats get into the body of an organism, one quickly loses track of the fats since they mix with similar substances already present. However, one can find out what happens to fat which contains radioactive tritium.

A biologist feeds a group of mice a near-starvation diet containing radioactive fat. The biologist thinks that since the mice are extremely underfed they will quickly use all the fat in their diet for energy. At the end of 10 days the mice are filled and the following data are recorded on the basis of careful measurements:

Amount of Radioactive fat comsumed by the mice	Total amount of fat found stored in the bodies of the mice at end of 10 days	Percentage of stored fat in the bodies of the mice which is radioactive diet fat
35 grams	12 grams	50%

1. Which of the following hypotheses was the biologist evidently testing in this experiment?

   +(A) Underfed animals will quickly use all fat in their diets.
   (B) Fat storage is a continual process in all animals.
   (C) Tritium is an essential part of the diet of an animal.
   (D) Radioactive material will kill mice.
   (E) The bodily processes of an animal on a diet containing tritium will be greatly changed.

2. Which of the following is a necessary assumption is this experiment?

   (A) Fats containing tritium are identical in all respects with natural fats.
   (B) Mice are better able than other animals to withstand doses of tritium.
   (C) Substances containing tritium will remain separated from similar natural substances.
   +(D) Mice will treat radioactive fats in the same way they treat natural fats.
   (E) Plants will react to tritium exactly as animals do.

3. How much radioactive fat was found stored in the fat bodies of the mice at the end of 10 days?

+ (A) 6 grams
(B) 12 grams
(C) 23 grams
(D) 29 grams
(E) 35 grams

5. If one makes the proper assumption in question 4, how much radioactive fat did the mice use for energy during the experiment?

(A) 6 grams
(B) 12 grams
(C) 23 grams
+ (D) 29 grams
(E) 35 grams

4. One could determine from the data given the amount of radioactive fat which the mice used for energy during the experiment if one assumes that

(A) Fluid excreted by the mice is 20% radioactive.
+ (B) All fat not stored is burned for energy.
(C) The mice weighed less at the conclusion of the experiment than at the beginning.
(D) A specific amount of energy results from the burning of 1 gram of fat.
(E) A greater amount of radioactive fat is burned for energy than is stored in fat deposits.

6. Of the following the most precise conclusion which can be drawn from this experiment is that mice on starvation diets

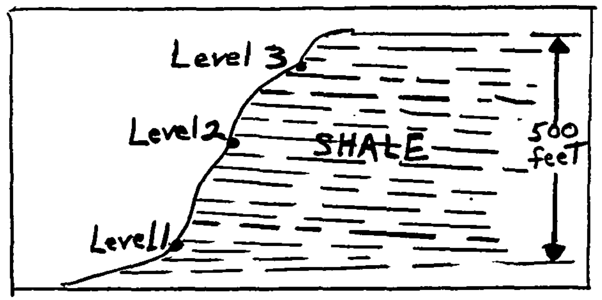
(A) Die within one day.
(B) Use all of the fat in their diets for energy.
(C) Use half of the fat in their diets for energy and store the other half.
+ (D) Store some of the fat in their diets.
(E) Can be kept healthy by giving them proper dosages of tritium.

+ Arrow indicates correct answer.

BSCS High School Biology: Green Version Sample Test

Directions: Each of the questions or incomplete statements in this test is followed by five suggested answers or completions. Select the one which is best in each case and then circle the corresponding letter.

Questions 1 - 7 related to the following situation:



A paleontologist (a biologist who studies prehistoric or fossil forms of life) is on a fossil-collecting trip in the desert badlands of northern Wyoming. He discovers a 500-foot cliff of rock made up of a thinly bedded shale (thin layers of mud deposited one on top of the other, which have become hardened and solidified with the passage of time). He further observes that the layers of shale are all flat-lying and have been relatively undistributed since the time they were first deposited (laid down).

The paleontologist discovers that the shale in the cliff contains fossils, which he proceeds to collect at three different levels as shown in the diagram.

Below is a list of the fossils which the paleontologist collects at each of the three levels:

Level 1	Level 2	Level 3
Many specimens of two different species of fish. Ferns. Palm fronds. Aquatic turtle shells. Eel grass.	A few fragments of the same two species of fish found in Level 1. Snail shells. Turtle shells (same as from Level 1). Eel grass.	Many specimens of the same two species of fish found in Level 1. Ferns.

1. The fossil specimens collected would suggest that through-out the time of the deposition of the shale, the region of northern Wyoming under study was probably

   (A) A desert.
   (B) Submerged deep under the ocean.
 + (C) A lowland region of fresh water lakes. and streams.
   (D) An area of high mountains.
   (E) Buried under thick glaciers.

3. All of the following species contained in the fossil collections probably belonged to a single community EXCEPT

   (A) Turtles.
   (B) Snails.
   (C) Eel grass.
 + (D) Palm trees.
   (E) Fishes.

5. Which one of the following conclusions concerning the climate in northern Wyoming during the time of deposition of the shale is suggested by the forms of life represented in the fossil collections?

   (A) The climate was considerably more arid than it is today.
   (B) The climate was considerably warmer and more humid than it is today.
   (C) The climate was much more variable than it is today.
   (D) The climate was becoming progressively colder during the period of deposition.
   (E) There is insufficient evidence to draw any conclusion concerning the climate during the time of deposition.

2. Which one of the following populations could be reasonably expected to be most numerous in the biological community represented by the fossil collections?

 + (A) Eel grass.
   (B) Palm trees.
   (C) Fishes.
   (D) Turtles.
   (E) Snails.

4. Which of the following conclusions concerning the fossil populations is least reasonable?

   (A) There are samples of different populations of the same species at each of the three levels.
 + (B) The density of the fish population living at the time level 2 was deposited was probably about the same as when levels 1 and 3 were deposited.
   (C) The snail population was greatest during the time level 2 was deposited.
   (D) Both species of fish could still be living.
   (E) The mortality rate of fishes was greatest during the time represented by level 2.

6. The most reasonable conclusion regarding the potential energy available to the animals represented in the fossil collection is that the potential energy available.

+ (A) Was greater during the time represented by level 1 than during the time represented by level 2.
(B) Was the same in northern Wyoming during the time of the deposition of the shale as it is there at the present time.
(C) From the palm trees was greater than that from the Eel grass.
(D) Was greater during the time represented by level 3 than during the time represented by level 1.
(E) Was less during the period of deposition of the shale in northern Wyoming than in a present-day desert region.

7. The absence of any evidence of remains of Eel grass, turtle shells and snails in Level 3 might be explained by any of the following, EXCEPT:

(A) There was an element of chance which determined whether a given plant or animal happened to die under conditions just right for its being preserved as a fossil.
(B) There was an element of chance as to the particular fossil specimens the paleontologist happened to find in the rocks.
(C) The physical environment during the time of the deposition of level 3 was noticeably different from that in the previous time periods.
(D) The turtles and snails eliminated the Eel grass at the time level 2 was deposited.
+ (E) Each species of plant or animal occupies a particular niche in relation to other species with which it occurs.

+ Arrow indicates correct answer.

1965 Revised Laboratory Facilities Checklist

Facility	16 pts.	12 pts.	8 pts.	4 pts.	Your School
	Point Value				
Category A					
1. Fixed laboratory installations - maximum possible score 216 pts.					
Demonstration table	1				
Work counter (peripheral) - linear ft.	120	60	30	15	
Sinks - regular	4	3	2	1	
- laundry			2	1	
Water - cold	4 taps	3 taps	2 taps	1 tap	
- hot			2 taps	1 tap	
Outlet - gas	7	5	3	2	
- electrical	7	5	3	2	
Compressed air				yes	
Garbage disposal				yes	
Shelf storage sq. ft.	450	300	200	100	
Preparation room	large	medium	small		
Life alcove	large	medium	small		
Project work area	large	medium	small		
Science library/min. 50 vols.	large	medium	small		
Display cases (in halls)			2	1	
Light and ventilation	good	fair	poor		
Sub-total points					
2. Budget considerations - maximum possible score 48 pts.					
Funds for perishables, glassware, chemicals, specimens, etc.	\$500/yr	\$250/yr	\$125/yr	\$50/yr	
Funds available during year as needed	yes				
Capital outlay funds	\$500/yr	\$250/yr	\$125/yr	\$50/yr	
Sub-total points					

Facility	Point Value 16 pts.	12 pts.	8 pts.	4 pts.	Your School	
Category A (continued)						
3. Microscopes - maximum possible score 32 pts.						
Compound microscopes	28	14	7	4	____	
Binocular stereomicroscopes	28	14	7	4	____	
Sub-total points						____
4. Lab assistants - maximum score 16 pts.						
Paid lab assistants - 5 hrs per week per section	1	____	____	____	____	
Sub-total points						____
Category B	12 pts.	9 pts.	6 pts.	3 pts.	Your School	
5. Major equipment - maximum possible score 111 pts.						
Refrigerator	1	____	____	____	____	
Gas range/oven	1	____	____	____	____	
Incubator	2	1	____	____	____	
Balances (.01 g)	4	3	2	1	____	
Autoclave	1	____	____	____	____	
Pressure cooker	2	1	____	____	____	
Centrifuge	____	____	2	1	____	
Temp, humidity and light controlled chamber	____	____	1	____	____	
Fume hood	____	1	____	____	____	
Laboratory cart	2	1	____	____	____	
Power supply units (AC/DC portable)	____	____	2	1	____	
Sub-total points						____

Facility	12 pts.	9 pts.	6 pts.	3 pts.	Your School	
	Point Value					
Category C						
6. Small equipment - maximum possible score 70 pts.						
Basic laboratory equipment *	many	adeq.	few	sparse		
Aquaria	4	3	2	1		
Terraria	4	3	2	1		
Glassware	many	adeq.	few	sparse		
Collecting equipment	many	adeq.	few	sparse		
Animal cages	8	6	4	2		
Covered disposal containers	2	1				
Electric hot plates		2	1			
Chemicals	many	adeq.	few	sparse		
Sub-total points						
7. Demonstration aids - maximum possible score 48 pts.						
Specimen sets	many	adeq.	few	sparse		
Models and charts	many	adeq.	few	sparse		
Prepared microscope slides	many	adeq.	few	sparse		
Overhead projector		1				
Cartridge projector	1					
Slide projector		1				
Microprojector			1			
Sub-total points						

All Facilities - maximum possible score 541 pts. ______

Your School - total score ______

* Includes such items as centigrade thermometers, pipetts, gas burners, dissecting sets, tripod stands, ring stands, etc.