A Statistical Analysis of the Factors Influencing Student Achievement and Instructional Effectiveness in the Audio-Tutorial Biological Science Program at Western Michigan University

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A STATISTICAL ANALYSIS OF THE FACTORS INFLUENCING STUDENT ACHIEVEMENT AND INSTRUCTIONAL EFFECTIVENESS IN THE AUDIO-TUTORIAL BIOLOGICAL SCIENCE PROGRAM AT WESTERN MICHIGAN UNIVERSITY

by

William L. Wissinger

A Project Report Submitted to the Faculty of the School of Graduate Studies in partial fulfillment of the Specialist in Arts Degree Science Education

Western Michigan University
Kalamazoo, Michigan
August 1968
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William L. Wissinger
WISSINGER, William Lawrence
A STATISTICAL ANALYSIS OF THE FACTORS INFLUENCING STUDENT ACHIEVEMENT AND INSTRUCTIONAL EFFECTIVENESS IN THE AUDIO--TUTORIAL BIOLOGICAL SCIENCE PROGRAM AT WESTERN MICHIGAN UNIVERSITY.

Western Michigan University, Ed.S., 1968
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CHAPTER I

The Problem and It's Background

Introduction to the problem

Since the Fall semester, 1966, 2,500 Western Michigan University students have completed Biological Science 107 as partial fulfillment of their science requirement in the General Studies Curriculum. While they were enrolled in this course, the students were exposed to a "unique" learning situation centered around an audio-tutorial teaching approach.

The incorporation of this teaching method was undertaken to re-establish a laboratory oriented study of the principles related to "life science" which had been absent during the preceding year in which a traditional lecture approach had been relied on to compensate for a large student enrollment and lack of adequate laboratory facilities. In spite of a further increase in student enrollment during the Fall semester, 1966, this laboratory centered orientation was made possible by employing the a-t\textsuperscript{1} teaching approach which required a single conventional laboratory facility equipped for a-t instruction.

It would appear from this standpoint that the a-t teaching method had supplied the answer to what had to be done to meet the

\textsuperscript{1}The abbreviation a-t will be used throughout this writing to refer to Audio-tutorial system.
instructional requirements of Biological Science 107. But on this basis alone, it was not possible to determine how effective this teaching "innovation" had been in terms of its ability to induce student achievement.

In response to this stimulus, this writer formulated three questions regarding the audio-tutorial Biological Science Program at Western Michigan University:

1. What level of achievement has been demonstrated by students participating in the a-t program?
2. What organizational aspects, student ability, and performance factors associated with them contributed to student achievement levels in the new program?
3. How effective had these aspects of the new program been in inducing student achievement?

The answers to these questions could not be found by inspection of enrollment success displayed by the program but required a consideration of the areas within the program influencing student achievement and the inter-relationships of factors contributing to student achievement inherent in these areas. If these factors could be defined, the effectiveness of the program could be measured.

Although the immediate concern of this study was with the effectiveness of the Biological Science Program at Western Michigan University, it was hoped that the results of the investigation would also provide a meaningful body of information that could be used in developing new or improving the existing a-t program.

**Literature review of the audio-tutorial teaching approach**

The concept of the audio-tutorial teaching approach was first
introduced by Postlethwait\textsuperscript{1} at Purdue University in 1961 to adjust for the diversity of student backgrounds in his freshman botany course. Since its introduction, this type of teaching method has found increasing acceptance at the college and university level. Among the institutions employing a-t programs are the University of North Dakota, Eastern Michigan University, Utah State University, Oakland Community College, in addition to the two previously mentioned. In addition to biology, this teaching method has been employed in geology and geography programs, while several other disciplines have indicated an interest in its use.

Besides compensating for student backgrounds, the a-t program's emphasis on individual learning, induced level of inquiry, ability to handle large student enrollment, and "limited" facility requirement all represent characteristics promoting its use.

From the standpoint of philosophical and conceptual support, the a-t method has been well received in the literature. Those opposed to such a program have given arguments centered around initial capital expense, lack of student-teacher identification, fear of mass education, and professional conservatism for not adopting the audio-tutorial teaching method. Other subjective evaluations in the form of attitudinal surveys (i.e., Geoghegan\textsuperscript{2}) have

\begin{flushleft}
\textsuperscript{1}Postlethwait, S. N., "Teaching Tools and Techniques." Pacific Speech, 1:4, p. 57.
\end{flushleft}

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reported favorable student reaction to the a-t teaching method.

In addition to an attitudinal survey, Geoghegan also dealt with a subjective evaluation of the a-t teaching method in terms of time spent in the learning center by the students versus their final grade and a comparison of final student grades in the program to final student grades in a conventional lecture program.

From this study, Geoghegan concluded that in using an a-t approach there was a definite correlation between final grade and the time the student spent in the laboratory. He also reported that compared to the conventional lecture approach, the new program had also resulted in increased student achievement.

Following Geoghegan's study, this writer\(^1\) undertook a study of the same program to evaluate the unit tests employed. In this study, the comparison of final grades under the conventional lecture method and final grades using the a-t approach were again considered for the second semester of the program's operation.

However, the inability of this writer to duplicate the earlier results of Geoghegan, with respect to the laboratory time versus final grade aspect of the program, raised several questions of the reported results. Because of this, three conclusions were drawn:

1. The reports were valid on the basis of their findings and data collected to formulate their conclusions;


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2. The reports did not take into consideration the differences in program structure and test populations used in their individual studies; and

3. The studies attempted to measure qualities that were too general in nature, and conclusions were formulated without giving consideration to the multiple factors affecting their interpretation.

In reaction to these conclusions, the new program considered in both reports was reviewed to determine which of the areas in it actually measured student achievement. The program was also reviewed to determine whether it would provide adequate data on which a new study, one concerned with determining the effectiveness of these aspects, the student ability, performance factors, as well as the program organizational factors influencing this effectiveness, could be based. It was decided that three general aspects of the program should be considered:

1. the demonstrated student achievement;
2. the laboratory influence on student achievement; and
3. the principles-oriented unit tests.

The purpose of this study was to promote an understanding of the singular determinants influencing student achievement under an audio-tutorial teaching approach. By collecting data which could be subjected to statistical analysis using various correlation techniques, a more authoritative evaluation of the new teaching approach could be formulated.

**Investigational objectives**

The specific objectives of this study were to:

1. measure student achievement in terms of the final grade and the unit test scores for each of the three fifteen week sessions;
2. measure student performance and ability factors in terms of:
   a. time used in the laboratory,
   b. verbal ability, and
   c. mathematical ability;
3. correlate these five factors;
4. evaluate and compare the unit tests employed during the three test sessions; and
5. determine how effective the program has been in inducing student achievement and the factors exerting the greatest influence on achievement by the use of the audio-tutorial approach.

The rationale for the theory supporting this study was based on the definition of teaching given by Smith,¹ "Teaching is a system of actions intended to induce learning." Unlike Smith's work, the evaluation of the instructor's function to induce learning, the learner's feedback activities and demonstrated achievement were used to evaluate self-induced learning in the audio-tutorial method.

The acceptance of this definition allowed for the importance of singular area factors to be weighed as heavily as student achievement. By doing this, it permitted the program and achievement factors to be evaluated in relation to their influence to induce students to achieve as a result of a specific instructional approach.

Investigational hypothesis

If the audio-tutorial teaching approach employed in the General Studies Biological Science Program at Western Michigan

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University was subjected to a systematic statistical analysis of the demonstrated student achievement levels resulting from its use, then distinct patterns of relationship could be found which would permit the definition of those factors influencing achievement and their relative importance to the self-learning situation. This would allow the program to be evaluated in terms of its instructional effectiveness.
CHAPTER II

Methods and Procedures

Definition of population and sampling techniques

The general populations selected for this study consisted of three former groups of biological science students. Except for the unit test item-analysis data, in which all students from the Winter 1967 and Fall 1967 semesters under Dr. Imy V. Holt, Mrs. Donna Schumann, and Mrs. Phoebe Rutherford were employed, the study was restricted to students enrolled in Dr. Holt's classes during the Fall 1966, Winter 1967, and Fall 1967 semesters. The students were predominately freshman level, enrolled in non-science curricula, and participated in the a-t program during one of the three test semesters.

Sample sizes varied according to the purpose for which they were intended. To determine demonstrated achievement levels in the three test semesters, all freshman students enrolled in Dr. Holt's classes were used:

1. 252 students from the Fall 1966 semester;
2. 156 students from the Winter 1967 semester; and
3. 444 students from the Fall 1967 semester.

From each of these groups, a 30 per cent sample was selected which was highly restricted on the basis of available norming data, number of students at each grade level representative of the total individual class per cent, and balanced in terms of the per cent
of male and female students actually enrolled in each semester.

These groups were as follows:

1. 74 students from the Fall 1966 semester;
2. 46 students from the Winter 1967 semester; and
3. 126 students from the Fall 1967 semester.

In the evaluation of the unit tests, two groups were used:

1. 477 students enrolled in the a-t program under all three instructors during the Winter 1967 semester;¹ and
2. 1,020 students enrolled in the a-t program under all three instructors during the Fall 1967 semester.

Data and Instrumentation

The raw data used in this study were collected from four sources:

1. the grade books for Dr. Holt's Fall 1966, Winter 1967, and Fall 1967 classes;
2. item-analysis data sheets from the Western Michigan University Testing Center for the Fall 1967 unit tests;
3. verbal and mathematical ability scores for students who took the S.A.T. college entrance examination supplied by the Western Michigan University Admissions Office; and
4. an earlier report by this writer.²

Unit test instruments employed during the three test semesters were teacher-made. During the Fall 1966 semester, each instructor used his own tests. During the Winter 1967 semester, a change was instituted such that all three instructors were using a single set of four 50-item "standardized" tests. During the Fall 1967 semes-
75-item "standardized" tests were used.

The S.A.T. scores were selected at the suggestion of Mr. Rus­
sel Gabier, Director of Admissions for Western Michigan University,
who felt that these scores were a more reliable and valid measure
of the student's ability than the other available test scores in
their records and that more students had taken this entrance test
which would allow a larger sample to be used.

In defining the populations and samples used in this study,
it was necessary to make the following assumptions about the S.A.T.
tests:

1. The S.A.T. tests administered to the Fall 1966-67 and
1967-68 freshman students were equal in reliability
and validity which would allow the grouped data of
the three test populations to be compared on the
basis of per cent difference between their average
scores and those for all seniors (national H.S.
averages).

2. Since the verbal and mathematical score per cent
differences were equal or approximately equal for all
W.M.U. freshmen and the selected samples used in this
study, the samples could be considered as represent­
ative of the classes from which they were drawn.

In addition to group norming, the S.A.T. scores were consid­
ered as achievement influencing factors under the student ability
heading.

Procedure employed to determine demonstrated student achievement

In measuring demonstrated student achievement, two factors
were considered:

1. final student grades; and
2. total unit test point averages.
These data were collected from the grade books of Dr. Holt's classes during the three test semesters. The final grade data were treated in terms of the per cent of freshman students per grade level for each semester. The measure of student test performance was based on the per cent average of total test points per grade level for each of the three test semesters for the selected student samples only.

Correlation techniques applied to achievement influencing factors

The major concern of this study was centered around the correlation of achievement influencing factors involved in the a-t program. To obtain this information, data were collected for representative samples of the student populations enrolled in the Fall 1966, Winter 1967, and Fall 1967 a-t programs under Dr. Holt. These data consisted of:

1. time used in the laboratory by each student;
2. total unit test points earned by each student;
3. final grade assigned to each student; and
4. verbal and mathematical S.A.T. scores for each student.

Using this information, two-variable correlations were performed using the "scattergram" method to obtain Pearson r correlation coefficients for each of the population samples. The index of predictive efficiency (E) for each r value was obtained from Peatman's Table G., Various Functions of Pearson's r Correla-

tion Coefficient,\textsuperscript{1} to facilitate intra-semester evaluation. To simplify inter-semester comparison, the $r$ values were converted to $z$ score values.\textsuperscript{2} The level of significance was tested by using Table 7, Critical Absolute Values of Correlation Coefficient $r$, presented by Crow, et al.\textsuperscript{3} Rejection of the null hypothesis was set at the alpha ($5\%$) level.

Because the factors being correlated were closely inter-related, a second correlation technique was performed. The purpose of this was to obtain a more objective two-factor correlation value by eliminating possible contamination effects produced by a third influencing variable. It also allowed a comparison to be made of the obtained values to determine degrees of factor influence on achievement determining aspects of the a-t teaching program.

This work was done using the two-variable $r$ coefficients and the partial $r$ correlation method.\textsuperscript{4} The $r$ values obtained from the partial $r$ technique were then converted to $E$ index and $z$ score values with their level of significance tested using the same methods used in the two-variable correlation tests.


\textsuperscript{2}Downie, op. cit., p. 155.


\textsuperscript{4}Downie, op. cit., Pp.203-4.
The final correlation technique employed in this study was used to determine the combined effects of two variables on a single dependent variable. Similar to the partial r technique, this would provide a measure of the degree of two combined factors' influence on achievement determining aspects inherent in the a-t program.

The multiple R correlation technique was employed in this analysis, based on the two-variable correlation data. The E index values, z score equivalents, and level of significance were treated as they were in both of the preceding correlation techniques.

Evaluation procedure applied to the unit tests

Because the quality of the unit test is directly proportional to the test's ability to measure student achievement, an item-analysis was performed on tests used during the Winter 1967 and Fall 1967 semesters. In both cases, the statistical design of T. L. Kelly was used.

For the analysis of the four 75-item tests used during the Fall 1967 semester, the operation was performed by the Western Michigan University Testing Service. Although several item statistics were reported, only the following were utilized in this study:

1\textsuperscript{loc. cit., p. 205.}
2\textsuperscript{loc. cit., p. 229.}
1. average difficulty of the whole test;
2. average difficulty of individual items; and
3. average discrimination of the whole test.

The average difficulty values of the individual test items were employed as frequency values to determine the internal reliability of each test using the Kuder-Richardson No. 20 formula.1

The Fall 1967 data were then compared to similar data reported for the Winter 1967 tests by this writer.2 Because of insufficient information on the tests used during the Fall 1966 semester, no attempt was made to include those tests in this study.

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1loc. cit., p. 220.

2Wissinger, op. cit., p. 21.
CHAPTER III

Data Analysis and Interpretation

Demonstrated achievement of students participating in the audio-tutorial teaching-learning situation

The measured performance displayed by students since the initiation of the audio-tutorial teaching approach in the Biological Science Program during the Fall 1966 semester is shown in Fig. 1.

![Figure 1. Per cent of students per grade category in relation to final grade categories. (Holt-whole class)
Here it was shown that a variable degree of student achievement resulted during the three test semesters of a-t operation. Although there was a large degree of fluctuation by the students in the middle grade range (B-C-D), distinct trends were present at the extreme ends of the grading scale. Since its initiation, the a-t program, on the basis of Fig. 1 alone, appears to have produced a very undesirable effect on student achievement by creating a steady increase in the per cent of students achieving E grades and a steady decrease in the per cent of students achieving A grades.

However, in looking at demonstrated student achievement on the unit tests employed in the a-t program since its initiation, another type of pattern was revealed (see Fig. 2, p. 17).

From this it was seen that changes in the testing instrument had increased the range of student performance. Although the test averages remained fairly constant at the C and E grade levels, they had steadily increased at the A and B levels. While the B, C, and D range students were only slightly segregated during the Fall 1966 semester by the unit tests, the tests in each succeeding semester displayed ability to separate the students into their proper grade level.

Through comparison of these demonstrated achievement graphs, it was found that the seemingly negative effect of the a-t program on final grades was the direct result of a more efficient segregation of students into grade levels on the basis of their demonstrated achievement. But this still did not represent all of the
program's aspects, and the causes of fluctuating student achievement were only partially accounted for by the unit tests.

**Interrelationships among achievement influencing factors and their effect on demonstrated student achievement using a-t instruction**

By looking at the correlations of the achievement influencing factors to final grades, two distinct patterns were found regarding their relationship with final grade.

When compared on the basis of z score equivalents for each semester, a steady increase was seen in the student ability
factors' (verbal and mathematical ability) relationship to final grade. In both cases, it was also found that these factors did not obtain a significant level (z greater than or equal to 2.00) until the Fall 1967 semester. Although both increased in their relation to final grade, the verbal ability had a higher correlation to final grade than the mathematical ability in all three semesters (see Fig. 3 below).

![Graph showing correlations of achievement influencing factors to final grade categories based on z score equivalents. (Table 3, p. A-3)](image-url)
The increased relationship of these ability factors tended to support directional changes occurring in the per cent of students receiving A and E grades. It showed that this increased relationship of mathematical and verbal ability to final grade would eliminate those students who received "marginal" A grades from the A group and drop those students who received "marginal" D grades into the E category.

Another factor contributing to these same phenomena was at first attributed to the steady increase, similar to that seen in verbal and mathematical ability, displayed by the correlation of unit tests to final grade. Significant in its relationship to final grade in all three semesters, it too showed a constant increase noted by its score values in terms of z equivalents. However, this might also have reflected the fact that it was being directly influenced by verbal and mathematical ability and was simply showing an increase in predictive validity with regard to final student grade.

A further supporting factor for this conclusion was the fact that the effect of total test points on final grade went from 54 per cent in the Fall of 1966 to 31 per cent in the Winter of 1967 and back up to 56 per cent during the Fall of 1967. This would dictate that directional trends of grades at the extreme ends of the grading scale would not occur in response to fluctuation of the unit test influence on final grade.

This new factor of decreased relationship of test points to
final grade, when considered with a similar trend found in the relationship between time used in the laboratory and final grade, could explain the sharp increase of students receiving B grades in the Winter 1967 semester and the concurrent decrease in the number of D grade students. As the relationship of the unit tests decreased in terms of final grade, the laboratory time underwent a similar decrease in relationship. It did so to such a degree that it no longer proved to be a significant influence on final grade. This was seen in the fact that where it had been highly significant in the Fall 1966 semester and the Fall 1967 semester, its z score value had fallen below the 2.00 required to reject the null hypothesis in the Winter 1967 semester (see Fig. 3, p. 18).

Because such a condition existed, it was inferred from Fig. 1 that those who benefited most were primarily the upper range C students and, to a lesser extent, the upper range D students, who would then have had an easier time raising themselves to the next higher level.

In addition to this, "bonus" points which affected approximately 33 per cent of the final grade were "given" for student laboratory attendance during the Winter 1967 semester. By "giving" these points for attendance, thereby decreasing the grade evaluation on demonstrated achievement measures, those students of lesser ability were the primary beneficiaries.

When partial r correlations were performed, the same general trends were found to exist (see Fig. 4, p. 21).
Figure 4. Partial $r$ correlations of achievement influencing factors to final grade categories based on $z$ score equivalents. (Table 4, p. A-4)

In Fig. 4 it was shown again that laboratory time was directly related to final grade which was in turn directly related to the influence of unit tests on final grade. When verbal and mathematical abilities were correlated to final grades, partialing out the mathematical factor in the former produced less change in each of the three test semesters than the partialing out of the verbal factor in the latter. This further showed that final grade was more sensitive to verbal than it was to mathematical ability. Additional supporting evidence of the earlier conclusions was found when multiple correlations were performed (see Fig. 5, p. 22).
Figure 5. Multiple R correlations of achievement influencing factors to final grade categories based on z score equivalents. (Table 5, p. A-5)

Fig. 5 demonstrated that the combined effects of verbal and mathematical ability influence on final grade had produced a steady increase in correlation with each succeeding semester. When the laboratory factor was introduced to the correlation, a sharp decline in the test's relation to final grade resulted which was directly in relation to the decline of unit test influence on final grade during the Winter 1967 semester. The degree of the drop was not as great in the cases where the verbal ability was considered. This again showed that verbal ability was more influential on final grade than mathematical ability.

The second measure of demonstrated student achievement levels induced by the a-t program considered in this study dealt with
total test points earned by students at each grade level. When the unit tests were correlated with achievement influencing factors, the following results were found (see Fig. 6 below):

![Figure 6](image)

**Figure 6.** Correlations of achievement influencing factors to total unit test points earned per semester based on z score equivalents. (Table 3, p. A-3)

When correlated to test points, the verbal and mathematical abilities showed a higher index of predictive efficiency than when they were correlated to final grade (Table 3, lines c, d, h, and i, p. A-3) in each of the three test semesters. Unlike the tendency of these factors to increase in value with each semester when correlated to final grade, they corresponded to the fluctuation of
unit test influence on final grade. Although all correlations of achievement influencing factors involving unit test points were significant, the verbal ability was found to have a greater degree of predictive efficiency in relation to test point totals than the mathematical ability in each of the three test semesters.

While the effect of laboratory time on test points did not show the sharp drop displayed by the effect of laboratory time on final grade, its value remained above the significant level in all three semesters, in spite of a drop in value during the Winter 1967 semester.

It was again inferred by the graphics illustrated in Fig. 6 that the increase in the students receiving B range grades and the decrease in the number of D range grades was due to the drop of influence of unit tests on final grades during the Winter 1967 semester. This same decrease of test influence was also shown to affect a decrease in the relationship of test points and the time used in the laboratory during the same period.

In the partial r correlations performed, the greater influence of the verbal ability compared to mathematical ability on unit test point totals was also emphasized. It was found that when the effects of the verbal ability were partialed out, the unit test to mathematical ability relation was the only one falling below the significant level. It was also found that \( r_{(\text{test})(\text{verbal}) \cdot (\text{math})} \) values were higher than \( r_{(\text{test})(\text{math}) \cdot (\text{verbal})} \) values in each of the three test semesters (see Fig. 7, p. 25).

The multiple correlations involving the unit tests further
Figure 7. Partial r correlations of achievement influencing factors to total unit test points earned per semester based on z score equivalents. (Table 4, p. A-4)

substantiated the effect of the decreased influence of unit tests on final grade. All of these correlations revealed a decrease in the relationship of the achievement influencing factors to the unit tests during the Winter 1967 semester. It was also shown, through a comparison of the E values resulting from the correlations of laboratory plus verbal effects on total unit test points and laboratory plus mathematical effects, that in each semester, those involving the presence of the verbal quantity were consistently higher than when the mathematical ability was being correlated (see Fig. 8, p. 26). This again showed the dominance of the verbal ability over the mathematical ability in terms of student performance.
The relation of student ability and performance factors to program effectiveness resulting from audio-tutorial instruction

The methods used to define patterned relationships in demonstrated student achievement were also employed to define the effectiveness of two program aspects being considered in this study:

1. the laboratory; and
2. the unit tests.

The first aspect of the a-t program which was investigated dealt specifically with the effectiveness of the laboratory or "learning center" which represented the unique aspect of the audio-
tutorial teaching approach. In earlier studies by Geoghegan\(^1\) and this writer,\(^2\) considerable attention was given to the correlation of time used in the laboratory and final grade. For the samples used in this study, the following relationships were found (see Fig. 9 below):

![Graph](image)

**Figure 9.** Hours used in laboratory per semester in relation to final grade categories. (Holt-samples)

From Fig. 9 it was seen that there had been a variable but


steady increase in the amount of time used in the laboratory by each grade level with each succeeding semester. This could be partially accounted for by the fact that during the Fall 1966 semester, one hour of attendance per week was "suggested" by the instructors which was then increased to two hours per week in the Winter 1967 semester and further increased to three hours per week in the Fall 1967 semester. In addition, laboratory quizzes were required at the end of each laboratory unit during the Winter 1967 and Fall 1967 semesters.

This resulted in a disproportionate increase in laboratory time at all grade levels. From the evidence presented by Fig. 9 it was seen that the change in program requirements had resulted in increased laboratory attendance overall, but the middle grade range students were not being successfully segregated on the basis of the time they were using in the laboratory.

When correlations of verbal and mathematical ability to time used in the laboratory were performed, two distinct patterns evolved (see Fig. 10, p. 29).

Here it was demonstrated that the relation between laboratory time and mathematical ability showed continual increase in each successive semester. Opposed to this, the relation of laboratory time to verbal ability reflected a sharp drop in value during the Winter 1967 semester and was attributed to the decreased influence on final grade exerted by the unit tests. By carrying this comparison further, it was hypothesized from the available data that verbal ability was the primary determinant of student partici-
Figure 10. Correlations of achievement influencing factors to hours used in laboratory per semester based on z score equivalents. (Table 3, p. A-3)

...pation in an audio-tutorial program. However, this was not because of a lower ability level, as might be expected, but was due to an apparently higher level of motivation to participate in students having higher levels of verbal ability.

The decreased unit test influence on final grade resulted in a similar drop in the influence of the laboratory on final grade. The same pattern could be seen in the verbal relationship but not in the mathematical pattern which supported the hypothesis that student behavior stemming from their verbal ability was the most influential factor in an a-t teaching system.

Partial r correlations further supported these conclusions (Table 4, p. A-4). Although it had been determined that verbal
ability was an important factor in time spent in the laboratory, when it was partialed out of the correlation between laboratory time and mathematical ability, the increase trend was still present with each successive semester. Intra-semester comparisons of Z values for each semester were found to show the dominance of verbal ability over mathematical ability in the determination of time the students used the laboratory and its sensitivity to changes in program organization (Table 4, lines g and h, p. A-4).

The combined effects of verbal and mathematical ability on laboratory time showed continual increases. However, they did not become significant factors until the Fall 1967 semester (Table 5, line d, p. A-5).

Although the analysis of the tests has been reserved for final consideration in this study, it should be evident from the discussion to this point that the unit tests have not only been an important measuring instrument but also a major factor in the success of the a-t program.

The increase in predictive validity suggested by Fig. 2 (p. 17) between the unit tests used in the Fall 1966 and Winter 1967 semester was attributed to the fact that the Winter 1967 tests were the result of the combined efforts of the three instructors teaching in the program. From Table 2 (p. A-2), it was seen that the increase in predictive validity between the Winter 1967 and Fall 1967 semesters could be directly attributed to the increased test discrimination and test reliability which could not be accounted.
for entirely by the lengthening of the tests from 50-items to 75-
items alone. This was especially true of the third and fourth
unit tests.

The fact that the unit tests had become better predictors of
final grades was further supported by the correlation of final
grade to total test points (Table 3, line b, p. A-3). In ref-
erence to this same table, it was seen that in terms of unit test
achievement, except for the Fall 1967 semester, the verbal ability
of the student had been the single most influential ability factor.
Although the time used in the laboratory and mathematical ability
were found to be significant factors, they did not affect test
achievement to the degree the verbal ability had. It could also
be seen that in the Fall 1967 semester program, the student's
mathematical ability, which exerted about the same influence as time
used in the laboratory in the two previous semesters, became a
greater determinant of student performance on the unit tests than
the laboratory time.

Table 4 (p. A-4) demonstrated the results obtained when the
third contaminating variable was partialed out of the correlation.
Here it was shown that the single most influential determinant of
unit test performance was the student's verbal ability. In addition
to this, the conclusions based on Table 3 (p. A-3) were further
supported.

Table 5 (lines f and g, p. A-5) demonstrated that when the
combined effects of laboratory time plus verbal ability and labora-
tory time plus mathematical ability were correlated with total test
points, the former correlations were equal to or greater than the correlations involving the mathematical ability.
CHAPTER IV

Summary and Conclusion

Due to the statistical nature of the investigational technique employed in this study, it has been necessary, up to this point, to become involved in a micro-inspection of results. However, the final conclusions to be drawn from them were simplified as the result of patterned trends revealed in the achievement influencing factors inherent in the a-t instructional approach.

Although considerable fluctuation had been displayed in measures of demonstrated student achievement regarding final grades, it was shown that this was primarily due to the variation in influence of the unit tests on the student's final grade. When this influence was reduced and the decrease replaced by "bonus" points for non-achievement measuring activities, the upper D and C grade level students who had not exerted an extra effort were benefited at the expense of those "marginal" grade students who would have been able to raise their grade level through additional participation in the laboratory aspect of the program.

In spite of the fact that the reliability and predictive validity of the unit tests had steadily increased, this improvement was also overshadowed when "bonus" points for laboratory attendance were partial determiners of final grade. If the attendance points had been determined on a "scaled" basis such that extra student participation would have been rewarded, this would have
been a more reliable grade determinant as well as a motivation factor for the lower ability student. However, an across the board attendance point scheme was shown to be detrimental to the program.

Directly related to this was the decline of the time in the laboratory to final grade relationship resulting from the decreased influence of unit tests on final grade. This fact points out the need to evaluate student achievement on his demonstrated performance. It is only when this is done that the a-t teaching method will provide an effective teaching approach.

The demonstrated student achievement on unit tests was directly related to the improved quality of the testing instruments in terms of segregating students into grade levels. While increasing the score discrimination range, the test difficulty was not relative to the "scaled" grading system desired for the program. Because the tests were measuring at a lower level than the grading scale, participation may have been induced to some degree, but for students of lower ability this could have had an adverse motivating effect. Therefore, the difficulty of the unit tests must be decreased to correlate with the grade scale employed.

In terms of demonstrated student achievement, the verbal ability, which could be considered a measure of the student's ability to deal with abstract constructs that are the products of inquiry and experience, was found to be consistently more influential than his mathematical ability, his ability to deal with concrete sensory experiences which have relationships between themselves, in this
a-t program. This suggested that a review of those aspects of the
program concerned with sensory experiences, more specifically the
laboratory demonstration material in terms of its subject matter
presentation, should be carried out. The data showed a steady
increase in a positive correlation trend between laboratory time
to verbal and mathematical ability. This indicated that the lab-
oratory had become more successful in segregating students on their
ability and it is possible that the laboratory material may have had
a negative effect on students of lower ability due to the quantity
of material and/or difficulty of material. An important factor
here would be the influence exerted on laboratory attendance by the
laboratory quizzes which were required of the students during the
Winter 1967 and Fall 1967 semesters, but were not considered here.

An additional factor regarding the laboratory participation is
the fact that the students enrolled in the course are non-science
majors whose primary purpose for being in the course is to fulfill
a curriculum requirement. This would introduce another motivation
factor and suggests that a greater emphasis should be placed on
relating biological science to the student in terms of its impor-
tance to the individual. In order to accomplish this in the labor-
atory, consideration might be given to reducing the emphasis on
terminology and devote more attention to biological principles and
their implications as they affect the individual. The main purpose
for doing this would be to have the student want to learn rather
than have to learn the subject matter and want to attend rather
than have to attend the laboratory.
On the basis of the findings resulting from this investigation, this writer concluded that the audio-tutorial instructional approach as it has been presented in the Biological Science 107 Program at Western Michigan University represents a valid and effective "teaching system." Although it has had several undesirable aspects since its incorporation, these have been either eliminated or improved in the course of the program's development. The fact that the program has increased its ability to evaluate student achievement in relation to performance in the course is its most desirable characteristic and indicates that it has been successful in inducing student achievement. Although problems dealing with motivation and ability factors have not been completely overcome, they are not unlike those problems associated with other "teaching systems" and do not constitute valid reasons on which arguments for rejecting this type of teaching method can be based.
PERTINENT LITERATURE


### TABLE 1

**Norming Data***

<table>
<thead>
<tr>
<th></th>
<th>Fall 1966</th>
<th>Winter 1967</th>
<th>Fall 1967</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Verbal</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>All H.S. seniors (national)</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>W.M.U. freshmen-% natl.</td>
<td>+6</td>
<td>+5</td>
<td>+12</td>
</tr>
<tr>
<td>Sample (Holt)-% natl.</td>
<td>+4</td>
<td>+4</td>
<td>+12</td>
</tr>
<tr>
<td><strong>Mathematical</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>All H.S. seniors (national)</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>W.M.U. freshmen-% natl.</td>
<td>+6</td>
<td>+6</td>
<td>+12</td>
</tr>
<tr>
<td>Sample (Holt)-% natl.</td>
<td>+2</td>
<td>+6</td>
<td>+12</td>
</tr>
<tr>
<td>% male students (Holt)</td>
<td>25</td>
<td>26</td>
<td>26</td>
</tr>
<tr>
<td>% male students (sample)</td>
<td>27</td>
<td>24</td>
<td>26</td>
</tr>
<tr>
<td>% female students (Holt)</td>
<td>75</td>
<td>74</td>
<td>74</td>
</tr>
<tr>
<td>% female students (sample)</td>
<td>73</td>
<td>76</td>
<td>74</td>
</tr>
<tr>
<td>Class size (Holt)</td>
<td>252</td>
<td>156</td>
<td>444</td>
</tr>
<tr>
<td>Sample size (Holt-30%)</td>
<td>74</td>
<td>46</td>
<td>126</td>
</tr>
<tr>
<td>% error in sample</td>
<td>-2.7</td>
<td>-4.3</td>
<td>-5.2</td>
</tr>
<tr>
<td><strong>Total enrollment</strong></td>
<td>840</td>
<td>477</td>
<td>1,020</td>
</tr>
</tbody>
</table>

*Verbal and mathematical data based on figures adjusted to percent male and female students in samples. The actual test scores and averages have been omitted at the request of the Western Michigan University Admissions Office.*
# TABLE 2

## Unit Test Item-Analysis Data

<table>
<thead>
<tr>
<th></th>
<th>Ave. Difficulty</th>
<th>Ave. Discrimination</th>
<th>Internal Reliability</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Whole Test-%</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### Unit test I - The Cell

<table>
<thead>
<tr>
<th>Season</th>
<th>Ave. Difficulty</th>
<th>Ave. Discrimination</th>
<th>Internal Reliability</th>
</tr>
</thead>
<tbody>
<tr>
<td>Winter 1967-50 items</td>
<td>65.6</td>
<td>26</td>
<td>.72*</td>
</tr>
<tr>
<td>Fall 1967-75 items</td>
<td>60.8</td>
<td>28</td>
<td>.80</td>
</tr>
</tbody>
</table>

### Unit test II - Ecology

<table>
<thead>
<tr>
<th>Season</th>
<th>Ave. Difficulty</th>
<th>Ave. Discrimination</th>
<th>Internal Reliability</th>
</tr>
</thead>
<tbody>
<tr>
<td>Winter 1967-50 items</td>
<td>67.4</td>
<td>26</td>
<td>.78*</td>
</tr>
<tr>
<td>Fall 1967-75 items</td>
<td>59.3</td>
<td>27</td>
<td>.78</td>
</tr>
</tbody>
</table>

### Unit test III - Inheritance

<table>
<thead>
<tr>
<th>Season</th>
<th>Ave. Difficulty</th>
<th>Ave. Discrimination</th>
<th>Internal Reliability</th>
</tr>
</thead>
<tbody>
<tr>
<td>Winter 1967-50 items</td>
<td>62.8</td>
<td>24</td>
<td>.69*</td>
</tr>
<tr>
<td>Fall 1967-75 items</td>
<td>61.1</td>
<td>30</td>
<td>.82</td>
</tr>
</tbody>
</table>

### Unit test IV - Evolution

<table>
<thead>
<tr>
<th>Season</th>
<th>Ave. Difficulty</th>
<th>Ave. Discrimination</th>
<th>Internal Reliability</th>
</tr>
</thead>
<tbody>
<tr>
<td>Winter 1967-50 items</td>
<td>61.0</td>
<td>20</td>
<td>.59*</td>
</tr>
<tr>
<td>Fall 1967-75 items</td>
<td>65.8</td>
<td>25</td>
<td>.75</td>
</tr>
</tbody>
</table>

*Figures represent rtt values computed to permit comparison of 50 item test if lengthened to 75 items using Spearman-Brown formula with the exception of Unit test I in which three items were eliminated due to presence of more than one possible correct answer.

(op. cit., Downie, p. 219.)
TABLE 3

Correlation Data Involving Two Variables

<table>
<thead>
<tr>
<th>Line</th>
<th>Fall 1966 n=74</th>
<th>Winter 1967 n=46</th>
<th>Fall 1967 n=126</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>r</td>
<td>z</td>
<td>E-%</td>
</tr>
<tr>
<td>a. r(lab)(grade)</td>
<td>.78</td>
<td>6.5</td>
<td>37</td>
</tr>
<tr>
<td>b. r(test)(grade)</td>
<td>.58</td>
<td>4.8</td>
<td>18</td>
</tr>
<tr>
<td>c. r(verb)(grade)</td>
<td>.14</td>
<td>1.2</td>
<td>1</td>
</tr>
<tr>
<td>d. r(math)(grade)</td>
<td>-.06</td>
<td>-.5</td>
<td>0</td>
</tr>
<tr>
<td>e. r(lab)(verb)</td>
<td>.05</td>
<td>.4</td>
<td>0</td>
</tr>
<tr>
<td>f. r(lab)(math)</td>
<td>.01</td>
<td>.1</td>
<td>0</td>
</tr>
<tr>
<td>g. r(lab)(tests)</td>
<td>.35</td>
<td>2.9</td>
<td>6</td>
</tr>
<tr>
<td>h. r(tests)(verb)</td>
<td>.49</td>
<td>4.1</td>
<td>13</td>
</tr>
<tr>
<td>i. r(tests)(math)</td>
<td>.35</td>
<td>2.9</td>
<td>6</td>
</tr>
</tbody>
</table>
### TABLE 4

Correlation Data Eliminating Effect of a Third Influencing Variable

| Line | $r$ | $z$ | E-| | | E-|| E-|| E-| |
|------|----|----|---|---|---|---|---|---|---|
| a.    | .78 | 6.5 | 37 | .30 | 2.0 | 5.37 | 4.1 | 7 |
| b.    | .78 | 6.5 | 37 | .29 | 1.9 | 4.38 | 4.2 | 8 |
| c.    | .20 | 1.7 | 2.18 | 1.2 | 2.28 | 3.1 | 4 |
| d.    | .16 | 1.3 | 1.27 | 1.8 | 4.34 | 3.8 | 6 |
| e.    | -.17 | -1.4 | 0.12 | .8 | 1.16 | 1.8 | 1 |
| f.    | -.11 | -.9 | 0.21 | 1.4 | 2.29 | 3.2 | 4 |
| g.    | .05 | .4 | 0.04 | -.3 | 0.14 | 1.6 | 1 |
| h.    | -.02 | -.2 | 0.07 | .5 | 0.08 | .9 | 0 |
| i.    | .37 | 3.1 | 7.34 | 2.3 | 6.53 | 5.9 | 15 |
| j.    | .50 | 4.2 | 13.46 | 3.1 | 11.64 | 7.1 | 23 |
| k.    | .11 | .9 | 1.18 | 1.2 | 2.31 | 3.4 | 5 |
| l.    | .37 | 3.1 | 7.34 | 2.3 | 6.52 | 5.8 | 15 |
| m.    | .37 | 3.1 | 7.31 | 2.1 | 5.32 | 3.5 | 5 |
| n.    | .38 | 3.2 | 8.34 | 2.3 | 6.30 | 3.3 | 5 |
TABLE 5

Correlation Data Combining the Effects of Two Predictor Variables on a Single Dependent Variable

<table>
<thead>
<tr>
<th>Line</th>
<th>Fall 1966</th>
<th>Winter 1967</th>
<th>Fall 1967</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>n=74</td>
<td>n=46</td>
<td>n=126</td>
</tr>
<tr>
<td></td>
<td>Sig.5%-z=2.0</td>
<td>Sig.5%-z=2.0</td>
<td>Sig.5%-z=2.0</td>
</tr>
<tr>
<td>a. R grade.(verb)(math)</td>
<td>.20 1.7 2</td>
<td>.30 2.0 5</td>
<td>.44 4.9 10</td>
</tr>
<tr>
<td>b. R grade.(verb)(lab)</td>
<td>.79 6.6 39</td>
<td>.39 2.6 8</td>
<td>.52 5.8 15</td>
</tr>
<tr>
<td>c. R grade.(math)(lab)</td>
<td>.78 6.5 37</td>
<td>.35 2.3 6</td>
<td>.49 5.4 13</td>
</tr>
<tr>
<td>d. R lab.(verb)(math)</td>
<td>.00 0.0 0</td>
<td>.01 .1 0</td>
<td>.22 2.4 2</td>
</tr>
<tr>
<td>e. R test.(verb)(math)</td>
<td>.49 4.1 13</td>
<td>.46 3.1 11</td>
<td>.71 7.9 30</td>
</tr>
<tr>
<td>f. R test.(math)(lab)</td>
<td>.49 4.1 13</td>
<td>.45 3.0 11</td>
<td>.60 6.7 20</td>
</tr>
<tr>
<td>g. R test.(verb)(lab)</td>
<td>.58 4.8 19</td>
<td>.54 3.6 16</td>
<td>.69 7.7 28</td>
</tr>
</tbody>
</table>