1972

The effectiveness of field trips compared to media in teaching selected environmental concepts

Eugene Ralph Brady
Iowa State University

Follow this and additional works at: https://lib.dr.iastate.edu/rtd
Part of the Science and Mathematics Education Commons

Recommended Citation
Brady, Eugene Ralph, "The effectiveness of field trips compared to media in teaching selected environmental concepts" (1972). Retrospective Theses and Dissertations. 5887.
https://lib.dr.iastate.edu/rtd/5887

This Dissertation is brought to you for free and open access by the Iowa State University Capstones, Theses and Dissertations at Iowa State University Digital Repository. It has been accepted for inclusion in Retrospective Theses and Dissertations by an authorized administrator of Iowa State University Digital Repository. For more information, please contact digirep@iastate.edu.
INFORMATION TO USERS

This dissertation was produced from a microfilm copy of the original document. While the most advanced technological means to photograph and reproduce this document have been used, the quality is heavily dependent upon the quality of the original submitted.

The following explanation of techniques is provided to help you understand markings or patterns which may appear on this reproduction.

1. The sign or “target” for pages apparently lacking from the document photographed is “Missing Page(s)”. If it was possible to obtain the missing page(s) or section, they are spliced into the film along with adjacent pages. This may have necessitated cutting thru an image and duplicating adjacent pages to insure you complete continuity.

2. When an image on the film is obliterated with a large round black mark, it is an indication that the photographer suspected that the copy may have moved during exposure and thus cause a blurred image. You will find a good image of the page in the adjacent frame.

3. When a map, drawing or chart, etc., was part of the material being photographed the photographer followed a definite method in “sectioning” the material. It is customary to begin photoing at the upper left hand corner of a large sheet and to continue photoing from left to right in equal sections with a small overlap. If necessary, sectioning is continued again — beginning below the first row and continuing on until complete.

4. The majority of users indicate that the textual content is of greatest value, however, a somewhat higher quality reproduction could be made from “photographs” if essential to the understanding of the dissertation. Silver prints of “photographs” may be ordered at additional charge by writing the Order Department, giving the catalog number, title, author and specific pages you wish reproduced.

University Microfilms
300 North Zeeb Road
Ann Arbor, Michigan 48106
A Xerox Education Company
BRADY, Eugene Ralph, 1933-
THE EFFECTIVENESS OF FIELD TRIPS COMPARED TO MEDIA IN TEACHING SELECTED ENVIRONMENTAL CONCEPTS.

Iowa State University, Ph.D., 1972
Education, scientific

University Microfilms, A XEROX Company, Ann Arbor, Michigan

© 1972
Eugene Ralph Brady

ALL RIGHTS RESERVED

THIS DISSERTATION HAS BEEN MICROFILMED EXACTLY AS RECEIVED.
The effectiveness of field trips compared to media in teaching selected environmental concepts

by

Eugene Ralph Brady

A Dissertation Submitted to the Graduate Faculty in Partial Fulfillment of The Requirements for the Degree of DOCTOR OF PHILOSOPHY

Major: Education

Approved:

Signature was redacted for privacy.

In Charge of Major Work

Signature was redacted for privacy.

For the Major Area /

Signature was redacted for privacy.

For the Graduate College

Iowa State University
Ames, Iowa
1972

Copyright © Eugene Ralph Brady, 1972. All rights reserved.
PLEASE NOTE:

Some pages may have
indistinct print.
Filmed as received.

University Microfilms, A Xerox Education Company
<table>
<thead>
<tr>
<th>TABLE OF CONTENTS</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>INTRODUCTION</td>
<td>1</td>
</tr>
<tr>
<td>Statement of the Problem</td>
<td>5</td>
</tr>
<tr>
<td>Purpose of the Study</td>
<td>5</td>
</tr>
<tr>
<td>Definitions</td>
<td>6</td>
</tr>
<tr>
<td>REVIEW OF LITERATURE</td>
<td>8</td>
</tr>
<tr>
<td>Environmental Education</td>
<td>8</td>
</tr>
<tr>
<td>Field Trips</td>
<td>13</td>
</tr>
<tr>
<td>Use of Field Trips in Science</td>
<td>16</td>
</tr>
<tr>
<td>Use of Field Trips in Related Areas</td>
<td>20</td>
</tr>
<tr>
<td>METHOD OF PROCEDURE</td>
<td>28</td>
</tr>
<tr>
<td>Objectives</td>
<td>28</td>
</tr>
<tr>
<td>Hypotheses</td>
<td>29</td>
</tr>
<tr>
<td>Selection of the Sample</td>
<td>30</td>
</tr>
<tr>
<td>Student Schedule</td>
<td>31</td>
</tr>
<tr>
<td>Content of the Course</td>
<td>35</td>
</tr>
<tr>
<td>Method of Collecting Data</td>
<td>37</td>
</tr>
<tr>
<td>Statistical Design</td>
<td>42</td>
</tr>
<tr>
<td>FINDINGS</td>
<td>44</td>
</tr>
<tr>
<td>Comparison of Pretest Scores to Posttest Scores</td>
<td>47</td>
</tr>
<tr>
<td>Comparison of Field Trips to Media</td>
<td>53</td>
</tr>
<tr>
<td>Comparison of Student Achievement by Units</td>
<td>59</td>
</tr>
<tr>
<td>Retention Test</td>
<td>67</td>
</tr>
<tr>
<td>Student Attitude Towards Ecological Problems</td>
<td>69</td>
</tr>
<tr>
<td>Student Attitude Towards Biology</td>
<td>72</td>
</tr>
<tr>
<td>DISCUSSION OF THE FINDINGS</td>
<td>74</td>
</tr>
<tr>
<td>Attitudes Towards Environmental Problems</td>
<td>80</td>
</tr>
<tr>
<td>Student Attitude Towards Field Trips</td>
<td>81</td>
</tr>
<tr>
<td>SUMMARY OF RESULTS</td>
<td>84</td>
</tr>
<tr>
<td>RECOMMENDATIONS FOR FUTURE STUDIES</td>
<td>86</td>
</tr>
<tr>
<td>BIBLIOGRAPHY</td>
<td>87</td>
</tr>
<tr>
<td>ACKNOWLEDGEMENTS</td>
<td>90</td>
</tr>
<tr>
<td>APPENDIX A. ACHIEVEMENT AND ATTITUDE TESTS</td>
<td>91</td>
</tr>
<tr>
<td>APPENDIX B. FIELD TRIP EXERCISES</td>
<td>141</td>
</tr>
</tbody>
</table>
LIST OF TABLES

Table 1. Statistical Analysis of Achievement Tests 38
Table 2. Comparison of Control Group to Experimental Group by Covariants 46
Table 3. Distribution of Students With Each Covariant 47
Table 4. Pretest-Posttest Achievement Experimental Group 48
Table 5. Pretest-Posttest Control Group 48
Table 6. Correlation for All Variables Control Group 49
Table 7. Correlation for All Variables Experimental Group 51
Table 8. Analysis of Variance: Posttest Scores 54
Table 9. Analysis of Covariance: Posttest Scores 54
Table 10. Comparison of Posttest Scores based on GPA 56
Table 11. Comparison of Posttest Scores based on I. Q. 56
Table 12. Comparison of Posttest Scores based on Science Background 57
Table 13. Mean Posttest Achievement Scores 58
Table 14. Analysis of Variance: Unit I Achievement Scores 59
Table 15. Analysis of Variance: Unit II Achievement Scores 59
Table 16. Analysis of Variance: Unit III Achievement Scores 60
Table 17. Analysis of Covariance: Unit I Achievement Scores 60
Table 18. Analysis of Covariance: Unit II Achievement Scores 61
Table 19. Analysis of Covariance: Unit III Achievement Scores 61
Table 20. Mean Scores: Unit I and Unit II 62
Table 21. Unit II Test Scores based on GPA 65
Table 22. Comparison of Unit II Scores based on I. Q. 65
Table 23. Comparison of Unit II Scores based on ITED 66
Table 24. Analysis of Variance: Retention Test 67
Table 25. Analysis of Covariance: Retention Test 67
Table 26. Comparison of Posttest to Retention Test 68
Table 27. Pretest to Posttest Attitude Scores: Experimental Group 69
Table 28. Pretest to Posttest Attitude Scores: Control Group 69
Table 29. Correlation of Attitude Scores to Covariants 70
Table 30. Analysis of Variance Posttest Attitude Scores 71
Table 31. Analysis of Covariance Posttest Attitude Scores 71
Table 32. Attitudes Towards Biology 72
<table>
<thead>
<tr>
<th>Figure</th>
<th>Description</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>Figure 1.</td>
<td>Interaction Between Treatment and Sex</td>
<td>58</td>
</tr>
<tr>
<td>Figure 2.</td>
<td>Interaction Between Treatment and Sex: Unit I</td>
<td>63</td>
</tr>
<tr>
<td>Figure 3.</td>
<td>Interaction Between Treatment and Sex: Unit II</td>
<td>63</td>
</tr>
</tbody>
</table>
INTRODUCTION

The need to develop an effective environmental education program ranks as one of the major challenges facing education in the next decade. Schoenfeld (1970) has termed this "nothing less than human survival."

In the past when the nation has been faced with major problems, it has looked to its educational system for help in solving them. In the past fifteen years, such areas as race relations, space technology and drug addiction have made demands upon the school curriculum. Education is now being asked to be a major agent in solving the environmental problems.

Previously most programs related to the environment have dealt with the more gross aspects of the subject. Such topics as soil conservation, water conservation and wildlife management have been the major subjects of these programs. The extent and size of the current problem serves as evidence that the previous programs are not adequate for the present needs.

For environmental education to achieve its greatest impact, it must (White, 1970):

1. Provide factual information which will lead to an understanding of the total environment.

2. Develop a concern for environmental quality which will motivate citizens to work toward solutions dealing with environmental problems.

3. Inform citizens how they can play an effective role in achieving the goals derived from their attitudes.

In view of these objectives, any environmental program must be concerned with providing accurate factual information upon which
environmental decisions can be based. Decisions based on emotion or faulty information will serve to compound the already existing problem.

Of equal importance is the building of proper attitudes. Correct attitudes towards the environment and natural resources in general are created over a person's lifetime. "...Unless we shape good attitudes, especially in young people, all of the current talk about the environment will be meaningless" (Ashbaugh, 1970). Finally the program must provide direction and guidance on how and where an individual may best expend his energy to help solve these problems.

There is an urgent need for research to provide some basic information upon which the new environmental programs can be built. Research is needed in at least three areas. First the basic question of what should be taught must be answered. Of all the articles pertinent to environmental education, one (Roth, 1970) has made concrete suggestions as to what should be taught. A second area of concern is the level at which these basic principles can be taught effectively. The final area needing research concerns the best method of teaching these ideas and concepts. The last two areas have not received even the preliminary experimental study afforded the first basic question. All three areas need to be investigated in considerable depth.

While there has been very little experimental response to the last question on how to teach the subject, there has been a very active response by commercial companies. A multitude of commercially prepared materials have appeared on the market. These are represented by such devices as environmental games, audio-tutorial packages,
filmstrips and films.

Schools have responded by attempting to provide more opportunities for students to become familiar with their environment. There has been renewed interest in taking field trips, in developing arboretums and in establishing educational parks.

All of these approaches have one element in common; that is, they attempt to make the student more aware of his environment and the impact he is making on his environment. The assumption behind these efforts has been clearly stated: "A closed system of textbook/classroom is not enough. Children must deal with real information gleaned from the real world. They must examine measurable aspects of the environment on a comprehensive scale" (Naylon, 1970a).

One of the methods receiving strong support from those involved with environmental programs has been the use of field trips. This technique is not new to the educational strategies used by teachers. The ancient Greek word for school, Lyceum, literally means little wolf. This term was applied to the ancient Greek schools because of Aristotles' tendency to take his students on field trips where the wolves were found.

Historically modern day field trips had their origin in Europe. Prior to 1900 European students and teachers were involved in such trips. The type and duration of these field trips showed considerable variation. Some of the field trips were primarily recreational in nature; others stressed physical fitness and still others were taken for their educational value. They varied in length from a few hours to extended overnight trips lasting for several days.
In the United States the field trip was used only occasionally prior to 1920. A survey of the educational literature (Clark, 1943) found only four articles relating to such trips for the years 1920-1924. The number of articles continued to increase until between 1935 and 1938, 185 articles appeared in print. No further tabulation of the number of articles appearing in the journals has been made since then. However, a cursory examination of the number of articles under the topic field trips in the Educational Index would lead one to believe that these trips have continued to gain in importance as a teaching method.

The major values attributed to the use of field trips can be summarized as follows:

1. They provide more concrete learning experiences. It is presumed that this will result in more meaningful and lasting learning experiences for the student.

2. They allow the student to see the subject in its natural setting. Thus the student sees the inter-relations between the various parts of the subject being studied.

3. They stimulate and maintain student interest in the subject.

While the field trip is strongly advocated by its proponents, certain problems, basically administrative, have caused many educators to look to other sources for means of providing students with a broader range of experiences. Most notable of these has been the use of audiovisual materials. Films, filmstrips and audio tapes have been used to take the students on a vicarious journey outside of the classroom. Many of the values attributed to field trips have been
cited for these types of media.

This investigation was designed to compare field trips to media as a means of teaching selected environmental concepts.

It would seem that this research has certain implications in terms of how the schools' environmental program is to operate. If research shows that field trips are an essential ingredient of the program, then it becomes necessary to identify resource areas available to the school, to train teachers in the use of these areas, to construct appropriate teaching units and to provide adequate time and equipment for these field exercises. If on the other hand, the goals of environmental education can be achieved by other means, then such factors as time, expense and disruption of the school schedule will tend to limit the use of field trips.

Statement of the Problem

The problem in this investigation was to evaluate the effectiveness of field trips compared to the effectiveness of media in teaching selected environmental concepts. These two methods were evaluated in terms of student achievement and their effect on student attitude towards environmental problems.

Purpose of the Study

The purpose of the study was to develop and evaluate two methods of teaching environmental concepts in a general biology class. The experiment was designed to answer the following questions:
1. Is there any difference in understanding selected environmental concepts between those students taught using field trips and those taught using media?

2. Is there any difference in understanding selected environmental concepts between those students taught using field trips and those taught using media; when prior knowledge, I. Q., grade point average and background in science are used as covariants?

3. Is there any difference in attitude towards the current environmental crisis between those students taught using field trips and those taught using media?

4. Is there any difference in attitude towards the current environmental crisis between those students taught using field trips and those taught using media when previous attitude, I. Q., grade point average and background in science are used as covariants?

5. Is there any difference in understanding selected environmental concepts based on the sex of the student?

6. Is there any difference in attitude towards environmental problems based on the sex of the student?

Definitions

For the purpose of this study the following definitions were used.

1. Environmental education -- The process of providing individuals with an understanding of the dynamic relationship between the physical and biotic segments of the environment. Inherent within this idea is the concept that man is part of and subject to those
interactions. Furthermore, man has and is disrupting this dynamic balance in a way that is detrimental to all life, including his own.

2. **Field trip** -- A learning activity designed to accomplish specific predetermined objectives, related to an educational unit, in which the student leaves the school building for a period of time. The field trip in this sense is used as one method of teaching in a larger teaching strategy.

3. **Multi media** -- The use of a variety of audio and visual materials, such as slides, filmstrips, motion pictures, work sheets and other appropriate materials in teaching a particular unit. These materials are selected and arranged on the basis of their characteristics to achieve a particular objective. The concept of multi media does not imply that all of these materials will be used in a single teaching exercise, but rather that several different materials will be used during the time the student is involved in covering the unit.

4. **Control group** -- Those students who remained in the classroom and were taught through the use of media.

5. **Experimental group** -- Those students who during part of their learning experiences went on field trips.
The current concept of environmental education is new to the school curriculum. Consequently, any review of literature as to the method of teaching such a unit is bound to produce limited results. The number of articles related to the use of field trips in other areas are more numerous. Unfortunately, as is the case with so many of the articles pertaining to education, very few of them are based on experimental results. The vast majority reflect the opinion of the author or are testimonials for some particular method. While these may have value to classroom teachers in planning teaching exercises, they are of questionable value in planning research. As a result, this review of literature will be based primarily on those articles which reflect an experimental basis. Three areas have been reviewed: environmental education, field trips related to science, and field trips in related areas.

Environmental Education

A pilot study has been conducted by the Research Division of the National Education Association (1970), concerning the status of environmental education in the public schools. The survey was limited to schools with enrollment of 1000 students or more. A summary of this survey has been reported in Todays Education (1970). The following characteristics were noted:

1. A majority of environmental education programs are entitled "Outdoor Education" and are intended either to give pupils a general acquaintance with the outdoors and nature or to provide them with a general awareness of man in relation to his environment.
2. The programs are aimed chiefly at pupils in the upper elementary grades.

3. A majority of the programs operate either year around or throughout the entire school year, but in most instances scheduling is limited to the regular school week.

4. The great majority of programs combine classroom study with visits to sites outside the classroom. Almost all of these provide students with special preparation prior to the visits and conduct follow-up activities afterwards. Discussion and reading in the class, audiovisual presentations, and visits to the classroom by resource persons are all widely used as prior preparation for on-site experience. The most widely used types of follow-up activities involve oral reports and discussions; the examination, identification and use of specimens gathered at the site; displays and exhibits and written reports or essays. Films, slides, and transparencies, further reading and art activities are also often used in follow-up of on-site experience.

5. The areas of study included in the greatest number of programs are conservation, ecology, biology, insect study, geology, botany, general science and weather study.

6. The curriculum is most often determined by an instructional team. In many cases the teacher prepares a field lesson for each trip. Student interest is also considered in planning the curriculum.

7. Most programs attempt to determine whether student attitudes toward their environment have changed.

8. Most programs that include students at the secondary level grant academic credit for work done in the program, but relatively few programs give grades.

9. In a majority of programs students visit places where they stay overnight. Most of these sites have cabins or bunkhouses, cooking and dining facilities and an infirmary.

10. Typical sites include forest or woodland, ponds, or lakes, a recreation area, campgrounds and wildlife natural area.

11. For a site that is used for single day field trips, 50 miles from the school district appears to be the maximum feasible distance; for overnight sites, 100 miles is the maximum.

12. Most programs use the services of the regular school staff, classroom teachers and principals, with the assistance of resource personnel. Part-time staffing is more common than full-time staffing.
13. The great majority of persons in charge of environmental education programs are academically well qualified as educators, holding a master's degree or higher; but few of them have had pre-service training, specifically in the area of environmental studies.

14. Local sources of funds are of prime importance in the financing of environmental education programs.

The study (NEA, 1970) revealed three different types of programs, varying in grade placement and in content offered. The most common program includes elementary and secondary grades. While a school may have an environmental program at both the elementary and secondary level, this does not imply that the program exists at all grade levels. Of those schools having an environmental program at both the elementary and secondary levels, 51% covered six or more grades at the elementary level and 39.7% covered six or more grades at the secondary level. The majority of the elementary schools placed their emphasis on grades 4-8, while the secondary schools emphasized grades 10-12 (NEA, 1970). The program is designed to cover a wide range of topics, with particular emphasis on man and his environment. Those schools which have both elementary and secondary programs showed the greatest diversity in terms of activities, sites and use of personnel.

The next most common arrangement (NEA, 1970) based on grade, is the elementary program. This type of program is generally limited to one year (60.6%) and is most commonly found at the sixth grade level. The program is designed to provide the students with an appreciation of nature and to help them enjoy the out-of-doors. Many of the programs are limited to one season of the year. At that time the students leave the school and are taken to some site away from school. This camp-like experience represents the entire program in many cases.
The least common of the environmental programs are those which are limited to the secondary level. These programs operate within the traditional curriculum and the student receives academic credit for them. Most of the emphasis is placed on the more technical and scientific aspects of the environment. The learning activities are generally centered in the classroom, with some field trips utilized to cover specific topics.

In a more detailed examination of problems related to teaching about the environment, Naylon (1970b) cited six weaknesses. His survey of teachers and principals, in both public and private schools, revealed the following:

1. A need for pertinent curriculum development in the area of environmental education. Three areas were cited: lack of curriculum guides which were based on integrated subject matter, lack of help in developing materials and no provisions for revision of existing guides. These weaknesses were cited by 77.9% of the respondents.

2. The lack of a specific time allotment to teach environmental units. This was cited by 50% of the educators.

3. That 31.6% of the teachers indicated the textbook "served as the sole course of study."

4. Textbooks were selected on the basis of their appeal to a broad audience. These texts generally emphasized plant and animals study. The appropriateness of the texts was questioned by 42.9% of the teachers.

5. Evaluation of such skills as "ability to structure inquiry, maintain data records, formulate and test hypothesis or arrive at conclusions" was lacking in 77.4% of the cases. This appears to contradict the report that 60.5% of students actively participated in scientific investigations.

6. The lack of in-service training. This was listed by 84.5% of the sample.

There seems to be little question of the necessity for environmental education. Nor does there seem to be any doubt that such
programs are going to reflect a new emphasis. The questions are what concepts should they emphasize, and what materials and methods will best achieve the desired results? To say they should be man centered and that they need to reflect man's social characteristics is of limited value for those faced with the responsibility of establishing such programs.

An attempt at moving from a theoretical framework to an operational basis has been proposed by Roth. He attempted to identify those concepts which scholars, working in the area of environmental management, felt were most essential to an environmental education program (Roth, 1970).

A preliminary list of concepts was compiled by surveying the literature in eight areas, generally associated with environmental management. These included wildlife management, plant ecology, water management, soils, political science, economics, sociology and cultural anthropology. From this survey 89 concepts were selected. These 89 concepts were then presented to an inter-disciplinary panel of scholars at the University of Wisconsin. These scholars revised and added to the list. A final list of 128 concepts was then submitted to 669 scholars throughout the nation. This group was asked to rank the concepts. A 90% level of agreement was required before a concept was classified as being a vital one. On this basis a final list of 111 concepts was compiled.

The concept receiving the greatest support was that "living things are interdependent with one another and their environment." Twelve other areas were also identified. These included 16 concepts
in environmental management, 8 concepts in management techniques, 18 concepts in economics, 11 concepts in environmental problems, 9 concepts in adaptation and evolution, 18 concepts in natural resources, 10 concepts in socio-cultural environment, 4 concepts dealing with cultural aspects, 5 concepts related to politics, 7 concepts based on the family and 4 concepts of a psychological nature.

Such work as this has implication for future research and for development of new programs.

Field Trips

Schools and teachers have in many cases relied almost exclusively upon the use of written texts and the verbal presentation of material. Such reliance upon these techniques has often resulted in students memorizing what the teacher assigned without really comprehending the meaning of the content.

This emphasis has been maintained despite the insistence of many educators that students must be actively engaged in the learning process. As Garry and Kingsley, (1970) put it, "Comprehension rests on experiences which the individual has already had,... concepts grow from concrete experiences and the meaning of a word is clear only when one knows the thing it signifies. Perception of concrete things is basic to all understanding, yet ignoring this or remaining in ignorance of it, teachers too often taught words without the experiential background necessary to give them real meaning."

Field trips have served as one means of providing students with concrete experiences. Various values have been attributed to these
trips. A recent summary of these purported values has been made by Sorrentino and Bell, (1970). A survey of the literature yielded 167 statements from 70 sources attesting to the value of field trips. Those value statements which had common elements were grouped together. The following 16 statements represent this synthesis. The number of times each value was cited and the percentage of the total sources is also presented.

<table>
<thead>
<tr>
<th>General Statements</th>
<th>Number of Responses</th>
<th>Per Cent of Total Responses</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. They provide first-hand experiences which increased the knowledge.</td>
<td>38</td>
<td>54.3</td>
</tr>
<tr>
<td>2. They stimulate interest, motivation and appreciation of some phase of science.</td>
<td>29</td>
<td>41.4</td>
</tr>
<tr>
<td>3. They give meaning to the learning process and the interrelationships of the subject matter.</td>
<td>24</td>
<td>34.3</td>
</tr>
<tr>
<td>4. They improve observation and perceptual skills.</td>
<td>18</td>
<td>25.7</td>
</tr>
<tr>
<td>5. They develop the individual's sense of responsibility, cooperation, leadership and social recognition.</td>
<td>15</td>
<td>21.4</td>
</tr>
<tr>
<td>6. They provide a channel for community-school relationships by students, parents or industry.</td>
<td>10</td>
<td>14.3</td>
</tr>
<tr>
<td>7. They provide an opportunity for discovery, inquiry and investigation.</td>
<td>9</td>
<td>12.9</td>
</tr>
<tr>
<td>8. They provide an opportunity for growth of desirable attitudes.</td>
<td>5</td>
<td>7.1</td>
</tr>
<tr>
<td>9. They provide an opportunity to develop an interest in out-of-school activities.</td>
<td>4</td>
<td>5.7</td>
</tr>
<tr>
<td>10. They assist in developing an interest in a vocation.</td>
<td>4</td>
<td>5.7</td>
</tr>
</tbody>
</table>
11. They provide an opportunity to improve teacher-student rapport. 3 4.3
12. They provide an opportunity for greater student participation. 3 4.3
13. They improve retention of knowledge. 2 2.9
14. They satisfy the urge of migratory instinct. 1 1.4
15. They provide the opportunity to learn the use of certain techniques. 1 1.4
16. They provide physical exercise. 1 1.4

The above statements represent values that are supposed to occur from the use of field trips. Sorrentino and Bell, (1970) compared this list with the experimental evidence available. They were able to find evidence to support only six of the above statements and only two of these by more than one experiment.

The contention that field trips increased knowledge (Statement 1) was supported by four experiments and refuted by one investigation. Statements 2, 3, 9, and 13 were supported by one experiment. Two investigators reported results dealing with attitude (Statement 8) with contradictory results. Out of a possible 112 combinations (16 statements times 7 experiments) only 11 of the combinations have been investigated. Of these, two show negative results for the use of field trips.

It is apparent that experimental data dealing with field trips are limited. While there is considerable literature concerning this subject, most of it is based on the writer's opinions and feelings.

It seems pertinent to this paper to review those studies which have an experimental basis. This section of the review will be
divided into two parts; those findings related to the use of field trips in science and those in other areas.

Use of Field Trips in Science

The use of field trips is often associated with the teaching of science. Atyeo, (1939) in his review of the use of field trips, reported that 80% of the schools which responded to the questionnaire indicated that field trips were used in their science courses.

The first attempt to experimentally evaluate the use of field trips in science was reported by Curtis, (1944). Using fifth grade students as his population, he measured the effectiveness of the use of field trips in a unit on erosion and soil conservation. The experiment was limited to 32 students. These were assigned into two treatment groups. Both groups received the same instruction in the classroom and both groups took the same field trips. However, the control group was tested immediately after the classroom presentation, while the experimental group was tested after the students had taken the field trips. Four teacher devised tests were used as the evaluative instruments. These included a multiple choice test to measure the students' ability to apply principles; a test using still pictures to measure students' understanding of the relationships between factors related to erosion and soil conservation; and a second multiple choice test which tested the students' ability to apply principles to an abstract situation. The final test was an oral test measuring the student's depth of understanding of the principles involved. This final test was evaluated in terms of the length of meaningful response.
made by the students.

The overall results showed a statistically significant difference in favor of the experimental group. On the two multiple choice tests the difference was significant at the .02 level. The test which utilized still pictures measured three different factors: application of principles, relationships between ideas related to soil conservation and the length of the sequence of relationships. On this test the difference was significant at the .001 level.

When the unit was divided into four sub units, an analysis of the two groups showed that individual sub units might vary from the results for the overall unit.

A non statistical approach was used to evaluate part four of the test. In this case, the criteria was the meaningful length of the student's reply. The mean length of response of the experimental group was almost twice as long as that of the control group.

While a significant difference was found in favor of the field trip group, the difference may not have been entirely due to the teaching method. The amount of instructional time received by the field trip group prior to the test was longer than that of the control group. While the amount of time spent in the classroom was the same for both groups, the experimental group spent an additional 22 minutes in the field for each hour spent in the classroom before taking the test. No attempt was made by Curtis to adjust for this difference in instructional time.

Development of scientific attitudes was the subject of an experiment conducted by Harvey (1951). Using 68 ninth grade general science
students as the population, a matched pair experiment was designed. Students were matched on the basis of their scores on the Otis Mental Achievement Test. These paired individuals were then randomly assigned to either the control or experimental groups. A pretest-posttest method was employed using the Caldwell and Curtis test (this instrument was designed by the authors of the text) and some teacher constructed items. The test was divided into two parts. One part was used as a pretest and the second part as the posttest. A t-test was used to determine if any statistically significant difference existed between the mean scores of the control and experimental groups.

During the experiment both the control and experimental groups were involved in the use of field trips. However, the experimental treatment group was administered the test after the field trip, while the control group was tested prior to the field trip.

The results of the experiment were statistically significant in favor of the experimental group. An analysis by sex indicated a difference in favor of the girls over the boys in the experimental group. No comparable difference was found in the control group.

An experiment designed to measure the difference in factual information gained by students who participated in field trips as opposed to those who used slides, in the study of geology, was conducted by Benz, (1962). The study was conducted using ninth grade students in a general science course. A control group and an experimental group were obtained by random assignment. The control group was composed of 42 boys and 16 girls, while the experimental group was composed of 39 boys and 16 girls. A pretest-posttest design was used.
The test was constructed by the investigator. Using the Sperman-Brown method, a split half reliability of 0.854 was obtained. The students in the experimental group were taken on field trips to view selected geological phenomena. The control group viewed the same sites using slides. A t-test was used to measure the mean difference in gain of the two groups.

The results showed a significant gain for both methods. When the two methods were compared, those in the field trip group showed a higher gain. However, it was statistically significant for only one class.

A similar experiment (Glenn, 1969) was conducted to compare the effectiveness of field trips to 35mm slides and classroom discussion in teaching observation and formulating hypotheses concerning geological features. Results from this experiment indicated that those students taught using 35mm slides scored significantly higher in formulating hypotheses than did those students who used either the field trip or discussion method. There was no significant difference between the discussion and field trip methods for this factor.

In terms of observation, 35mm slides and field trips both scored significantly higher than the discussion group. However, there was no difference between the slides and those students taking field trips.

Bennett, (1963) in a Ph. D. dissertation, compared the effectiveness of the field trip to the discussion method in teaching a two-week unit of ecology to seventh grade students. The unit of study was the class, as the students had been sectioned on the basis of their reading ability. The students were divided into a control group and an experi-
mental group. The classes in each group were further divided into a high and low group. This division was made on the basis of a class mean I. Q. of 111. The data were analyzed using analysis of variance with one covariant. The variables were treatments, intelligence groups and the interaction between treatment and intelligence.

The result obtained from the analysis indicated that both methods were effective means of teaching ecology. A comparison of the two methods did not indicate any significant difference as to treatment.

Use of Field Trips in Related Areas

The use of field trips is not limited to the field of science. Social science courses and classes in the practical arts have employed field trips as a means of providing concrete experiences relating to the classroom topics and in teaching processes.

The pioneer study of field trips was made in the area of geography (Crawford and Grinstead, 1930). The investigation was composed of four separate but closely related experiments. In the first two investigations a rotational design was used. In the last two investigations an equivalent group design was used. The students in the first two investigations were above average, having an I. Q. of 125 and over. The latter two groups had mean I. Q.'s of 109 and 105 respectively.

The results of the experiment were highly significant for the field trip method over the discussion method. A higher level of significance was achieved for the first two groups than for the latter two groups. While the cause for this was not investigated, the authors suggested this was probably due to the difference in I. Q.
The most thorough treatment of the topic has been done by Atyeo, (1939). The major portion of his work is descriptive in nature dealing with the history of field trips, values of field trips, and the procedure of using field trips. Reference to these aspects of the study have been made in other parts of this paper.

Atyeo conducted his investigation on the use of field trips using history as the subject matter area. A matched pair design was used. The individuals were matched using I. Q. scores and previous achievement in history as the criteria for matching. Thirty-two pairs were originally selected, with six pairs being dropped during the course of the experiment. Field trips were taken to museums to study selected topics in the unit. The control group was taught by the discussion method. A t-test was used to compare the means of the two groups. This experiment was carried out with two different groups of students.

A comparison of the experimental group to the control group indicated a significant difference for the experimental group. Atyeo used an item analysis to try to determine if the type of question the students could answer was related to a particular method. The findings indicated that the field trip was more effective where the student was required to make comparisons or show knowledge dealing with concrete objects. The discussion method proved better where memorization of such things as dates and names was expected. In terms of student interest, a third difference was also noted. Those students who had been exposed to field trips showed a greater interest in visiting the countries they studied, while the control group indicated a preference for reading about them.
The impact of an extended field trip was the subject of an investigation by Fraser, (1939). Utilizing 56 seniors as the treatment group, a field trip lasting eleven days was conducted. This trip dealt with the farming practices under the Tennessee Valley Association in terms of land utilization and public versus private ownership of utilities. The purpose of the study was to evaluate gains in knowledge, ability to identify problems related to management of the soil, application of principles in solving these problems and attitude change. A pretest-posttest design was employed. No control group was used in the experiment.

Each of the subject matter posttests showed a significant gain. When the students were divided into three groups on the basis of academic ability, the high group showed a greater gain than did either the middle or low group. The low ability group always showed the least gain, except in the area of identifying poor land practices. A correlation study was conducted to see if there was any significant change in student attitude, during the course of the experiments. While no significant change was found, some interesting trends occurred. The change that did occur was in a positive direction, based on Fraser's opinion. Those students who were in the upper one-third of the group showed the greatest change in attitude with the lowest group showing the least change.

Facilities of the Port Authority in New York City was used as the sites for field trips in a study conducted by Lansing and Cronholm, (1955). Students were randomly assigned to two groups. These students represent all four grades at the senior high school level.
Those students in the experimental group visited various places under the Port Authority control. Members of the control group used materials prepared by the Port Authorities. The same topics were covered by each group.

The results of the experiment were inconclusive. There was no statistically significant difference between the control group and the experimental group. A comparison of mean score showed the control groups achieved slightly higher than the experimental groups.

Use of field trips by students from nine Minneapolis public schools was the subject for an investigation by Clark, (1943). Three hundred and thirty-five sixth grade students from ten schools composed the sample. A rotational design was used so that each class had an opportunity to be a part of the control group and the experimental group. This design was used to equate differences in teacher and student characteristics. Over an eight week period the two groups covered four units. The first unit dealt with Egypt, the second with printing while transportation and communications comprised the last two units.

The results for each unit were determined. On the Egyptian unit the control group scored significantly higher (.01 level) than did the experimental group. Students with I. Q.'s of 110 or more profited more from the control method. No difference in achievement was reported based on sex. The experimental group was significantly higher than the control group on the printing unit. Again no difference in achievement based on sex was observed. A difference in achievement based on sex was reported for the transportation unit. Boys from both
the control and experimental groups achieved higher than did the girls. When the mean score for boys in the experimental group was compared to that of boys from the control group, a significant difference was obtained. The same comparison for girls revealed no significant difference. On the communications unit the experimental group showed a significant gain over the control group.

Clark studied one other aspect of learning, that of retention over a period of time. The result of this comparison was not significant either in terms of relative or absolute retention for either group.

The most recent investigation of field trips was conducted by McCaslin, (1970) when he studied their use in teaching vocational agriculture. Twelve Iowa high schools were selected for the study. These were assigned randomly to either the control group or the experimental group. The same materials were covered by each group, with the only difference being the experimental groups were taken on field trips in each of the four units. The four units were animal health, commercial fertilizers, small gasoline engines and farm credit. Those students in the experimental groups were involved in four field trips per unit or a total of sixteen field trips. McCaslin was interested in studying the effect on overall student achievement and on student achievement when certain covariant factors such as academic ability, interest, aptitude, socio-economic factors, school characteristics, teacher characteristics and home characteristics were controlled.

On the basis of his findings, McCaslin, (1970) concluded: (1) there is a significant gain in both control and experimental groups, (2) there is no significant difference in gain between control and
experimental in terms of overall achievement, (3) there are several covariant factors that affect achievements. These factors vary from unit to unit. Determining factors in three of the four units were interest in social service and semesters of vocational agriculture. Seven other factors, crop acres, scientific interest, total farm acres, pretest scores, agricultural interest, class size and clerical interest were factors in two of the units. It is of interest to note that intelligence was a factor in only one unit, farm credit.

A field trip consists of three distinct phases; the pre-field trip preparation, the field trip itself and finally the post field trip discussion. It has been commonly assumed by most writers that a thorough pre-field trip introduction was essential for an effective field trip.

An investigation to study this assumption was conducted by Delaney, (1967). This investigation compared the achievement on a multiple choice test of students who had been given only a cursory introduction to those who had a thorough introduction in which the objectives to be achieved and particular points to look for was stressed. Homogeneous grouping was employed in the schools which were used in the study. Grouping was on the basis of the California Mental Maturity Test and several reading scores. A matched group design using a posttest only design was utilized for evaluation of this investigation.

Those students in the experimental group who were classified as average and below average showed a significantly higher gain than did the control group. For those students in the high ability classes,
there was no significant difference in achievement based on method.

Eleven studies are cited in the above review of literature dealing directly with the use of field trips. These eleven studies tested one or more factors in relationship to the use of field trips. Ten different factors were evaluated by one or more investigators. The findings are far from conclusive for any of these factors.

The most commonly evaluated factor has been student achievement on factual information tests. Two aspects of this factor have been analyzed: (1) Are field trips an effective teaching method, and (2) Are field trips more effective than other teaching methods? The answer to the first question is yes. It seems logical that any well organized and planned teaching method is better than none at all. The answer to the second question is not so evident. It would appear the use of field trips is more effective than the discussion method. When the field trip is compared to methods which employ some form of media, the answer may well be no.

Results based on only one investigation support the use of field trips in teaching scientific attitudes and developing interest in the subject matter. While the difference was not significant, the worth of field trips as an agent in changing student attitude seemed to have some value. On the other hand, field trips were less effective or no better than 35mm slides in teaching hypothesis formation and observation.

Certain student characteristics, namely sex and intelligence, interacted with the use of field trips to affect student achievement. In the case of sex, the results were contradictory. In one study the
girls showed a higher level of achievement while in a second study the boys showed a greater gain. Such results suggest that other factors such as interest and previous experiences were operating. As might be expected, students with the greater amount of academic ability showed the greatest increase in achievement.
METHOD OF PROCEDURE

The purpose of this study was to compare the effectiveness of field trips to that of media in teaching selected environmental concepts. In particular the study was concerned with measuring the effects of field trips and media on student achievement and change in student attitude towards the environmental crisis. Four student characteristics; grade point average, background in science, intelligence as measured by I. Q. tests and previous knowledge or attitude were used as covariants. The relationship of sex to each of the two main criteria and the interaction of sex and treatment was also evaluated. Evaluation of the two main criteria and the effects of the interaction were made using teacher constructed instruments. The values for the covariants were obtained using standardized tests.

Objectives

The objectives for this study can be stated as follows:

1. To ascertain if there was any significant gain in information between the two groups of students when one was taught using field trips and the other was presented with similar experiences through the use of media.

2. To ascertain if there was any significant change in student attitude towards environmental problems between the two groups of students when one was taught using field trips and the other group was presented with similar experiences through the use of media.
Hypotheses

Specifically the following hypotheses were tested. The hypothe­ses have been stated in the null form to facilitate evaluation.

Four student characteristics; pretest scores, grade point aver­age, I. Q. scores and ITED science scores were used as covariants.

1. There is no significant difference in achievement between group means of students taught using field trips and those taught using media on selected environmental concepts as measured by the following achievement tests:
   a. Pretest
   b. Test on classification and energy
   c. Test on population and communities
   d. Test on environmental problems
   e. Posttest
   f. Retention test

2. There is no significant difference in achievement between group means of boys and girls.

3. There is no significant difference in attitude towards environmental problems between group means of students taught using field trips and those taught using media as measured by a teacher-constructed attitude scale.

4. There is no significant difference in attitude towards en­vironmental problems between group means of boys and girls.

5. There is no significant interaction between treatment and sex as measured by achievement scores.

6. There is no significant interaction between treatment and sex as measured by attitude scores.
Selection of the Sample

This investigation was conducted using the general biology students at Perry Community High School as the subjects. The Perry High School student population is drawn from the City of Perry and the surrounding agricultural area. It is typical of Iowa schools which draw from an area in which the main sources of employment are agriculture, light industry and business. Of the students entering Perry High School, over 97% complete the graduation requirements. Of these approximately 50% will continue their education at the college level while the other 50% may choose to enter a trade school, military service, an apprenticeship program, or go directly into the job market.

The subjects, for this study, consisted of 99 biology students. Biology is an elective course at Perry Community High School. Most students elect to take the course during their sophomore year although some juniors and seniors are usually enrolled. All students enrolled regardless of their class designation were included in the study.

Students were registered by the guidance department for biology during the spring of their freshman year. During the summer prior to the study, a number was assigned to each student. The students were then randomly assigned to either the field trip group or the media group by the use of a random numbers table.

For the purpose of this study, the field trip group was considered to be the experimental group, and students in the media group were designated as the control group.

Two teachers were involved in teaching the general biology course.
The investigator had full-time responsibility in this area and was responsible for developing and directing the program. A second instructor had part-time responsibilities in biology. The undergraduate major of both teachers was biology. Both teachers had a master's degree in science education, with the investigator's emphasis being biology and the other teacher's emphasis being earth science. Both teachers had more than eight years teaching experience.

Each teacher was involved in instructing both the experimental and control groups. The investigator was responsible for all large group presentations. In addition, he was responsible for four laboratory sections and eight small group sections. The second instructor was involved with two laboratories and two small groups. Because the small groups had been scheduled independently within the experimental-control group framework, it was possible for a student to have one instructor for laboratory work and the other one for small group.

In addition to the two regular staff members, a student teacher from Iowa State University was also utilized. This person had instructional duties under both teachers. Inasmuch as he worked with both teachers, he was able to function as a liaison person and help facilitate uniform instruction among all groups. The assignment of teachers to sections was made by the Westinghouse Learning Corporation Computer.

Student Schedule

Perry Community High School operated on a modular schedule, composed of 22 "mods" each day. Each "mod" was twenty minutes in length.
The four phases of instruction associated with modular scheduling were employed in the biology classes. These were large group instruction, small group instruction, laboratory instruction and independent study. In the spring of 1971 each teacher was asked to submit for the following year a time and phase plan for his classes. At that time, a decision was made to utilize the following time and activity structure.

<table>
<thead>
<tr>
<th>Learning Activity</th>
<th>Meetings per cycle</th>
<th>Mods per meeting</th>
<th>Number of students per section</th>
</tr>
</thead>
<tbody>
<tr>
<td>Large group instruction</td>
<td>1</td>
<td>3</td>
<td>99</td>
</tr>
<tr>
<td>Small group instruction</td>
<td>2</td>
<td>2</td>
<td>7-14</td>
</tr>
<tr>
<td>Laboratory instruction</td>
<td>2</td>
<td>3</td>
<td>16-22</td>
</tr>
<tr>
<td>Independent study</td>
<td>as needed</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

The above represents a student's schedule for one cycle. A cycle was composed of six days. The above schedule was repeated every six days. During each cycle an individual student receives 13 mods or 260 minutes of biology instruction.

The decision to investigate the effectiveness of field trips required some modification of the schedule. It was felt that adequate time should be provided to ensure the success of such trips. Consequently, those students assigned to the experimental group were placed in a single two-hour laboratory period. It was felt this would provide adequate time for most field exercises and still keep the instructional time the same for each group.

Large Group Instruction: Students from both the control and experimental groups were combined to form one large group section.
This phase of instruction was used primarily to:

1. Provide all students with the same general information pertaining to the topic under discussion.

2. Administer tests and other evaluative instruments.

Very little opportunity was provided for student participation. However, each student was provided with an outline of the material covered by the instructor. Materials appropriate to large group instruction were employed. For the purpose of this study, such materials were limited to worksheets, teacher prepared overlays and 16mm films which introduced general concepts.

**Laboratory Instruction:** The type of laboratory instruction received by each group was considered to be the treatment variable.

Those students in the experimental group were taken on eight field trips over a twelve week period. The following criteria were followed in selecting and planning the field trips:

1. Each field trip must be related to a particular topic in the unit. The field trip was to be the major method of teaching that particular topic.

2. Students must be provided with an opportunity to actively participate in the collection of data. All necessary data were collected in the field. In some cases it was necessary to complete the analysis using equipment in the laboratory.

3. The student should be fully aware of the purpose and intent of each field trip. Therefore, each student was provided with a copy of the exercise. This included the objectives of the field trip stated in behavioral terms, directions for completing the exercise.
and a list of student activities.

4. The place to be visited must be near enough to Perry Community High School to allow its completion in the two hour period provided. It was not considered necessary that every aspect of the field trip be completed during the two hour period. Consequently, some analysis of the materials collected were made by the students during their unstructured time.

One week after completion of the field trip, each student submitted a report dealing with the field trip. This report included the following:

1. A statement of the problem being studied.
2. The data collected.
3. Answers to the questions asked on the laboratory sheet.
4. Analysis of the data collected.
5. Interpretation and discussion of the data.

Students assigned to the control group studied the same topics, using the same behavioral objectives. However, the material was presented using media. Where it was possible, the students were shown slides of the same area visited by the experimental group. Samples from the areas visited were collected and provided to the control group. Necessary data concerning the areas was provided on accompanying worksheets. Equipment used to collect the data was demonstrated.

In addition to the slides, filmstrips, single concept films and 16mm films were utilized when appropriate. Worksheets were prepared for each of these, and the students were asked to complete these work-
sheets. Every effort was made to make the control group’s learning experience as interesting and meaningful as possible.

The control group was asked to use the data provided and develop a laboratory report in the same manner as the experimental group.

Small Group Instruction: Small group instruction was designed to be student centered. It provided an opportunity for students to examine problems that had arisen in either the large group instruction or in their laboratory work. The small groups provided an excellent opportunity for post laboratory discussion. At least one small group discussion per cycle was used to review the laboratory work previously completed. Problems were identified, and student ideas concerning these problems were discussed. Students were encouraged to ask questions and to participate in the discussions.

Independent Study: Students in both the control group and the experimental group were asked to complete one independent study project during the course of the investigation.

Content of the Course

The content for the course was selected by the author and reflects a synthesis of materials used by him during the past five years. Basic Ecology, by Ralph and Mildred Buchsbaum, was used as the student text.

Field exercises and laboratory exercises were constructed by the biology staff. Each of the exercises had been used at least once in previous courses. Mimeographed copies of each exercise were provided for the students prior to their laboratory period. (See Appendix B
Research has shown that best results are obtained (Delaney, 1967) when students are provided with detailed pre-field trip instructions. It has been the experience of the investigator that similar results are achieved when laboratory exercises are fully explained to the students prior to beginning work. Consequently, thorough pre-field trip and pre-laboratory instructions were provided.

Each exercise contained a list of behavioral objectives. Behavioral objectives were not new to the students; nevertheless, the importance of utilizing these objectives was stressed throughout the unit.

The study was divided into three units. The first unit dealt with four topics: classification, physical factors in the environment, components of an ecosystem and energy flow.

The concepts of population dynamics, community structure and succession formed the basis of Unit II. The interaction between organisms and the interaction between organisms and their physical environment was stressed.

The final unit dealt with succession, major biomes and current problems associated with the environmental crisis. The object of this unit was to identify environmental problems and to pose possible solutions. The students were asked to approach the problem from the point of view of, How can man best utilize his natural resources with the least damage to the other elements of the environment?
Method of Collecting Data

It was necessary to collect information concerning student achievement and possible change in attitude towards environmental problems. Information concerning certain student characteristics was also obtained in order to evaluate their effect on student achievement and attitude.

Standardized tests which measured student achievement or attitude relevant to this study were not available. Consequently, it was necessary to construct these instruments.

A fifty-eight question multiple choice test was constructed. Selection of items was made from tests previously used by the investigator, standardized tests, and from the BSCS test booklet accompanying the Blue Version *Molecules to Man* and from the BSCS test book devised for the Green Version.

Most of the questions had been used on previous tests and item analyses were available. However, the entire test had not been previously used. Therefore, it was decided that the test should be field-tested prior to its use as an evaluative instrument. Copies of the test were submitted to two ecologists at Iowa State University for their comments. The test was revised in terms of their suggestions. It was then administered to a group of students who had completed the general biology course at Perry Community High School the previous year. An analysis of the test was made using the facilities of the Iowa State University Computer Center. The final form was then prepared based on this analysis.

The statistical analysis of all achievement tests can be found
in Table 1 below. The values reported in this table were for all 99 students involved in the investigation. Consequently, these values may differ slightly from the values reported separately for the two instructional groups.

Table 1. Statistical Analysis of Achievement Tests

<table>
<thead>
<tr>
<th></th>
<th>Pretest</th>
<th>Unit I</th>
<th>Unit II</th>
<th>Unit III</th>
<th>Retention test</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of items</td>
<td>58</td>
<td>42</td>
<td>30</td>
<td>33</td>
<td>40</td>
</tr>
<tr>
<td>Reliability</td>
<td>.83</td>
<td>.69</td>
<td>.68</td>
<td>.75</td>
<td>.80</td>
</tr>
<tr>
<td>Mean</td>
<td>35.10</td>
<td>30.70</td>
<td>18.47</td>
<td>19.84</td>
<td>24.22</td>
</tr>
<tr>
<td>Variance</td>
<td>58.60</td>
<td>21.39</td>
<td>17.48</td>
<td>25.85</td>
<td>33.62</td>
</tr>
</tbody>
</table>

Pretest: The test was administered during the first large group instruction period to determine the current knowledge of the students in terms of environmental concepts.

Posttest: The same instrument that was used for the pretest was used for the posttest. The posttest was administered during large group instruction at the completion of the study. It was felt that because of the twelve week interval between pretest and posttest, there would be very little carry over between the two tests.

Achievement tests: Three achievement tests were administered during the course of the study. These were constructed by the staff and consisted of 42, 30 and 33 multiple choice items on Unit Tests I, II and III respectively.

Retention test: A test to measure student retention was constructed by selecting 40 items from the posttest and the three
achievement tests. This test was administered as part of the semester test. Approximately six weeks had elapsed between completion of the study and the retention test.

The pretest, posttest, retention test and the three achievement tests were scored and analyzed, using the facilities of the Iowa State Computation Center. The following analysis was provided for each test: raw score, T score, estimate of reliability, standard error of measurement, mean score, standard deviation, and correlation of items with student score. A copy of each test can be found in the Appendix A.

**Attitude Scale:** As no standardized attitude scale relating to environmental problems was available, it was necessary to construct the scale used in this study. A Likert-type scale was chosen. The decision to use this type over other possible scales was based on the fact that the Likert scale is easier to construct and provides results comparable to the other forms.

On the Likert scale a series of statements are present. The student is asked to respond to each item in terms of how strongly he feels about the item. For this study a five choice scale was used.

5. I strongly agree with the statement.
4. I agree with the statement.
3. I have no opinion about the statement.
2. I disagree with the statement.
1. I strongly disagree with the statement.

A preliminary scale composed of 40 statements was constructed and administered to a sample of students who had completed general biology
the previous year. Those statements which showed a strong positive correlation with each other were selected. Prior to the construction of the final scale, it was decided that the final scale must show a coefficient of $R = .90$ or greater. The reliability of the scale was computed using the following formula (Brown, 1970).

$$R = \frac{nr}{1 + (n-1)r}$$

where

- $n =$ the number of items
- $r =$ the average off diagonal correlation
- $R =$ the reliability of the test

From the original 40 items a final scale of 15 items was constructed. Some of the statements were given a negative weight and some were weighed positively. The students' answer sheets were evaluated using a program supplied by the Iowa State Computation Center.

It seemed desirable to determine if certain student characteristics had an effect on change in attitude or gain in achievement based on the method of instruction. Four characteristics were considered in this study. They were sex, intelligence, grade point average and background in science.

The Otis-Lennon I. Q. test is administered each year to the freshman and junior classes. It was felt that this score was a representative measure of the student's academic ability. I. Q. scores were available for all students involved in the investigation.

On the basis of their I. Q., students were placed in one of three groups.
Group 1 = I. Q.'s of 120 to 141
Group 2 = I. Q.'s of 111 to 119
Group 3 = I. Q.'s of 87 to 110

The Iowa Tests of Educational Development were administered to all Perry High School students during the last week in September. The raw score obtained by each student on test number 3, Background in Science, was used as a measure of the student's science background. The percentile ranking based on these raw scores was used to divide the students into three groups.

Group 1 = 86 - 99 percentile
Group 2 = 50 - 85 percentile
Group 3 = 6 - 49 percentile

The students were also divided into three groups based on their grade point average (GPA). Grade point averages had been calculated through the last previous school year. Thus the GPA for a minimum of two semesters was available for all students. The following three groups were identified:

Group 1 = A GPA of 2.80-4.00
Group 2 = A GPA of 2.01-2.79
Group 3 = A GPA of 1.12-2.00

The basis for dividing each of the treatment groups into the three sub-groups was an arbitrary decision. However, such a division did provide an average group, an above average group and a group which might be classified as a superior group. These groups reflected to some degree the natural distribution of the students within the classes.
Statistical Design

A Pretest-Posttest control group design was selected for this investigation. Two equivalent groups were obtained by randomly assigning students to either a control or experimental group. Using Campbell's and Stanley's (1963) notation, the design can be represented as follows: 

\[
\begin{align*}
R & \quad O_1 \quad X \quad O_2 \\
R & \quad O_3 \quad O_4
\end{align*}
\]

- \( R \) = indicates the students were randomly assigned
- \( O_1 - O_3 \) = observations made prior to the treatment
- \( O_2 - O_4 \) = observations made after the treatment
- \( X \) = the experimental treatment

It can be assumed that randomization produces equivalent groups. To test this assumption, a t-test was employed to evaluate the difference in group means on the pretests.

\[
t = \frac{\bar{X}_1 - \bar{X}_2}{\sqrt{\frac{s^2_1}{n_1} + \frac{s^2_2}{n_2}}} \sqrt{\frac{1}{n_1} + \frac{1}{n_2}}
\]

In addition to the t-test, an analysis of variance and analysis of covariance were utilized as the statistical tools to compare the two groups. The following model for the analysis of variance was used (Snedecor and Cochran, 1967):

\[
Y_{ijk} = U + A_{ij} + B_{ij} + AB_{ij} + E_{ijk}
\]

where

- \( Y \) = the student's score
- \( U \) = the grand mean
A = the contribution due to the treatment effect
B = the contribution due to sex
AB = the contribution due to the interaction of sex and treatment
E = the random error associated with the student's score

The model used for the analysis of covariance was as follows (Snedecor and Cochran, 1967):

\[ Y_{ijk} = u + A_{ij} + B_{ij} + AB_{ij} + C_1 x_1 + C_2 x_2 \ldots + C_4 x_4 + E_{ijk} \]

where

- \( Y \) = the student's score
- \( u \) = the grand mean
- \( A \) = the contribution due to the treatment effect
- \( B \) = the contribution due to sex
- \( AB \) = the contribution due to the interaction of treatment and sex
- \( C_1 C_2 \ldots C_4 \) = regression coefficients, where \( C = 1 - 4 \)
- \( x_1 x_2 \ldots x_4 \) = the deviation of any x covariant from the x covariant mean, where \( x = 1 - 4 \)

These symbols were used for both models:

- \( i \) = the treatment effect, \( i = 1, 2 \)
- \( j \) = the sex of the student, \( j = 1, 2 \)
- \( k \) = a particular student in the \( i j \) cell

Evaluation of the results obtained from the analysis of variance, analysis of covariance and t-tests were made using a two tailed F test and t-test at the .05 and .01 levels.
FINDINGS

This study was designed to test the effectiveness of field trips as compared to the use of media in teaching selected environmental concepts. Two dependent variables, student achievement and student attitude, were analyzed. In addition, the interaction between the two treatments and the sex of the student was investigated. The two dependent variables were analyzed using pretest scores, I. Q., grade point average and background in science as covariants.

The original population was composed of 104 sophomore biology students. These students had elected during their freshman year to take biology. They were randomly assigned to one of the two treatment groups. The control group (non-field trip) was composed of 53 students while 51 students were placed in the experimental group (field trip). During the course of the investigation, five students dropped the course. Four of these were from the experimental group and one was from the control group. The data for these five students were reviewed and appeared to reflect average values for the variables being considered. While the loss of any individuals from the groups affect the results, it was felt this loss would be minimal and would not substantially affect the outcome of the investigation. Consequently, the data for these five students were removed from all test results. This provided a total N of 99, with 52 students being in the control group and 47 in the experimental group.

The effectiveness of the randomization process was ascertained using a t-test for each of the four covariants. The t model selected was dependent upon the absence or presence of homogeneity of variance.
between the two groups. An F test was calculated to determine if such homogeneity of variance did exist between the two groups.

\[ F = \frac{\text{Larger Variance}}{\text{Smaller Variance}} \]

Homogeneity of variance was found to exist for all covariants except the pretest achievement scores. A separate t model was utilized to test the difference for this variable.

\[ t = \frac{\bar{x}_1 - \bar{x}_2}{\sqrt{\frac{s_1^2}{n_1} + \frac{s_2^2}{n_2}}} \]

The pooled t model was used for the other covariants.

\[ t = \frac{\bar{x}_1 - \bar{x}_2}{\sqrt{\left(\frac{\sum x_1^2}{n_1} + \frac{\sum x_2^2}{n_2 - 2}\right)\left(\frac{1}{n_1} + \frac{1}{n_2}\right)}} \]

The results of these analyses are indicated in Table 2. The t values reported in Table 2 were all below the .05 level of significance, with only the t value of 1.689 for pretest attitude approaching the .05 level of significance. However, inspection of the variance column showed that the variance of the control group was consistently larger than the experimental group.
Table 2. Comparison of Control Group to Experimental Group by Covariants

<table>
<thead>
<tr>
<th>Group</th>
<th>Mean</th>
<th>Variance</th>
<th>t Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pretest Control</td>
<td>23.31</td>
<td>81.71</td>
<td>0.079</td>
</tr>
<tr>
<td>Pretest Exp.</td>
<td>23.43</td>
<td>33.42</td>
<td></td>
</tr>
<tr>
<td>I. Q. Control</td>
<td>113.60</td>
<td>174.64</td>
<td>0.729</td>
</tr>
<tr>
<td>I. Q. Exp.</td>
<td>111.79</td>
<td>127.08</td>
<td></td>
</tr>
<tr>
<td>GPA Control</td>
<td>2.49</td>
<td>0.53</td>
<td>0.218</td>
</tr>
<tr>
<td>GPA Exp.</td>
<td>2.46</td>
<td>0.35</td>
<td></td>
</tr>
<tr>
<td>ITED Control^</td>
<td>19.19</td>
<td>30.59</td>
<td>1.117</td>
</tr>
<tr>
<td>ITED Exp.^</td>
<td>20.53</td>
<td>40.82</td>
<td></td>
</tr>
<tr>
<td>Pretest Attitude</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Control</td>
<td>57.46</td>
<td>37.86</td>
<td>1.692</td>
</tr>
<tr>
<td>Pretest Attitude</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Experimental</td>
<td>55.13</td>
<td>59.20</td>
<td></td>
</tr>
</tbody>
</table>

^Test Number 3 ITED Background in Natural Science

The distribution of students for the covariants I. Q., G. P. A. and science background showed two different patterns based on the ability groupings indicated on page 41. The control group generally had a larger number of students at both ends of the distribution, while the experimental group seemed to be clustered nearer the mean. Distribution for these covariants is shown in Table 3.
Table 3. Distribution of Students With Each Covariant

<table>
<thead>
<tr>
<th>Covariants</th>
<th>Control Group&lt;sup&gt;a&lt;/sup&gt;</th>
<th>Experimental Group&lt;sup&gt;a&lt;/sup&gt;</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>I. Q.</td>
<td>15</td>
<td>14</td>
</tr>
<tr>
<td>GPA</td>
<td>19</td>
<td>23</td>
</tr>
<tr>
<td>Science Background</td>
<td>22</td>
<td>13</td>
</tr>
</tbody>
</table>

<sup>a</sup> Group 1 = superior students, Group 2 = above average students, Group 3 = average students as defined for each covariant on page 41.

While the mean differences were slight, the difference in variance and distribution suggested that the four covariants: pretest scores, I. Q. scores, grade point average and background in science, might significantly affect any comparisons of the two groups. Consequently, an analysis of covariance was utilized in comparing the two treatment groups.

A correlation matrix was constructed for both the experimental and control group. These are shown in Tables 6 and 7. The level of significance is indicated for each correlation.

Finally a comparison of the difference in achievement scores for each group was made, using t-tests, analysis of variance and analysis of covariance.

Comparison of Pretest Scores to Posttest Scores

To determine to what extent the two teaching methods had been successful, a t-test was conducted between the pretest and posttest scores. As pretest and posttest scores for the same individual can be expected to have a positive correlation, a t model was selected which would correct for this factor.
\[ t = \sqrt{\frac{n_1}{s_1^2} + \frac{n_2}{s_2^2} - 2r \left( \frac{s_1}{\sqrt{n_1}} \right) \left( \frac{s_2}{\sqrt{n_2}} \right)} \]

The degrees of freedom for this model are the number of pairs minus 1.

Table 4. Pretest-Posttest Achievement Experimental Group

<table>
<thead>
<tr>
<th></th>
<th>Pretest</th>
<th>Posttest</th>
<th>t value^a</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean</td>
<td>23.43</td>
<td>36.31</td>
<td></td>
</tr>
<tr>
<td>Variance</td>
<td>33.42</td>
<td>38.96</td>
<td></td>
</tr>
<tr>
<td>N number</td>
<td>47</td>
<td>47</td>
<td>10.40**</td>
</tr>
<tr>
<td>Correlation</td>
<td></td>
<td></td>
<td>0.510</td>
</tr>
</tbody>
</table>

^a .01 \text{t}_{46} = 2.692 In the expression .01 \text{t}_{46} = 2.015 the .01 indicates the level of significance and the 46 indicates the degrees of freedom. Similar notation is used in other subsequent tables.

** Denotes a highly significant t value at the .01 level of confidence. This notation is used in other subsequent t tables.

Table 5. Pretest-Posttest Achievement Control Group

<table>
<thead>
<tr>
<th></th>
<th>Pretest</th>
<th>Posttest</th>
<th>t value^a</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean</td>
<td>23.31</td>
<td>34.85</td>
<td></td>
</tr>
<tr>
<td>Variance</td>
<td>81.71</td>
<td>52.45</td>
<td>7.17**</td>
</tr>
<tr>
<td>N number</td>
<td>52</td>
<td>52</td>
<td></td>
</tr>
<tr>
<td>Correlation</td>
<td></td>
<td></td>
<td>0.210</td>
</tr>
</tbody>
</table>

^a .01 \text{t}_{51} = 2.678
Table 6. Correlation for all Variables Control Group (n=52)

<table>
<thead>
<tr>
<th></th>
<th>Pretest</th>
<th>Posttest</th>
<th>Unit I</th>
<th>Unit II</th>
<th>Unit III</th>
<th>Pretest Attitude</th>
<th>Posttest Attitude</th>
<th>Attitude To Class</th>
<th>L. Q. Scores</th>
<th>GPA</th>
<th>ITED Science Background</th>
<th>Difference Pre-Posttest</th>
<th>Sex</th>
<th>Difference Attitude Scores</th>
<th>Retention Scores</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pretest</td>
<td>1.000</td>
<td>0.210</td>
<td>0.365**</td>
<td>0.132</td>
<td>0.443**</td>
<td>0.149</td>
<td>0.026</td>
<td>0.041</td>
<td>0.492**</td>
<td>0.367**</td>
<td>0.660**</td>
<td>-0.146</td>
<td>-0.134</td>
<td>-0.191</td>
<td>0.704**</td>
</tr>
<tr>
<td>Posttest</td>
<td></td>
<td>1.000</td>
<td>0.631**</td>
<td>0.590**</td>
<td>0.662**</td>
<td>0.494**</td>
<td>0.289**</td>
<td>0.140</td>
<td>0.656**</td>
<td>0.762**</td>
<td>0.709**</td>
<td>0.607**</td>
<td>0.035</td>
<td>-0.074</td>
<td>0.726**</td>
</tr>
<tr>
<td>Unit I</td>
<td></td>
<td></td>
<td>1.000</td>
<td>0.625**</td>
<td>0.703**</td>
<td>0.487**</td>
<td>0.294*</td>
<td>0.175</td>
<td>0.663**</td>
<td>0.762**</td>
<td>0.734**</td>
<td>0.093</td>
<td>-0.122</td>
<td>-0.168</td>
<td>0.724**</td>
</tr>
<tr>
<td>Unit II</td>
<td></td>
<td>0.132</td>
<td></td>
<td>0.583**</td>
<td>0.573**</td>
<td>0.454**</td>
<td>0.322*</td>
<td>0.172</td>
<td>0.551**</td>
<td>0.572**</td>
<td>0.603**</td>
<td>0.129</td>
<td>0.032</td>
<td>-0.113</td>
<td>0.650*</td>
</tr>
<tr>
<td>Unit III</td>
<td></td>
<td>0.443**</td>
<td>0.662**</td>
<td></td>
<td>1.000</td>
<td>0.592**</td>
<td></td>
<td></td>
<td>0.685**</td>
<td>0.682**</td>
<td>0.680**</td>
<td></td>
<td></td>
<td></td>
<td>0.680**</td>
</tr>
<tr>
<td>Pretest Attitude</td>
<td></td>
<td>0.149</td>
<td>0.494**</td>
<td>0.487**</td>
<td>0.454**</td>
<td></td>
<td></td>
<td></td>
<td>0.343*</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Posttest Attitude</td>
<td></td>
<td>0.026</td>
<td>0.289**</td>
<td>0.294*</td>
<td>0.322*</td>
<td></td>
<td></td>
<td></td>
<td>0.516**</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Attitude To Class</td>
<td></td>
<td>0.041</td>
<td>0.140</td>
<td>0.175</td>
<td>0.172</td>
<td></td>
<td></td>
<td></td>
<td>0.090</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>0.029</td>
</tr>
<tr>
<td>L. Q. Scores</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>0.680**</td>
<td></td>
<td></td>
<td></td>
<td>0.709**</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>GPA</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>0.734**</td>
<td></td>
<td></td>
<td></td>
<td>0.603**</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>ITED Science Background</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>0.603**</td>
<td></td>
<td></td>
<td></td>
<td>0.680**</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Difference Pre-Posttest</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>0.680**</td>
<td></td>
<td></td>
<td></td>
<td>0.586**</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sex</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>0.709**</td>
<td></td>
<td></td>
<td></td>
<td>0.680**</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Difference Attitude Scores</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>0.734**</td>
<td></td>
<td></td>
<td></td>
<td>0.586**</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Retention Scores</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>0.603**</td>
<td></td>
<td></td>
<td></td>
<td>0.709**</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*Denotes an r value .273 which is significant at the .05 level.
**Denotes an r value .354 which is significant at the .01 level.
<table>
<thead>
<tr>
<th>Retention Score</th>
<th>Difference Attitude Score</th>
<th>Sex</th>
<th>ITED</th>
<th>Science Background</th>
<th>GPA</th>
<th>I.Q. Scores</th>
<th>Attitude To Class</th>
<th>Posttest</th>
<th>Attitude To Class</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.273</td>
<td>0.192</td>
<td></td>
<td>0.733</td>
<td>0.726</td>
<td>0.7244</td>
<td>0.191</td>
<td>0.240</td>
<td>1.000</td>
<td>0.352*</td>
</tr>
<tr>
<td>0.005</td>
<td>0.109</td>
<td></td>
<td>0.031</td>
<td>0.017</td>
<td>0.027</td>
<td>0.036**</td>
<td>0.020</td>
<td>1.000</td>
<td>-0.066</td>
</tr>
<tr>
<td>0.000</td>
<td>0.070</td>
<td></td>
<td>0.076</td>
<td>0.017</td>
<td>0.194</td>
<td>0.066</td>
<td>0.000</td>
<td>1.000</td>
<td>0.376**</td>
</tr>
<tr>
<td>0.000</td>
<td>0.065</td>
<td></td>
<td>0.066</td>
<td>0.672**</td>
<td>0.000</td>
<td>0.203</td>
<td>0.125</td>
<td>1.000</td>
<td>0.000</td>
</tr>
<tr>
<td>0.000</td>
<td>0.000</td>
<td></td>
<td>0.010</td>
<td>0.000</td>
<td>0.000</td>
<td>-0.041</td>
<td>1.000</td>
<td>1.000</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Table 7. Correlation for all Variables Experimental Group (n=47)

<table>
<thead>
<tr>
<th></th>
<th>Pretest</th>
<th>Posttest</th>
<th>Unit I</th>
<th>Unit II</th>
<th>Unit III</th>
<th>Pretest Attitude</th>
<th>Posttest Attitude</th>
<th>Attitude To Class</th>
<th>I. Q. Scores</th>
<th>GPA</th>
<th>ITED Science Background</th>
<th>Difference Pre-Posttest</th>
<th>Sex</th>
<th>Difference Attitude Scores</th>
<th>Retention Scores</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pretest</td>
<td>1.000</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Posttest</td>
<td>0.510**</td>
<td>1.000</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Unit I</td>
<td>0.523**</td>
<td>0.645**</td>
<td>1.000</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Unit II</td>
<td>0.626**</td>
<td>0.707**</td>
<td>0.649**</td>
<td>1.000</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Unit III</td>
<td>0.403**</td>
<td>0.709**</td>
<td>0.420**</td>
<td>0.693**</td>
<td>1.000</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pretest Attitude</td>
<td>0.254</td>
<td>0.211</td>
<td>0.128</td>
<td>0.252</td>
<td>0.097</td>
<td>1.000</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Posttest Attitude</td>
<td>0.313*</td>
<td>0.382**</td>
<td>0.221</td>
<td>0.331**</td>
<td>0.180</td>
<td>0.308**</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Attitude To Class</td>
<td>0.320*</td>
<td>0.315*</td>
<td>0.248</td>
<td>0.276**</td>
<td>0.359**</td>
<td>0.180</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>I. Q. Scores</td>
<td>0.474**</td>
<td>0.554**</td>
<td>0.483**</td>
<td>0.520**</td>
<td>0.342**</td>
<td>0.167</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>GPA</td>
<td>0.586**</td>
<td>0.584**</td>
<td>0.573**</td>
<td>0.614**</td>
<td>0.363**</td>
<td>0.249</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>ITED Science</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Background</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Difference</td>
<td>-0.436**</td>
<td>0.552**</td>
<td>0.169</td>
<td>0.133</td>
<td>0.352**</td>
<td>-0.025</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sex</td>
<td>-0.013</td>
<td>0.142</td>
<td>0.173</td>
<td>0.197</td>
<td>0.164</td>
<td>0.190</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Difference</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Attitude Scores</td>
<td>0.029</td>
<td>0.145</td>
<td>0.103</td>
<td>0.012</td>
<td>0.037</td>
<td>-0.536</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Retention Scores</td>
<td>0.494**</td>
<td>0.755**</td>
<td>0.675**</td>
<td>0.674**</td>
<td>0.653**</td>
<td>0.146</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

* Denotes an r value N of .288 which is significant at the .05 level.
** Denotes an r value N of .373 which is significant at the .01 level.
<table>
<thead>
<tr>
<th></th>
<th>Posttest Attitude</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Attitude To Class</td>
<td></td>
<td></td>
</tr>
<tr>
<td>I. Q. Scores</td>
<td></td>
<td></td>
</tr>
<tr>
<td>GPA</td>
<td></td>
<td></td>
</tr>
<tr>
<td>ITED Science Back-</td>
<td></td>
<td></td>
</tr>
<tr>
<td>ground</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Difference Pre-Post-</td>
<td></td>
<td></td>
</tr>
<tr>
<td>test</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sex</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Difference Attitude</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Score</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Retention Score</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<p>| | | | | | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>0.415**</td>
<td>0.580**</td>
<td>-0.117</td>
<td>0.097</td>
<td>0.177</td>
<td>0.322*</td>
</tr>
<tr>
<td></td>
<td>0.303*</td>
<td>-0.026</td>
<td>-0.012</td>
<td>0.019</td>
<td>0.290</td>
<td>0.191</td>
</tr>
<tr>
<td></td>
<td>0.489***</td>
<td>0.026</td>
<td>0.120</td>
<td>0.120</td>
<td>0.452**</td>
<td>0.343*</td>
</tr>
<tr>
<td></td>
<td>0.624***</td>
<td>0.235</td>
<td>-0.235</td>
<td>0.043</td>
<td>0.343*</td>
<td>0.179</td>
</tr>
<tr>
<td></td>
<td>0.159</td>
<td>0.133</td>
<td>0.179</td>
<td>0.133</td>
<td>1.000</td>
<td></td>
</tr>
<tr>
<td></td>
<td>0.311*</td>
<td>0.009</td>
<td>0.162</td>
<td>0.162</td>
<td>1.000</td>
<td></td>
</tr>
<tr>
<td></td>
<td>0.144</td>
<td>0.032</td>
<td>1.000</td>
<td>0.032</td>
<td>1.000</td>
<td></td>
</tr>
</tbody>
</table>
The t values reported in Tables 4 and 5 were significant beyond the .01 level. This would indicate that both the use of field trips and the use of media can be employed successfully in teaching selected environmental concepts.

Comparison of Field Trips to Media

Comparison of two or more treatments has commonly been made using either a t-test or an analysis of covariance (Campbell and Stanley, 1963). When a t-test is used, the test is applied to the mean gain scores. The analysis of covariance is used to test the mean posttest scores, using the pretest and any other variables the investigator feels are significant, as covariants. These two tests along with an analysis of variance were employed in comparing the two treatments.

The analysis of covariance is a more powerful statistical tool than the other two tests. For this reason it was used as the major test of significance.

Four covariants were used in the analysis of covariance. These were pretest scores, I. Q. scores, grade point average and scores from the Science Background Test of the Iowa Test of Educational Development. Two independent variables, treatment and sex, were considered along with the interaction of treatment and sex.
Table 8. Analysis of Variance: Posttest Scores

<table>
<thead>
<tr>
<th>Source</th>
<th>df</th>
<th>SS</th>
<th>MS</th>
<th>F-Ratio^a</th>
</tr>
</thead>
<tbody>
<tr>
<td>Treatment</td>
<td>1</td>
<td>53.56</td>
<td>56.56</td>
<td>1.17</td>
</tr>
<tr>
<td>Sex</td>
<td>1</td>
<td>14.52</td>
<td>14.51</td>
<td>0.31</td>
</tr>
<tr>
<td>Treatment by Sex</td>
<td>1</td>
<td>106.94</td>
<td>106.94</td>
<td>2.33</td>
</tr>
<tr>
<td>Residual</td>
<td>95</td>
<td>4345.51</td>
<td>42.74</td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>98</td>
<td>4520.54</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

^a .05^F 1,95 = 3.94 In the expression .05^F 1,95 = 3.94 the .05 indicates the level of significance and the 1,95 indicates the degrees of freedom. Similar notation is used in other subsequent F tables.

When posttest achievement scores were analyzed (Tables 8 and 9), no significant difference was found between treatments or between boys and girls. Nor was there a significant interaction between treatment and sex. When the four covariants were used, the results were similar with the exception that a significant interaction between treatment and sex was obtained.

Table 9. Analysis of Covariance: Posttest Scores

<table>
<thead>
<tr>
<th>Source</th>
<th>df</th>
<th>SS</th>
<th>MS</th>
<th>F-Ratio^a</th>
</tr>
</thead>
<tbody>
<tr>
<td>Treatment</td>
<td>1</td>
<td>53.56</td>
<td>53.56</td>
<td>3.42</td>
</tr>
<tr>
<td>Sex</td>
<td>1</td>
<td>14.51</td>
<td>14.51</td>
<td>0.92</td>
</tr>
<tr>
<td>Treatment by Sex</td>
<td>1</td>
<td>106.94</td>
<td>106.94</td>
<td>6.84*</td>
</tr>
<tr>
<td>Residual</td>
<td>91</td>
<td>1422.61</td>
<td>15.63</td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>94</td>
<td>1597.64</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

^a .05^F 1,91 = 3.95 .01^F 1,91 = 6.93

* Denotes a significant F value at the .05 level of confidence. This notation is used in other subsequent F tables.
Based on the analysis of the posttest one would conclude that there is no significant difference between the two treatments in teaching selected environmental concepts. Nor is there any significant difference in achievement between boys and girls in learning selected environmental concepts. Specifically, one would fail to reject hypotheses numbers 1 and 2.

1. There is no significant difference in achievement between the group means of students taught using field trips, and those taught using media on selected environmental concepts.

2. There is no significant difference in achievement between the group means of boys and girls.

An inspection of the means for the two treatment groups revealed that the experimental group showed a mean of 36.32 as compared to a mean of 34.85 for the control group. An analysis of the posttest scores on the basis of the sub-groups listed on page 41 was made (Tables 10, 11 and 12) to determine if this difference was related to any particular segment of the population.
Table 10. Comparison of Posttest Scores based on GPA

<table>
<thead>
<tr>
<th>Group</th>
<th>X</th>
<th>S²</th>
<th>n</th>
<th>t Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Experimental</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Superior</td>
<td>43.33</td>
<td>10.50</td>
<td>9</td>
<td>2.346*</td>
</tr>
<tr>
<td>Control</td>
<td>38.79</td>
<td>48.95</td>
<td>19</td>
<td></td>
</tr>
<tr>
<td>Experimental</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Above Average</td>
<td>35.38</td>
<td>30.49</td>
<td>26</td>
<td>0.782</td>
</tr>
<tr>
<td>Control</td>
<td>34.09</td>
<td>40.36</td>
<td>23</td>
<td></td>
</tr>
<tr>
<td>Experimental</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Average</td>
<td>33.08</td>
<td>32.27</td>
<td>12</td>
<td>1.668</td>
</tr>
<tr>
<td>Control</td>
<td>29.10</td>
<td>29.66</td>
<td>10</td>
<td></td>
</tr>
</tbody>
</table>

* Denotes a significant t value at the .05 level of confidence. This notation is used in all subsequent t tables.

Table 11. Comparison of Posttest Scores based on I. Q.

<table>
<thead>
<tr>
<th>Group</th>
<th>X</th>
<th>S²</th>
<th>n</th>
<th>t Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Experimental</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Superior</td>
<td>41.22</td>
<td>30.44</td>
<td>9</td>
<td>0.158</td>
</tr>
<tr>
<td>Control</td>
<td>41.53</td>
<td>16.84</td>
<td>15</td>
<td></td>
</tr>
<tr>
<td>Experimental</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Above Average</td>
<td>38.00</td>
<td>20.80</td>
<td>16</td>
<td>1.990</td>
</tr>
<tr>
<td>Control</td>
<td>34.36</td>
<td>39.48</td>
<td>14</td>
<td></td>
</tr>
<tr>
<td>Experimental</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Average</td>
<td>33.09</td>
<td>35.52</td>
<td>22</td>
<td>1.262</td>
</tr>
<tr>
<td>Control</td>
<td>30.78</td>
<td>39.63</td>
<td>23</td>
<td></td>
</tr>
</tbody>
</table>
Table 12. Comparison of Posttest Scores based on Science Background

<table>
<thead>
<tr>
<th>Group</th>
<th>$\bar{X}$</th>
<th>$s^2$</th>
<th>n</th>
<th>t Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Experimental Superior</td>
<td>41.64</td>
<td>20.09</td>
<td>14</td>
<td>0.4867</td>
</tr>
<tr>
<td>Control Superior</td>
<td>40.86</td>
<td>23.08</td>
<td>22</td>
<td></td>
</tr>
<tr>
<td>Experimental Above Average</td>
<td>36.10</td>
<td>24.35</td>
<td>20</td>
<td>1.8020</td>
</tr>
<tr>
<td>Control Above Average</td>
<td>32.85</td>
<td>27.81</td>
<td>13</td>
<td></td>
</tr>
<tr>
<td>Experimental Average</td>
<td>30.92</td>
<td>24.41</td>
<td>13</td>
<td>1.3307</td>
</tr>
<tr>
<td>Control Average</td>
<td>28.59</td>
<td>21.38</td>
<td>17</td>
<td></td>
</tr>
</tbody>
</table>

Only those students in the superior sub-group, based on grade point average, showed a significant t value. In all other sub-groups the t values failed to reach the .05 level of significance.

A significant F value at the .05 level was obtained on the post-test for the interaction between treatment and sex. Inspection of the adjusted means (Table 13) for treatment by sex reveals that boys in the experimental group showed a higher adjusted mean achievement score than those in the control group. The girls in the experimental group showed only a slightly higher adjusted mean score than did the girls in the control group.
Table 13. Mean Posttest Achievement Scores

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Boys</th>
<th>Girls</th>
</tr>
</thead>
<tbody>
<tr>
<td>Experimental Groups</td>
<td>37.77</td>
<td>35.33</td>
</tr>
<tr>
<td>Control Group</td>
<td>34.48</td>
<td>35.06</td>
</tr>
</tbody>
</table>

The interaction between treatment and sex can be represented graphically.

Figure 1. Interaction Between Treatment and Sex

The F value of 6.84 is sufficient to allow the rejection of hypothesis number 5: There is no significant interaction between treatment and sex as measured by posttest achievement scores. The hypothesis was rejected at the .05 level when the achievement scores were adjusted for the four covariants.

The alternative hypothesis is: There is a significant interaction between treatment and sex. This interaction occurred between the experimental treatment and boys. Specifically, boys from the
experimental group showed higher posttest achievement scores than did boys from the control group.

Comparison of Student Achievement by Units

It seemed possible that some of the environmental concepts being taught were more dependent upon field trip experiences than were other concepts. An analysis was made for each of the three units.

Table 14. Analysis of Variance: Unit I Achievement Scores

<table>
<thead>
<tr>
<th>Source</th>
<th>df</th>
<th>SS</th>
<th>MS</th>
<th>F-Ratio&lt;sup&gt;a&lt;/sup&gt;</th>
</tr>
</thead>
<tbody>
<tr>
<td>Treatment</td>
<td>1</td>
<td>14.86</td>
<td>14.86</td>
<td>0.678</td>
</tr>
<tr>
<td>Sex</td>
<td>1</td>
<td>0.13</td>
<td>0.13</td>
<td>0.006</td>
</tr>
<tr>
<td>Treatment by Sex</td>
<td>1</td>
<td>49.64</td>
<td>49.64</td>
<td>2.266</td>
</tr>
<tr>
<td>Residual</td>
<td>95</td>
<td>2081.01</td>
<td>21.91</td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>98</td>
<td>2145.64</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<sup>a</sup> .05<sup>F</sup> 1,95 = 3.94  .05<sup>F</sup> 1,95 = 6.91

Table 15. Analysis of Variance: Unit II Achievement Scores

<table>
<thead>
<tr>
<th>Source</th>
<th>df</th>
<th>SS</th>
<th>MS</th>
<th>F-Ratio&lt;sup&gt;a&lt;/sup&gt;</th>
</tr>
</thead>
<tbody>
<tr>
<td>Treatment</td>
<td>1</td>
<td>35.17</td>
<td>35.17</td>
<td>2.191</td>
</tr>
<tr>
<td>Sex</td>
<td>1</td>
<td>4.10</td>
<td>4.10</td>
<td>0.256</td>
</tr>
<tr>
<td>Treatment by Sex</td>
<td>1</td>
<td>79.76</td>
<td>79.76</td>
<td>4.967*</td>
</tr>
<tr>
<td>Residual</td>
<td>95</td>
<td>1524.99</td>
<td>16.05</td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>98</td>
<td>1644.02</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<sup>a</sup> .05<sup>F</sup> 1,95 = 3.94  .05<sup>F</sup> 1,95 = 6.91
Table 16. Analysis of Variance: Unit III Achievement Scores

<table>
<thead>
<tr>
<th>Source</th>
<th>df</th>
<th>SS</th>
<th>MS</th>
<th>F-Ratio$^a$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Treatment</td>
<td>1</td>
<td>0.15</td>
<td>0.15</td>
<td>0.01</td>
</tr>
<tr>
<td>Sex</td>
<td>1</td>
<td>4.14</td>
<td>4.14</td>
<td>0.18</td>
</tr>
<tr>
<td>Treatment by Sex</td>
<td>1</td>
<td>12.83</td>
<td>12.83</td>
<td>0.55</td>
</tr>
<tr>
<td>Residual</td>
<td>95</td>
<td>2226.96</td>
<td>23.44</td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>98</td>
<td>2244.08</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

$^a$ $0.05 F_{1,95} = 3.94$ $0.05 F_{1,95} = 6.91$

Table 17. Analysis of Covariance: Unit I Achievement Scores

<table>
<thead>
<tr>
<th>Source</th>
<th>df</th>
<th>SS</th>
<th>MS</th>
<th>F-Ratio$^a$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Treatment</td>
<td>1</td>
<td>14.86</td>
<td>14.86</td>
<td>1.63</td>
</tr>
<tr>
<td>Sex</td>
<td>1</td>
<td>0.13</td>
<td>0.13</td>
<td>0.01</td>
</tr>
<tr>
<td>Treatment by Sex</td>
<td>1</td>
<td>49.64</td>
<td>49.64</td>
<td>5.45 *</td>
</tr>
<tr>
<td>Residual</td>
<td>91</td>
<td>829.63</td>
<td>9.12</td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>94</td>
<td>894.26</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

$^a$ $0.05 F_{1,91} = 3.95$ $0.05 F_{1,91} = 6.93$
Table 18. Analysis of Covariance: Unit II Achievement Scores

<table>
<thead>
<tr>
<th>Source</th>
<th>df</th>
<th>SS</th>
<th>MS</th>
<th>F-Ratio&lt;sup&gt;a&lt;/sup&gt;</th>
</tr>
</thead>
<tbody>
<tr>
<td>Treatment</td>
<td>1</td>
<td>35.17</td>
<td>35.17</td>
<td>4.84*</td>
</tr>
<tr>
<td>Sex</td>
<td>1</td>
<td>4.10</td>
<td>4.10</td>
<td>0.56</td>
</tr>
<tr>
<td>Treatment by Sex</td>
<td>1</td>
<td>79.76</td>
<td>79.76</td>
<td>10.99**</td>
</tr>
<tr>
<td>Residual</td>
<td>91</td>
<td>660.38</td>
<td>7.26</td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>94</td>
<td>779.41</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<sup>a</sup> .05<sub>F</sub> 1,91 = 3.95  .01<sub>F</sub> 1,91 = 6.93  ** Denotes a highly significant F value at the .01 level of confidence.

Table 19. Analysis of Covariance: Unit III Achievement Scores

<table>
<thead>
<tr>
<th>Source</th>
<th>df</th>
<th>SS</th>
<th>MS</th>
<th>F-Ratio&lt;sup&gt;a&lt;/sup&gt;</th>
</tr>
</thead>
<tbody>
<tr>
<td>Treatment</td>
<td>1</td>
<td>0.15</td>
<td>0.15</td>
<td>0.01</td>
</tr>
<tr>
<td>Sex</td>
<td>1</td>
<td>4.14</td>
<td>4.14</td>
<td>0.30</td>
</tr>
<tr>
<td>Treatment by Sex</td>
<td>1</td>
<td>12.83</td>
<td>12.83</td>
<td>0.94</td>
</tr>
<tr>
<td>Residual</td>
<td>91</td>
<td>1245.21</td>
<td>13.68</td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>94</td>
<td>1262.34</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<sup>a</sup> .05<sub>F</sub> 1,91 = 3.95  .01<sub>F</sub> 1,91 = 6.93  

The reliability of these three unit tests falls below the level of .80 suggested by Menne (1968) as the level of reliability that must be attained to warrant basing student grades on a particular test. This casts some doubt on these tests as effective measures for evaluating the two treatments. Nevertheless, a comparison of the two methods by unit seemed warranted.
When the analysis of variance (Tables 14-16) was used as the test of significance, no significant difference in achievement was found between the two treatments for any of the three units. Nor was there any significant difference in achievement between boys and girls. However, a significant difference at the .05 level was found in Unit II for the interaction between treatment and sex. No such interaction was found for Unit Tests I and III.

When the four covariants (Tables 17-19) were used however, a significant difference in achievement at the .05 level was found for Unit II. The mean scores on Unit II were 18.02 and 19.21 for the control and experimental groups respectively. Thus the difference in achievement scores was in favor of the field trip group. No significant difference in achievement scores was found for Units I and III.

The interaction between treatment and sex for Unit II changed from a significant level of .05 to the .01 level when the scores were adjusted using the four covariants. In addition to this, a significant interaction at the .05 level was found between treatment and sex on Unit I. No such interaction was found for Unit III. The direction of the interaction can be seen from Table 20 and from Figures 2 and 3.

Table 20. Mean Scores: Unit I and Unit II

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Unit I Boys</th>
<th>Unit I Girls</th>
<th>Unit II Boys</th>
<th>Unit II Girls</th>
</tr>
</thead>
<tbody>
<tr>
<td>Experimental</td>
<td>32.30</td>
<td>30.67</td>
<td>20.00</td>
<td>18.46</td>
</tr>
<tr>
<td>Control</td>
<td>30.05</td>
<td>31.17</td>
<td>17.86</td>
<td>18.13</td>
</tr>
</tbody>
</table>
No significant difference was found in achievement scores between boys and girls on any of the three units.

On the basis of the analysis of covariance, hypothesis number 1 could be rejected for Unit II; however, there was insufficient evidence to reject this hypothesis for Units I and III. Specifically this hypothesis states that there is no significant difference in achievement between the group means of students taught using field
trips and those taught using media on selected environmental concepts.

The alternative to this hypothesis is: There is a significant difference in achievement between group means of students taught using field trips and those taught using media on selected environmental concepts.

Hypothesis number 5 could be rejected for Units I and II, but not for Unit III. This hypothesis states: There is no significant interaction between treatment and sex as measured by achievement scores. The alternative to this hypothesis is: There is a significant interaction between treatment and sex as measured by achievement tests.

There was insufficient evidence to reject hypothesis number 2. This hypothesis states: There is no significant difference in achievement scores between the group means of boys and girls for Units I, II or III.

An analysis of the test scores for Unit II on the basis of the sub-groups listed on page 41 was made (Tables 21, 22 and 23) to determine if this difference was related to any particular segment of the population.
### Table 21. Unit II Test Scores based on GPA

<table>
<thead>
<tr>
<th>Group</th>
<th>$\bar{X}$</th>
<th>$S^2$</th>
<th>n</th>
<th>t Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Experimental</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>High Group</td>
<td>23.44</td>
<td>7.03</td>
<td>9</td>
<td>2.456 *</td>
</tr>
<tr>
<td>Control</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>High Group</td>
<td>20.21</td>
<td>12.18</td>
<td>19</td>
<td>1.145</td>
</tr>
<tr>
<td>Experimental</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Middle Group</td>
<td>18.65</td>
<td>11.68</td>
<td>26</td>
<td></td>
</tr>
<tr>
<td>Control</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Middle Group</td>
<td>17.39</td>
<td>17.61</td>
<td>23</td>
<td></td>
</tr>
<tr>
<td>Experimental</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Low Group</td>
<td>17.25</td>
<td>14.02</td>
<td>12</td>
<td>1.253</td>
</tr>
<tr>
<td>Control</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Low Group</td>
<td>15.30</td>
<td>12.23</td>
<td>10</td>
<td></td>
</tr>
</tbody>
</table>

### Table 22. Comparison of Unit II Scores based on I. Q.

<table>
<thead>
<tr>
<th>Group</th>
<th>$\bar{X}$</th>
<th>$S^2$</th>
<th>n</th>
<th>t Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Experimental</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>High Group</td>
<td>23.11</td>
<td>6.61</td>
<td>9</td>
<td>1.025</td>
</tr>
<tr>
<td>Control</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>High Group</td>
<td>21.73</td>
<td>12.21</td>
<td>15</td>
<td></td>
</tr>
<tr>
<td>Experimental</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Middle Group</td>
<td>19.69</td>
<td>12.50</td>
<td>16</td>
<td>1.952</td>
</tr>
<tr>
<td>Control</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Middle Group</td>
<td>17.14</td>
<td>12.90</td>
<td>14</td>
<td></td>
</tr>
<tr>
<td>Experimental</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Low Group</td>
<td>17.27</td>
<td>12.11</td>
<td>22</td>
<td>1.116</td>
</tr>
<tr>
<td>Control</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Low Group</td>
<td>16.13</td>
<td>11.48</td>
<td>23</td>
<td></td>
</tr>
</tbody>
</table>
Table 23. Comparison of Unit II Scores based on ITED

<table>
<thead>
<tr>
<th>Group</th>
<th>$\bar{X}$</th>
<th>$s^2$</th>
<th>n</th>
<th>t Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Experimental</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Superior</td>
<td>22.93</td>
<td>7.61</td>
<td>14</td>
<td>1.761</td>
</tr>
<tr>
<td>Control</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Superior</td>
<td>21.00</td>
<td>11.09</td>
<td>22</td>
<td></td>
</tr>
<tr>
<td>Experimental</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Above Average</td>
<td>18.95</td>
<td>8.57</td>
<td>20</td>
<td>2.021</td>
</tr>
<tr>
<td>Control</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Above Average</td>
<td>17.08</td>
<td>3.01</td>
<td>13</td>
<td></td>
</tr>
<tr>
<td>Experimental</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Average</td>
<td>15.62</td>
<td>7.76</td>
<td>13</td>
<td>0.298</td>
</tr>
<tr>
<td>Control</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Average</td>
<td>14.88</td>
<td>13.74</td>
<td>17</td>
<td></td>
</tr>
</tbody>
</table>

The analysis of Unit II test scores by the three covariants, I. Q., GPA and science background combined with ability grouping revealed only one significant difference in achievement between the two treatment groups. At the .05 level a significant difference was found for the superior group based on GPA. Students in the experimental group had a mean score of 23.44 compared to a mean of 20.20 for the control group or a difference of 3.24. Students with a high GPA ranking and field trip experience showed significantly higher achievement scores than did their counterparts who remained in the classroom.

The only other group to approach the .05 level of significance was the above average group for science background. The t value obtained was 2.028, while the .05 level of significance was 2.040.
Retention Test

A retention test composed of 40 items taken from the three unit tests and the final test was administered approximately six weeks after completion of the study. The analyses of this test are reported in Tables 24 and 25.

Table 24. Analysis of Variance: Retention Test

<table>
<thead>
<tr>
<th>Source</th>
<th>df</th>
<th>SS</th>
<th>MS</th>
<th>F-Ratio^a</th>
</tr>
</thead>
<tbody>
<tr>
<td>Treatment</td>
<td>1</td>
<td>10.95</td>
<td>10.95</td>
<td>0.283</td>
</tr>
<tr>
<td>Sex</td>
<td>1</td>
<td>0.00</td>
<td>0.00</td>
<td>0.000</td>
</tr>
<tr>
<td>Treatment by Sex</td>
<td>1</td>
<td>54.82</td>
<td>54.82</td>
<td>1.42</td>
</tr>
<tr>
<td>Residual</td>
<td>95</td>
<td>3677.34</td>
<td>38.71</td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>98</td>
<td>3743.11</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

^ .05^ 1,95 = 3.94

Table 25. Analysis of Covariance: Retention Test

<table>
<thead>
<tr>
<th>Source</th>
<th>df</th>
<th>SS</th>
<th>MS</th>
<th>F-Ratio^a</th>
</tr>
</thead>
<tbody>
<tr>
<td>Treatment</td>
<td>1</td>
<td>10.95</td>
<td>10.95</td>
<td>0.753</td>
</tr>
<tr>
<td>Sex</td>
<td>1</td>
<td>0.00</td>
<td>0.00</td>
<td>0.000</td>
</tr>
<tr>
<td>Treatment by Sex</td>
<td>1</td>
<td>54.82</td>
<td>54.82</td>
<td>3.771</td>
</tr>
<tr>
<td>Residual</td>
<td>91</td>
<td>1323.44</td>
<td>14.54</td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>94</td>
<td>1389.21</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

^ .05^ 1,91 = 3.95
No significant difference was found between the two treatment groups in terms of retention of the material studied. From the results of this test, one would fail to reject the following hypotheses.

1. There is no significant difference in achievement on a retention test between the group means of students taught using field trips and those taught using media on selected environmental concepts.

2. There is no significant difference in achievement scores on a retention test between the group means of boys and girls.

5. There is no significant interaction between treatment and sex as measured by achievement scores.

Very little difference between posttest and retention test scores was found for either treatment. The relationship of these two tests can be seen in Table 26.

Table 26. Comparison of Posttest to Retention Test

<table>
<thead>
<tr>
<th>Group</th>
<th>Posttest Mean</th>
<th>%</th>
<th>Retention Mean</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Experimental</td>
<td>36.32</td>
<td>62.62</td>
<td>24.64</td>
<td>61.60</td>
</tr>
<tr>
<td>Control</td>
<td>34.84</td>
<td>60.08</td>
<td>23.79</td>
<td>59.47</td>
</tr>
</tbody>
</table>

When the retention test means were adjusted to compensate for the difference in test length, the experimental group showed a mean of 35.73 and the control group showed an adjusted mean of 34.50, based on 58 items.
Student Attitude Towards Ecological Problems

A second facet of this study was the effect of field trips on student attitude towards ecological problems. Pretest scores, I. Q. scores, grade point averages and background in science were again used as covariants. Treatment, sex and interaction of sex and treatment were evaluated. Statistical analyses similar to those used in studying student achievement were used.

Table 27. Pretest to Posttest Attitude Scores: Experimental Group

<table>
<thead>
<tr>
<th></th>
<th>Pretest</th>
<th>Posttest</th>
<th>t Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean</td>
<td>55.13</td>
<td>58.09</td>
<td></td>
</tr>
<tr>
<td>Variance</td>
<td>59.20</td>
<td>65.21</td>
<td>2.185*</td>
</tr>
<tr>
<td>Standard Deviation</td>
<td>7.69</td>
<td>8.98</td>
<td></td>
</tr>
<tr>
<td>n Number</td>
<td>47</td>
<td>47</td>
<td></td>
</tr>
<tr>
<td>Correlation</td>
<td>0.308</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

\[ .05^{t46} = 2.015 \quad .01^{t46} = 2.692 \]

Table 28. Pretest to Posttest Attitude Scores: Control Group

<table>
<thead>
<tr>
<th></th>
<th>Pretest</th>
<th>Posttest</th>
<th>t Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean</td>
<td>57.46</td>
<td>59.63</td>
<td>2.514*</td>
</tr>
<tr>
<td>Variance</td>
<td>37.86</td>
<td>42.28</td>
<td></td>
</tr>
<tr>
<td>n Number</td>
<td>52</td>
<td>52</td>
<td></td>
</tr>
<tr>
<td>Correlation</td>
<td>0.516</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

\[ .05^{t51} = 2.010 \quad .01^{t51} = 2.678 \]
The \( t \) values in Tables 27 and 28 indicate that both the use of field trips and the use of media can result in significant changes in student attitude towards current ecological problems.

The correlations of the four covariants to the posttest attitude scores are shown in Table 29.

Table 29. Correlation of Attitude Scores to Covariants

<table>
<thead>
<tr>
<th>Covariants</th>
<th>Posttest Attitude Scores</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Experimental (n=47)</td>
</tr>
<tr>
<td>Pretest Attitude</td>
<td>.308*</td>
</tr>
<tr>
<td>I. Q.</td>
<td>.322*</td>
</tr>
<tr>
<td>GPA</td>
<td>.264</td>
</tr>
<tr>
<td>Science Background</td>
<td>.364*</td>
</tr>
</tbody>
</table>

* Denotes \( r \geq .288 \) required for a significant difference from zero at the .05 level of confidence.

** Denotes \( r \geq .273 \) required for a significant difference from zero at the .05 level of confidence.

**' Denotes \( r \geq .354 \) required for a significant difference from zero at the .01 level of confidence.

The presence of a significant correlation between the pretest and posttest scores for both groups indicates that students who displayed a positive attitude towards ecological problems at the beginning of the investigation continued to do so at the conclusion. Of the other three covariants, only science background showed a significant correlation for both groups.

The comparison of field trips to media (Tables 30-31) failed to reveal any significant difference between the two methods. Nor was there any difference between sex or the interaction of sex and treatment. Similar results were obtained when the four covariants were used in the analysis of covariance.
Table 30. Analysis of Variance Posttest Attitude Scores

<table>
<thead>
<tr>
<th>Source</th>
<th>df</th>
<th>SS</th>
<th>MS</th>
<th>F-Ratio^a</th>
</tr>
</thead>
<tbody>
<tr>
<td>Treatment</td>
<td>1</td>
<td>59.27</td>
<td>59.27</td>
<td>1.102</td>
</tr>
<tr>
<td>Sex</td>
<td>1</td>
<td>10.86</td>
<td>10.86</td>
<td>0.202</td>
</tr>
<tr>
<td>Treatment by Sex</td>
<td>1</td>
<td>34.49</td>
<td>34.49</td>
<td>0.641</td>
</tr>
<tr>
<td>Residual</td>
<td>95</td>
<td>5110.37</td>
<td>53.79</td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>98</td>
<td>5214.99</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

^a .05^ F 1,95 = 3.95

Table 31. Analysis of Covariance Posttest Attitude Scores

<table>
<thead>
<tr>
<th>Source</th>
<th>df</th>
<th>Residual</th>
<th>SS</th>
<th>MS</th>
<th>F-Ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td>Treatment</td>
<td>1</td>
<td></td>
<td>59.27</td>
<td>59.27</td>
<td>1.355</td>
</tr>
<tr>
<td>Sex</td>
<td>1</td>
<td></td>
<td>10.86</td>
<td>10.86</td>
<td>0.248</td>
</tr>
<tr>
<td>Treatment by Sex</td>
<td>1</td>
<td></td>
<td>34.49</td>
<td>34.49</td>
<td>0.788</td>
</tr>
<tr>
<td>Residual</td>
<td>91</td>
<td></td>
<td>3980.86</td>
<td>43.75</td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>94</td>
<td></td>
<td>4085.48</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

^a .05^ F 1,91 = 3.95

On the basis of these findings one would fail to reject hypotheses 3, 4 and 6.

Hypothesis 3 states: There is no significant difference in attitude towards environmental problems between the group means of students taught using field trips and those taught using media.

Hypothesis 4 states: There is no significant difference in
attitude towards environmental problems between the group means of boys and girls.

Hypothesis 6 states: There is no significant interaction between treatment and sex as measured by attitude scores.

Student Attitude Towards Biology

Form A of the Purdue Master Attitude Scale, A Scale to Measure Attitude Towards Any Subject was given at the conclusion of the investigation. This scale measures a student's overall attitude towards the class and does not directly measure his attitude towards the use of field trips. However, it was felt that if students responded more favorably towards one of the two treatments, this would be reflected in their overall attitude towards biology.

Table 32. Attitudes Towards Biology

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Mean</th>
<th>Variance</th>
<th>t Value&lt;sup&gt;a&lt;/sup&gt;</th>
</tr>
</thead>
<tbody>
<tr>
<td>Experimental</td>
<td>7.79</td>
<td>1.15</td>
<td>0.688</td>
</tr>
<tr>
<td>Control</td>
<td>7.93</td>
<td>1.16</td>
<td></td>
</tr>
</tbody>
</table>

<sup>a</sup> .05<sub>t</sub> 98 = 1.988

A value of 6.0 is considered to represent a neutral point on a scale which ranges from 1.0 to 10.3 (Remmers, 1960). The values of 7.79 and 7.93 represent positive attitudes towards biology for each group.

No significant differences in student attitude towards biology was found for either treatment group. The findings of this investi-
gation suggest that both teaching methods develop positive attitudes toward the subject.
DISCUSSION OF THE FINDINGS

Both the use of field trips and the use of media resulted in highly significant differences between the pretest and posttest achievement scores.

The maximum gain for any one student in the experimental group was 24 points and 23 points in the control group. Three students showed no gain between the pretest and the posttest. One of these students was in the experimental group and two were in the control group. The student from the experimental group had experienced a serious illness in the family and the subsequent loss of a younger brother. She was absent on several occasions and missed two field trips. A boy in the control group was chronically absent from school and in difficulty with the administration for cutting classes. The third student was a girl of average ability. She appeared to have a good attitude towards class. No apparent reason was found for her failure to show any growth in achievement.

From this study it would appear that both the use of media and the use of field trips are effective methods for teaching environmental concepts.

The comparison of field trips to media failed to find a significant difference between the two methods based on posttest scores. The .05 level was selected for the basis of significance. When the four covariants were utilized the F value approached; but did not reach the .05 level. However, students from the experimental group scored higher than those from the control group.

An analysis was made to determine if the difference that did
exist on the posttest was associated with I. Q., GPA or background in science. The students in each treatment were divided into three groups, superior, above average and average for each of these three covariants.

The only significant difference that was found occurred between the superior students in the field trip group and those in the control group based on the student's GPA.

When the study was analyzed by units using the four covariants, a significant difference was found at the .05 level for Unit II, but not for Units I and III. The mean score for the experimental group was 19.21 while the control group showed a mean of 18.01, or a difference of 1.20 in favor of students taking field trips.

The reason that Unit II showed a significant difference while Units I and III did not might be explained by the subject matter in Unit II, which dealt with population and community dynamics. Emphasis was placed on energy fixation, energy flow and the relationship of physical factors to populations and communities. Possibly these concepts can be more readily demonstrated in the field than through the use of media.

For example, students were asked to determine the productivity per square meter for several areas. In the case of the experimental group, the students collected the material and made the necessary measurements. Students in the control group viewed slides of how the data were collected and made their own calculations from information provided by the instructor.

One further observation may help explain this difference. The
interaction between the physical and biotic portions of the environment is not easily illustrated by the use of media. By being a part of an outdoor setting, a student may gain an impression of the interaction between the abiotic and biotic factors which cannot be achieved through the use of media or by the manipulation of data.

What may be of equal importance is the failure to find any significant difference between the two treatments for Unit III. This unit dealt largely with environmental problems facing man today. The topics covered and the duration of the unit was limited. As a result, any interpretation of the findings must be made within these limitations. Nevertheless, the findings of this investigation indicate that there is no significant difference between the two treatment groups for this topic. The topic of pollution has received extensive exposure from the mass media. Almost every major publication and TV network has carried articles or special programs dealing with this problem. Students have been exposed to the worst of the pollution problems. The result of this exposure may be that students are aware of the problems and that local exposure only reinforces their awareness of the problem. If this is true, then other factors may make media the preferred method. Students could be exposed to a wider range of topics, problems outside the students' immediate environment could be investigated, and the study of pollution problems could be more easily integrated into regular classroom activities.

When the difference between group means for Unit II was analyzed by I. Q., GPA, background in science and treatment method, the only significant difference that was found was in terms of the superior
student in the GPA sub-group. Students in the experimental group scored higher than similar students in the control group. Similar results were reported for posttest scores. No attempt was made to ascertain the cause for this difference. Nevertheless, one observation seems pertinent. The characteristics that are needed to achieve a high GPA may also be the same characteristics that are required to gain the maximum benefit from a field trip. These are high innate intellectual ability and the self discipline to carry a task to completion.

The latter characteristic seems particularly important for students involved in field trips. Some of the field trips in this investigation required considerable effort. Without being actively involved the students were unable to gain maximum benefit from these experiences.

Results by earlier investigators (Crawford and Grinstead, 1930; Fraser, 1939; Clark, 1943 and McCaslin, 1970) indicated the use of field trips were more effective with students of higher ability.

While this study does not refute their contentions, if high ability is defined in terms of GPA, it does fail to support them in terms of ability measured by I. Q. tests. This study would suggest that field trips or media may be used effectively with average, above average and superior students based on I. Q. or background in science. No data were available to indicate what effect field trips might have on achievement of below average students.

An interaction between sex and treatment was found for posttest scores and for scores from Units I and II. This interaction resulted
from the boys in the experimental group scoring significantly better than the boys in the control group. There was very little difference in achievement between the girls in the experimental group and those in the control group. However, in all analyses except one, the girls in the experimental group scored slightly higher than those in the control group. The one exception was Unit II, where the girls in the control group had a slightly higher mean than did girls in the experimental group.

In most studies dealing with the use of field trips, no significant interaction between method and sex has been reported. Clark (1943) found such an interaction on one unit. In his investigation he studied the effects of field trips in teaching units on transportation, communication, printing and Egypt. Of these four units, only the unit dealing with transportation yielded a significant interaction, with boys from the field trip group showing the higher achievement scores. Contradictory results were reported (Harvey, 1951) in an investigation dealing with the use of field trips in developing scientific attitudes. In this study the interaction was between girls and field trips.

Findings of these types suggest that field trips may show an interaction with a particular sex. However, the direction of the interaction is to some extent the results of the subject matter being studied. When the area being studied appeals to the interest or ability of one particular sex, then a subsequent interaction with that sex may occur.

A final achievement test was given six weeks after the completion
of the study. This test attempted to evaluate if students in a particular treatment group retained more information related to the subject than did students from the other treatment group. No significant difference was found for either treatment.

It is interesting to note that on a percentage basis there was about 1% difference between the group means of the examination administered at the completion of the study and the retention test administered six weeks later. This would suggest that students retained most of the material they had learned during the investigation. It would also suggest that the two methods are equally effective in terms of retention of material.

However, it should be kept in mind that the retention test was composed of questions taken from the final examination and the three unit tests. Thus, the students had been exposed to each question on a prior test. After each test the students were given a copy of the test and their own corrected answer sheet. They were encouraged to find their mistakes and determine the correct answer. If they had any questions or problems these were answered or explained by the instructor. Answer sheets and test booklets were collected at the end of the period and students were not allowed to study them again.

No attempt was made to evaluate the amount of learning that occurred as the result of taking the test and then reviewing the results. Nor, was there any evaluation of the correlation of the student's success on the first exposure to a question and his success on the same question on the retention test.
Attitudes Towards Environmental Problems

A significant difference between pretest and posttest scores was found for both treatment groups. It may be questioned whether a gain of 2.95 for the experimental group and 2.17 for the control group has any practical significance. Nevertheless, the fact still remains that attitudes were changed in the direction desired.

In this investigation emphasis was placed on providing students with factual information and developing essential ecological concepts. No attempt was made to appeal to the students' emotion or to frighten them with impending doom.

The results obtained would indicate that as a student developed a better understanding of ecological concepts, a concomitant result was a better attitude towards environmental problems. Possibly earlier and repeated exposure to the topic might have even greater effects, both in understanding of and attitudes towards the environment.

When the two methods were compared, no significant difference was found in favor of either method. Neither was there a significant interaction between treatment and sex. The failure to find evidence to support either method might be interpreted to mean that either or both methods might be utilized in developing proper attitudes towards the environmental problems.

The correlations of the four covariants to posttest attitude scores for both the experimental and control group were revealing. Of the four covariants only the pretest scores and science background
scores showed a significant correlation with both the experimental and control groups.

Findings of this nature support the earlier contention that proper attitude is related to prior knowledge of the problem. Furthermore, these findings would suggest that proper attitude towards environmental problems is not limited to any particular segment of the population in terms of intelligence or previous success in school. It should be remembered that this population was average or above average. Thus no inference can be drawn for the below average student. However, if future investigations would find similar results with below average students it would suggest that the attitude of all segments of the high school population could be changed to a more positive attitude. This change could further be brought about by providing the students with a better understanding of their relationship to their environment.

Student Attitude Towards Field Trips

The Purdue Master Attitude Scale failed to indicate any difference between the two groups in terms of their attitude towards biology.

No formal investigation of student feelings concerning the use of field trips or the use of media was made. However, informal discussions with the students revealed several interesting points. Some students in the control group asked why they could not go on field trips and in a few cases volunteered to go on field trips during their free time.
Students who participated in the field trips generally said they enjoyed them. Three negative points were made:

1. Some students did not enjoy the field trips when the weather was inclement. As the field trips were scheduled only once a cycle, it was necessary to go into the field under undesirable weather conditions. Girls particularly, did not like this aspect of field trips.

2. It was not always possible for the students to hear the instructor. This occurred despite the fact that the size of the group was never more than 22 students.

3. The field trips lasted too long. This feeling was generally expressed by students who showed little interest in the topic being studied. Consequently, these students did not take an active part in the field trip activities.

This investigator feels that if given a choice to participate either in field trips or to remain in the classroom, most students would select field trips. This observation is supported by the number of students who showed an interest in an extended field trip to the Black Hills in South Dakota. This field trip was scheduled to take place after school was out and covered a period of nine days. Each student paid his own expenses, with the exception of transportation. Of the 99 students involved in the investigation, 67 indicated a definite interest in going on the field trip. Of these 67 students, 19 made a final commitment to participate in the activity. A breakdown by treatment group revealed that 38 of the 67 students were from the experimental group while 29 were from the control group. Of the 19 students participating in the field trip, 13 were
from the experimental group and six were from the control group.

The results of this study are inconclusive. In all cases any difference between the two groups was in favor of field trip group. However, in only one case, Unit II, did the difference reach the .05 level of significance. These results might be interpreted to mean that field trips are more effective in teaching certain concepts, such as productivity and community structure, than is the use of media.

Certainly the results of this investigation fail to support the contention of some environmentalists who say that the only way to teach this subject is through the use of field trips.

Whether one can justify the use of field trips over media is a decision that individual teachers must make. Certainly other factors, such as cost, scheduling and availability of sites, must be considered.
SUMMARY OF RESULTS

The purpose of this investigation was to compare the effectiveness of field trips to media in teaching selected environmental concepts. Two areas were studied, student achievement and student attitude. In addition, the interaction between treatment and sex was investigated. Four student variables, pretest scores, I. Q., GPA and background in science were used as covariants.

The data from this investigation were analyzed using t-tests, analysis of variance and an analysis of covariance. The main statistical tool used was the analysis of covariance.

The results of this study may be summarized as follows:

1. A highly significant difference was found beyond the .01 level between pretest and posttest scores for both treatment groups. This would indicate that both field trips and media can be used as successful teaching methods in presenting selected environmental concepts.

2. A comparison of the two treatment groups failed to find any significant difference for either method on the posttest, Unit I test, Unit III test and the retention test. A significant difference in favor of the experimental group was found for Unit II when the scores were adjusted for the four covariants.

3. No significant difference was found in achievement between boys and girls.

4. When the four covariants were considered, a significant interaction occurred between treatment and sex. Such an interaction was found for the posttest, Unit I test and Unit II test. Boys in
the field trip group scored higher than did boys in the control group.

5. The use of field trips and media both resulted in a significant change in attitude toward current environmental problems. In both cases the change was considered to be a more positive attitude toward the problems.

6. Neither treatment was more successful in changing attitude towards current environmental problems than the other treatment.

7. There was no difference in attitude towards environmental problems based on sex.

8. No interaction between sex and treatment was found for attitude scores.

9. Students in both treatment groups reported a positive attitude towards biology.
RECOMMENDATIONS FOR FUTURE STUDIES

The results of this study suggest several other potential areas for future research.

1. The size and scope of this study limits one's ability to generalize to a larger population. This study needs to be replicated using a large population from more than one school.

2. The effect of the teacher variable needs to be studied in terms of teacher competencies to construct and conduct meaningful field trips.

3. The fact Unit II showed a significant difference suggests certain concepts may be better taught using field trips. The identification of these would facilitate the development of meaningful field experiences.

4. Other student characteristics may well have had an influence on how well a student learns under a particular teaching method. Such factors as student interest in science, student interest in the outdoors, and the ability to carry a project through to completion should be investigated as they relate to field trips.

5. A more comprehensive environmental scale is needed. A scale which would measure various aspects of the environmental problem would facilitate future research.

6. This study was conducted using sophomore students. The assumption that this is the best grade level to teach these concepts should be investigated. It may well be that earlier exposure to these concepts would be more meaningful. A corollary of this would be the effect of repeated exposure as compared to a one time exposure.
BIBLIOGRAPHY


Atyeo, Henry C. 1939. The excursion as a teaching technique. Teachers College, Columbia University, Contributions to Education, No. 761.


Fraser, James A. 1939. Outcomes of a study excursion, a descriptive study. Teachers College, Columbia University, Contributions to Education, No. 778.


Harvey, Helen W. 1951. An experimental study of the effects of field trips upon the development of scientific attitudes in a ninth grade general science class. Science Education 35, No. 3: 242-248.


Menne, John W. 1968. Use of computer analysis in evaluating and improving the measurement characteristics of examinations. Iowa State University of Science and Technology, Ames, Iowa, Department of Psychology Report 68-12.


ACKNOWLEDGEMENTS

The author would like to make special recognition of the help and guidance provided by Dr. Harold Dilts, who has served as chairman of my graduate committee and as such has supplied both encouragement and direction throughout the program.

I am deeply appreciative for the help and suggestions of Dr. Lois Tiffany, Dr. Ray Bryan, Dr. Trevor Howe and Dr. Roger Landers. As members of my graduate committee they have been most helpful in planning and directing this study.

A special thank you goes to Dr. John Menne and Mrs. Guy Hocking of the Iowa State Computer Center for their help in analyzing the data contained within this study.

Appreciation is expressed to the Board of Education of Perry Community Schools, Mr. Blaine Lytle, Superintendent, Mr. Tom Drake, Principal, and the Perry Senior High School Staff for their assistance and understanding.

Finally, to my wife Marilyn and my two daughters, Maribeth and Colleen, special appreciation is expressed for their understanding and encouragement throughout my graduate work.
APPENDIX A. ACHIEVEMENT AND ATTITUDE TESTS
ECOLOGY TEST

Prepared
by
The Department of Science
Perry Community Schools

Directions: This test consists of fifty-eight multiple choice items. You are to select the most correct answer. Mark your answer on the IBM provided. You will have fifty minutes to complete the test.
1. Classification, of plants and animals, is largely based on:
   (a) similarity or differences in structure
   (b) where the organism is commonly found
   (c) the importance of the organism to man
   (d) its color
   (e) all of the above

2. The genus names for cats (the domestic variety) is Felis. If the genus name for lion was once considered to be Felis, but is now Pantherus, this would indicate:
   (a) they were once thought to be related but are no longer considered to be related
   (b) they are closely related differing only in species name
   (c) they were at one time thought to be more closely related than they are now believed to be
   (d) the lion evolved from a cat

3. A biologist finds two organisms and wishes to determine if they are members of the same species. He would base his decision on:
   (a) do they look alike
   (b) are they found in the same environment
   (c) are they the same size
   (d) can they mate and produce fertile offspring
   (e) do they require the same type of food

4. Which of the following is not re-cycled in an ecosystem?
   (a) oxygen
   (b) water
   (c) minerals
   (d) energy
   (e) none of the above are re-cycled

5. Which of the following best describes a self-contained space craft?
   (a) an organ system
   (b) a population
   (c) a community
   (d) an ecosystem
   (e) a biosphere

6. The following diagram is a skeleton outline of the relationship of the living organisms in a community. Select the answer that correctly identifies the proper sequence.

```
1. decomposers 2. carnivores 3. herbivores 4. producers
(a) 1. decomposers 2. carnivores 3. herbivores 4. producers
(b) 1. producers 2. herbivores 3. carnivores 4. decomposers
(c) 1. producers 2. decomposers 3. herbivores 4. carnivores
(d) 1. herbivores 2. carnivores 3. producers 4. decomposers
(e) 1. carnivores 2. producers 3. herbivores 4. decomposers
```
7. Which of the following statements is true of territory rights in animals?
   (a) they are formed between members of the same species
   (b) they are in operation primarily during the reproductive season
   (c) they provide the minimum requirements, such as food, for survival
   (d) two of the above are correct
   (e) three of the above are correct

Use this information for questions 8-10. The following represents the minimum and maximum requirements for the following plants.

<table>
<thead>
<tr>
<th>Plant</th>
<th>A</th>
<th>B</th>
<th>C</th>
<th>D</th>
</tr>
</thead>
<tbody>
<tr>
<td>rainfall</td>
<td>20-40&quot;</td>
<td>20-80&quot;</td>
<td>20-45&quot;</td>
<td>5-10&quot;</td>
</tr>
<tr>
<td>light ft/c</td>
<td>1100-1500</td>
<td>900-1800</td>
<td>200-350</td>
<td>900-1700</td>
</tr>
<tr>
<td>nitrogen</td>
<td>30-50 ppm</td>
<td>10-50 ppm</td>
<td>25-60 ppm</td>
<td>10-20 ppm</td>
</tr>
<tr>
<td>phosphorous</td>
<td>10-40 ppm</td>
<td>5-35 ppm</td>
<td>5-30 ppm</td>
<td>5-15 ppm</td>
</tr>
</tbody>
</table>

8. If a given environment had the following conditions, light = 1200 foot candles, water = 30 inches, available nitrogen = 20 ppm and phosphate = 18 ppm, which factor would be the most serious limiting factor for plant A?
   (a) water
   (b) light
   (c) nitrogen
   (d) phosphorous
   (e) all four factors are equal as limiting factors

9. Which of these plants, based on the above factors, would show the widest range of distribution?
   (a) plant A
   (b) plant B
   (c) plant C
   (d) plant D

10. Which of these plants might more likely be found in the under canopy of a forest or woodland?
    (a) plant A
    (b) plant B
    (c) plant C
    (d) plant D

11. Which of the following statements is true of a climax community?
    (a) the type of vegetation will be the same in all climax communities
    (b) the type of vegetation will always be a woodland or forest
    (c) the type of vegetation will be determined by the climate and soil in a climax community
    (d) the type of vegetation will change very slowly in a climax community
    (e) the vegetation will be composed of only mature adult plants
12. The following represents a food chain.

\[
\text{grass} \rightarrow \text{insects} \rightarrow \text{birds} \rightarrow \text{wolves}
\]

The efficiency in transfer of energy (% of energy that is available and is converted into body weight at the next step) is:

(a) least between the grass and insects
(b) least between the insects and birds
(c) least between the birds and the wolf
(d) the same at all levels
(e) dependent upon the size of the organism

Use this information for questions 13-15. An area goes through succession in the following order:

Community A \(\rightarrow\) Community B \(\rightarrow\) Community C \(\rightarrow\) Community D

13. Which community would show the least amount of diversity in terms of life?

(a) community A
(b) community B
(c) community C
(d) community D

14. The most probable cause of the change from one type of community to the next is:

(a) there has been a major physical alteration (such as an earthquake, erosion) in the environment at each step, thus resulting in new communities
(b) the members of the previous community have changed the environment to the point where the conditions were more favorable to the next community than to the existing one
(c) there has been a climatic change favoring the new communities
(d) there is a competition among the various members of the community
(e) none of the above is an explanation of why communities change

15. In which community would the environmental conditions be most severe in terms of survival of plants and animals?

(a) community A
(b) community B
(c) communities A and D would be equally as severe, but more severe than B and C
(d) all of the communities would show the same degree of severity
(e) there is not enough information available to evaluate the question

Use the following information for questions 16 and 17. The following represents the data from three difference communities where trees are the dominant species. A survey of the height of only the dominant species shows the following number per acre.
16. Which of the above communities is probably a climax community?
   (a) community A
   (b) community B
   (c) community C
   (d) all of the communities are in a state of climax
   (e) none of the above communities could be considered in a
       state of climax

17. In which of the communities would you first expect to see a new
    dominant species?
   (a) community A
   (b) community B
   (c) community C
   (d) there is no indication that a new dominant species will
       appear

18. The removal of the decomposer organisms from a community would:
   (a) remove all disease producing organisms
   (b) remove all green plants from the system
   (c) cause the consumer organisms to utilize smaller producer
       organisms
   (d) prevent the process of respiration
   (e) prevent the re-cycling of essential minerals and nutrients

19. A food chain is an important concept in ecology, because:
   (a) it shows how energy is transferred from one organism to
       another
   (b) it shows the main source of food for the organisms
   (c) it shows the inner-relationships between the various
       organisms
   (d) it shows the relationship of size of organism to food
       source
   (e) it is based on the concept that all organisms have a
       place in nature

The following represents a pyramid of biomass (total weight of the indi-
viduals at a particular level). Assume that herbivores have an effi-
ciency of 15% and all carnivores have an efficiency of 20%. Use this
information for questions 20 and 21.

```
Birds
Insects
Plants
```
20. If the weight of the plant material was 1000 lbs., we could predict the weight of the birds would be:
   (a) less than 1000 lbs. but greater than 600 lbs.
   (b) less than 600 lbs. but greater than 300 lbs.
   (c) less than 300 lbs. but greater than 150 lbs.
   (d) less than 150 lbs. but greater than 75 lbs.
   (e) less than 75 lbs.

21. If we wished to have a larger population of birds, we could:
   (a) use larger insects
   (b) use larger plants
   (c) have the birds eat the plants
   (d) use larger birds
   (e) all of the above

Use this information for questions 22-24. The following represents the per cent of productivity per meter squared for three equivalent areas.

<table>
<thead>
<tr>
<th>Area A</th>
<th>Area B</th>
<th>Area C</th>
</tr>
</thead>
<tbody>
<tr>
<td>Alfalfa 92%</td>
<td>Alfalfa 32%</td>
<td>Blue Grass 60%</td>
</tr>
<tr>
<td>Clover 4%</td>
<td>Blue Grass 54%</td>
<td>Clover 15%</td>
</tr>
<tr>
<td>Dandelion 1%</td>
<td>Clover 3%</td>
<td>Quack Grass 5%</td>
</tr>
<tr>
<td>Quack Grass 3%</td>
<td>Dandelion 3%</td>
<td>Crab Grass 13%</td>
</tr>
<tr>
<td></td>
<td>Quack Grass 8%</td>
<td>Wild Phlox 4%</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Sour Dock 2%</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Misc. 1%</td>
</tr>
</tbody>
</table>

22. Which area would probably show the greatest amount of productivity per meter squared?
   (a) area A
   (b) area B
   (c) area C
   (d) all three areas would show the same degree of productivity
   (e) it is impossible to judge, based on the information provided

23. Which of the following has the greatest influence on the community from which the data for area C was calculated?
   (a) blue grass
   (b) clover
   (c) crab grass
   (d) quack grass
   (e) wild phlox

24. A new disease, caused by a fungus that effects only the dominant species, has developed. If the areas were ranked in order of damage from most damage to least damage, the order would be areas:
   (a) A, B, C
   (b) A, C, B
   (c) B, C, A
   (d) C, B, A
   (e) B, A, C
Use this information for questions 25 and 26. The following represents the growth curve of two species.

![Graph showing the growth curves of Species A and Species B over time.]

25. Species A and Species B are closely related. If both are found successfully living in the same community, we can assume that:
   (a) they occupy different niches  
   (b) they are isolated by some factor which reduces competition  
   (c) they have many needs that are common to both species  
   (d) two of the above are correct, true statements  
   (e) three of the above are correct, true statements

26. If both species occupied the same niche in the community, we could predict:
   (a) both species would die out due to the competition  
   (b) both species would survive at a level lower than either species would survive alone  
   (c) species A would probably survive and species B would die out  
   (d) species B would probably survive and species B would die out

Use this diagram for questions 27-30:

![Food web diagram showing the relationships between different species.]

The above diagram represents a simple food web. The arrows point towards the organism which preys on another organism, i.e. coyotes eat rabbits.

27. In terms of number of individuals, you would expect to find:
   (a) more snakes than gophers  
   (b) fewer insects than frogs  
   (c) more spiders than insect-eating birds  
   (d) more coyotes than rabbits
28. Which of the following is the most likely result of destroying all of the coyotes?
   (a) an increase in the amount of grass and shrubs
   (b) an increase in the deer population
   (c) an increase in the number of rabbits
   (d) an increase in the number of pocket gophers
   (e) two of the above are true

29. The total weight of the organisms in each group would be greatest for:
   (a) deer
   (b) coyotes
   (c) rabbits
   (d) grass
   (e) insects

30. The role of the shrubs and grasses in the food web is best described as:
   (a) shelter for the animals
   (b) a source of seeds
   (c) source of energy
   (d) a place for nests

31. The presence of large quantities of organic material in water entering a river or lake is:
   (a) helpful because it provides nutrients for plant growth
   (b) helpful because it serves as food for the animals
   (c) harmful because it depletes the free oxygen available in the water
   (d) harmful because aquatic organisms are highly sensitive to the odor
   (e) neither helpful or harmful as it does not effect the water

32. Primary treatment in sewage plant refers to:
   (a) the separation of large solid particles from the water portion
   (b) the addition of oxygen
   (c) the biological breakdown of the organic materials
   (d) two of the above are correct
   (e) three of the above are correct

33. One of the major pollutants found in water coming from a sewage plant is phosphate. The main cause of this pollution is:
   (a) the breakdown and decay of plant materials in the water
   (b) run off from farm fields, which have been fertilized
   (c) soaps and detergents used by housewives
   (d) two of the above
   (e) three of the above
34. As an engineer, you are asked to solve the phosphate problem of a city sewage plant. Which of the following solutions might work?
(a) grow aquatic plants in the water and harvest the plants
(b) spray the water into the air, before allowing it to enter the lake or river
(c) build lagoons, which have a large surface area
(d) add small fish and aquatic animals to the holding lagoon
(e) add either chlorine or fluorine to the water prior to dumping it into the river

35. The function of an anaerobic lagoon, in the treatment of water, is to breakdown organic materials in the water entering it. This is accomplished by:
(a) the action of bacteria
(b) the addition of oxygen
(c) the movement of the water
(d) two of the above
(e) three of the above

36. In the construction of a lagoon system, it would be desirable to:
(a) construct the primary, secondary and tertiary lagoons with large surface areas
(b) construct the primary lagoon with a small surface area and the other two with large surface areas
(c) construct all three with a limited surface area
(d) construct only the tertiary lagoon with a large surface area
(e) consider other factors, because the surface area is not important in a lagoon operation

37. The term biological oxygen demand (BOD) refers to:
(a) the amount of dissolved oxygen available to the organisms living in the water
(b) the oxygen needs of the organisms that live in the water
(c) the amount of oxygen necessary to complete the breakdown of the organic materials in the water
(d) the amount of oxygen that can be removed from the water molecules by living organisms
(e) the differences between the amount of oxygen used in respiration and the amount produced by photosynthesis

38. Which of the following would be a factor in affecting the biological oxygen demand in a lake?
(a) a decrease in the amount of sunlight
(b) the amount of nitrogen and phosphate entering the lake
(c) the size of the fish in the lake
(d) the depth of the lake
(e) the temperature of the water
39. In a sewage plant some of the organic material is removed in the trickling filters. The materials are removed by:
   (a) the living organisms (bacteria, algae, protozoans) found in the system
   (b) the rocks over which the water passes
   (c) the oxygen that is added
   (d) the chlorine and fluorine that is added
   (e) the solid portion falling to the bottom and the water going off the top

40. DDT kills insects by effecting their:
   (a) respiratory system
   (b) nervous system
   (c) digestive system
   (d) muscular system
   (e) all of the above

41. Birds which are basically carnivores are particularly susceptible to DDT. This is due to the fact:
   (a) DDT is not eliminated by most organisms and thus becomes more concentrated as it passes through the food chain to the birds
   (b) birds are more effected by DDT than other animals
   (c) the digestive system of birds allows the DDT to move directly into the blood stream
   (d) birds are less selective in the food they eat and thus are more apt to eat food containing DDT

42. A field or roadside ditch has been disturbed. We would predict that the first plants to grow there would be:
   (a) annuals
   (b) biennials
   (c) perennials
   (d) a combination of biennials and perennials
   (e) an equal number of annuals, biennials and perennials

43. It has been said that worn out cars represent a potential source of valuable metals. Which of the following could not be salvaged from such a car?
   (a) iron
   (b) zinc
   (c) copper
   (d) aluminum
   (e) tin

44. It is estimated that 9,000,000 cars are junked each year. As a result there is a large number of old car bodies left. Why are these old bodies not reclaimed for the metal in them?
   (a) there is no method available to process the car bodies so as to reclaim the metals
   (b) the cost to reclaim these metals is greater than the cost of purchasing new metal
(c) the metals that are in car bodies cannot be used again in cars and there is no other use for them
(d) two of the above are correct
(e) three of the above are correct

The diagram represents a slope starting at the river's edge and going up a hill. The height from the river to the top of the hill is 100 feet. The major woody plants and their approximate distribution is shown here. Use this diagram to answer questions 45-46.

45. What physical factor is the major limiting factor causing the difference in the major trees along the slope?
   (a) light
   (b) temperature
   (c) water
   (d) humus content and soil type
   (e) wind

46. Which place best represents an ecotone? Point:
   (a) A
   (b) B
   (c) C
   (d) D
   (e) E

47. It is estimated the population in the United States will double in the next:
   (a) 37 years
   (b) 63 years
   (c) 88 years
   (d) 140 years
   (e) 323 years
48. If the human population in a country showed a zero population growth, it would mean:
   (a) there would be a limited amount of food available
   (b) the death rate per thousand would equal the birth rate per thousand
   (c) there would be an equal number of individuals in each age group
   (d) disease would be the major limiting factor on the population growth
   (e) all of the above would be true

49. In a country that has people dying from starvation, the age group that is most seriously affected is the:
   (a) under 10 years of age group
   (b) 11-25 years of age group
   (c) 25-60 years of age group
   (d) those over 60
   (e) it is equally severe for all age groups

50. In terms of amount of food:
   (a) there is an unlimited amount
   (b) it will continue to increase as the population increases
   (c) it is limited to the amount of energy that can be fixed by photosynthesis
   (d) there is enough presently available to feed the entire world population at the present U. S. level if the food was properly distributed
   (e) the present production could be tripled by applying known agricultural methods to the land in the tropics

51. Which of the following represents the human growth curve?

52. Humus in the soil influences:
   (a) the per cent of water retaining capacity
   (b) the soil moisture present
   (c) the productivity of an area
   (d) two of the above are correct
   (e) three of the above are correct

53. Unless disturbed by man, a natural population through the years will tend to:
   (a) increase steadily
   (b) fluctuate
   (c) become extinct soon
   (d) decrease steadily
Use the following information to answer questions 54—56. In certain salt marshes, large populations of snails, crabs and insects harvest energy from plants and provide food for the rice rat and marsh wren. The rat and wren eat only a small portion of the annual production of snails, crabs and insects. The rats often adopt the bird nests as their own. The rats eat up to 40% of the eggs and young birds in the nests, but get only a minor fraction of their total diet in this way.

54. The most important limiting factor for the wrens appears to be:
   (a) annual production of marsh grasses
   (b) the annual productivity of first order consumers (snails, crabs, etc.)
   (c) competition for nesting space
   (d) predation by rice rats

55. The populations of snails, crabs and other first order consumers are most probably limited by:
   (a) annual production of marsh grasses
   (b) predation by rice rats
   (c) predation by marsh wrens
   (d) amount of carbon dioxide and water available

56. The most important limiting factor for the rice rat is:
   (a) annual production of marsh grasses
   (b) annual production of marsh wrens
   (c) not known from this description
   (d) the availability of grasses for nest sites

Use this information for questions 57 and 58. Twenty male and female deer are introduced onto a brush and grass covered island, where there are no natural enemies.

57. What will happen in future years?
   (a) the deer population will remain at twenty head
   (b) the deer population will get smaller
   (c) the deer will die from diseases
   (d) the population will continue to increase until there is very little brush or grass left

58. If wolves were then introduced onto the island, we can expect that eventually the wolves would:
   (a) kill many deer and then most of the wolves would starve, but the two populations could stabilize
   (b) understand the need for balance in nature and kill only enough of the deer so that some would remain
   (c) find something else to eat and leave the deer alone
   (d) replace the deer as the dominant animal species
ECOLOGY TEST UNIT I

Form A

Time Limit--50 minutes

DO NOT WRITE ON THE TEST BOOKLET

Directions:

General Directions:
Fill in the top of the answer sheet. Be sure you fill in:

(1) your name
(2) lab section number
(3) date
(4) Form
(5) name of test
(6) school
(7) test number

This test is composed of 42 questions. Each question has either four or five possible answers. Only one of these will be correct. You are to choose the most correct answer. Mark the answer sheet under the letter which corresponds to the letter of the correct response.
For questions 1-4 refer to the diagram on the last page of the test.

1. To divide the objects A, B, C, D, E, F, and G into the two indicated groups, what characteristic was used?
   (a) length of nail
   (b) size of head
   (c) if the nails were galvanized or not
   (d) thickness of nail
   (e) use of nail

2. If you were to divide A, C, D, and E on the basis of the size of the head you would place nails:
   (a) A & C together
   (b) C & D together
   (c) D & E together
   (d) A & D together
   (e) A & E together

3. Which nail would have the following set of characteristics, iron, large head, less than 3 inches long?
   (a) nail D
   (b) nail E
   (c) nail F
   (d) nail G
   (e) all of these

4. If you were to complete dividing the group B, F, G, you would have to make:
   (a) one more division
   (b) two more divisions
   (c) three more divisions
   (d) four more divisions
   (e) no more divisions

5. The fixed species concept suggests that:
   (a) species do not change
   (b) there is variation within the species
   (c) two different species cannot mate
   (d) species were formed by the evolutionary process
   (e) none of the above is correct

6. Which of the following is the correct order of classification?
   (a) kingdom, order, class, phylum, family, genus, species
   (b) kingdom, phylum, class, order, family, genus, species
   (c) kingdom, phylum, family, class, order, genus, species
   (d) kingdom, order, phylum, class, family, genus, species
   (e) none of the above

7. All micro-organisms belong to the kingdom:
   (a) plants
   (b) animals
   (c) protista
   (d) protozoa
8. A farmer wished to increase the water-retaining capacity of his soil. He might do this most effectively by:
   (a) increasing the amount of humus in the soil
   (b) adding sand to the soil
   (c) packing the soil
   (d) adding fertilizer to the soil
   (e) increase the amount of bacteria in the soil

9. Which of the following is more apt to be a limiting factor in an aquatic environment than in a terrestrial environment?
   (a) oxygen concentration
   (b) light
   (c) temperature
   (d) available nutrients
   (e) the factors listed above are equal in importance as limiting factors in either an aquatic or terrestrial environment

10. On the top of a mountain, a biologist notices that all of the trees have branches on the south side of the trunk, but not on the north side. He might conclude that:
    (a) disease was affecting the trees
    (b) a microclimate which favors growth on the south but not on the north side exists
    (c) trees of this species form branches on only one side
    (d) there is not enough light on the north side of the tree
    (e) all of the above are correct

11. Light would probably be a severe limiting factor:
    (a) on a mountain top
    (b) in a grassland
    (c) in a desert
    (d) in a forest or woodland
    (e) in all of the above habitats

12. A plant growing in the desert would:
    (a) be short and spread out along the ground
    (b) have an expansive root system
    (c) show a reduction in leaf size
    (d) two of the above are correct
    (e) three of the above are correct

13. An area has an annual rainfall of 25 inches. We would predict the major vegetation would be:
    (a) broad leaf forest
    (b) coniferous forest
    (c) grassland
    (d) desert
    (e) tundra
14. The humus content refers to:
   (a) the dead and decaying material in the soil
   (b) the ability of the soil to hold water
   (c) the amount of small rock particles found in the soil
   (d) the amount of plant life produced per given area
   (e) all of the above

15. A person who is interested in studying an ecosystem would be concerned with:
   (a) the producer organisms
   (b) the consumer organisms
   (c) the decomposer organisms
   (d) the physical aspects of the environment
   (e) all of the above

16. Ecology is the study of:
   (a) how to conserve natural resources
   (b) the interaction of living organisms and their environment
   (c) the cause and effect relationships of pollution
   (d) how to recycle valuable minerals such as iron and aluminum
   (e) the best method of producing more food

17. The range of tolerance:
   (a) is not very important for most living organisms
   (b) is the same for all organisms
   (c) is not based on scientific observations
   (d) has no effect on the growth of plants
   (e) varies with each organism

18. For plants growing on a mountaintop, the two most important limiting factors are probably:
   (a) soil nutrients and light
   (b) wind and soil nutrients
   (c) water and soil nutrients
   (d) temperature and light
   (e) wind and temperature

19. An ecological niche:
   (a) can contain many different organisms
   (b) is the job an organism has in its community
   (c) is the group of most useful animals in a community
   (d) is where an animal lives

20. Food webs:
   (a) are seldom found in nature
   (b) are more common than food chains in nature
   (c) are interesting to study, but provide little useful information
   (d) occur mainly on islands
21. Water retaining capacity:
   (a) is always the same as soil moisture
   (b) increases as humus content increases
   (c) is the same for all soil types
   (d) depends on the relative humidity

22. The effect of predation (feeding activity of carnivores):
   (a) is to lead other animals to food and water
   (b) is to stabilize population levels of other species in the food web
   (c) can reduce the productivity of an area
   (d) is not understood by scientists

23. Those organisms which return nutrients to the soil are called:
   (a) scavengers
   (b) producers
   (c) decomposers
   (d) disorganizers

24. Which relationship is different?
   (a) horse—donkey
   (b) cat—bird
   (c) hawk—mouse
   (d) snake—frog
   (e) fox—gopher

Question number 25 refers to a pine tree which grows in a forest, matures, dies and eventually falls to the forest floor where it begins to decay. Molds, mosses, algae, and microorganisms live in and or on the decaying log. Termites, worms, spiders, mice, and other organisms are also found living in or on the decaying log.

25. The decaying log and all the organisms living in and or on it could best be considered a (n):
   (a) ecosystem
   (b) population
   (c) community
   (d) society

26. Organisms that can live entirely by themselves with absolutely no relationships to other species are:
   (a) predators
   (b) herbivores
   (c) consumers
   (d) biotic
   (e) non-existent

27. The study of an ecosystem would be most concerned with:
   (a) determining population changes in the area being investigated
   (b) making measurements of regional variations in temperature, wind velocity and precipitation
(c) analyzing the inter-relationships of both living and non-living components of the region
(d) determining the effect of parasites on plants and animals found in the region

28. If all of the snakes were removed, most probably the:
   (a) salamanders would migrate
   (b) centipede density would decrease
   (c) nematode density would increase
   (d) spider population would be lowered

29. If there were a great increase in the fungi, which of the following would lead to dynamic equilibrium of the community?
   (a) an increase in amebas and paramecia
   (b) a decrease in nematodes and spiders
   (c) an increase in beetles and springtails
   (d) an increase in centipedes and nematodes

The next 3 items refer to a study of the north rim of the Grand Canyon. The area (700,000 acres) supported populations of deer, wolves, and mountain lions. In 1925 the wolves and mountain lions had been completely removed, and the deer population had increased 100,000. By 1940 the population of deer had dropped to 10,000 sick, weak, starved individuals. Use this information to answer the following questions.

30. The wolves and mountain lions played an important part in the life of the deer because they:
   (a) were in competition with one another and thus kept each other's number down
   (b) ate only the healthy deer
   (c) were probably necessary if the deer were to remain on the plateau
   (d) kept the population down to a point where the land could easily furnish sufficient food

31. By 1927 it was recognized that something should be done to correct the situation. The best long range solution to the problem would have been to:
   (a) allow unlimited hunting to reduce the population
   (b) allow limited hunting to try to maintain the population at 4,000
(c) reintroduce the wolves and mountain lions so that a natural balance would again be established
(d) remove all deer until the land had recovered and then reintroduce deer, mountain lions, and wolves so that nature could again establish a balance

32. The above information indicates that the plant community was reduced because:
   (a) the weather had been dry for several years previous causing a drought
   (b) the soil was not properly fertilized by the animal wastes and decayed remains of the wolves and mountain lions
   (c) the deer population was so great that all plants with food value were eaten
   (d) severe winters had reduced the food supply by freezing and killing much of the vegetation

33. Which of the following is not a consumer?
   (a) elephant
   (b) turkey vulture
   (c) tiger
   (d) wood tick
   (e) all of the above are consumers

34. Which of the following must constantly be added to an ecosystem?
   (a) oxygen
   (b) water
   (c) sunlight
   (d) all of the above

35. \[ \text{Sun} \rightarrow \text{Herbivores} \rightarrow \text{Carnivores} \]
   \[ \text{Green Plants} \leftarrow \text{Decomposers} \]

In the above diagram:
   (a) the herbivores are the most important members
   (b) energy is lost at each step
   (c) the decomposers return the energy to the green plants
   (d) nothing is recycled

36. The water cycle:
   (a) depends mostly on the use of water by plants
   (b) is not a true cycle
   (c) can function normally without evaporation
   (d) depends on energy from the sun
37. Decomposer organisms are important because:
   (a) they convert organic material to humus
   (b) they release nutrients from the humus that can be used by plants
   (c) they increase the water retaining capacity of the soil
   (d) they destroy disease causing organisms
   (e) they can remove nutrients from the air that can be used by the plants

Use this data for the following three questions.

<table>
<thead>
<tr>
<th>Plant</th>
<th>A</th>
<th>B</th>
<th>C</th>
</tr>
</thead>
<tbody>
<tr>
<td>Factor</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Temperature</td>
<td>40-100°F</td>
<td>70-110°F</td>
<td>40-120°F</td>
</tr>
<tr>
<td>Light</td>
<td>1000-5000 Ft.C.</td>
<td>400-800 Ft.C.</td>
<td>2000-5000 Ft.C.</td>
</tr>
<tr>
<td>Water</td>
<td>20&quot;-40&quot;</td>
<td>45&quot;-60&quot;</td>
<td>0&quot;-10&quot;</td>
</tr>
</tbody>
</table>

38. Which of the plants could grow successfully in Iowa?
   (a) plant A
   (b) plant B
   (c) plant C
   (d) all three plants
   (e) none of the plants

39. What would appear to be the most serious limiting factor for plant B?
   (a) temperature
   (b) light
   (c) water
   (d) all are of equal importance as limiting factors

40. Which plant would show the widest range of distribution?
   (a) plant A
   (b) plant B
   (c) plant C
   (d) plants A & B would show the same degree of distribution
   (e) plants B & C would show the same degree of distribution

The following represents a simple food chain in a lake:
Algae → Aquatic Insects → Minnows → Walleye Pike

41. We can be sure that if we determined the total weight of all the organisms at each level:
   (a) there would be approximately the same weight at each step
   (b) the weight of algae would be greater than for any other step
   (c) the weight of the walleye pike would be greatest
   (d) the weight of the minnows would be greater than the amount of weight of the aquatic insects, but less than the weight of the walleye pike
42. If we wished to feed the largest amount of people using the lake as the source of food, we would:
   (a) increase the number of walleye pike
   (b) introduce large minnows into the lake
   (c) remove the minnows and have the walleyes eat the aquatic insects
   (d) fertilize the lake to produce more algae
   (e) have man eat the algae
ECOLOGY TEST UNIT II

Prepared by
The Department of Science
Perry High School

Directions:

PLEASE READ THESE DIRECTIONS CAREFULLY

There are 30 multiple choice questions on this test. You are to pick the most correct answer for each question. You are to use two answer sheets, a punch check answer sheet and an IBM answer sheet. First record your answers on the punch check answer sheet. Then carefully transfer your answers to the IBM form. Be sure to use either a number two pencil or IBM marking pencil for marking your answer sheets.
1. Which of the following would be an example of a population?
   (a) 300 tenth grade students
   (b) 40 rabbits
   (c) 3000 white tailed deer killed during the 1970 hunting season
   (d) 10,000 pine trees per square mile
   (e) all of the above

2. Which of the following statements is true?
   (a) competition is greatest between different species
   (b) competition is greatest between members of the same species
   (c) the level of competition is the same, regardless of whether it is between members of the same species or members of different species
   (d) competition is least when the population size is greatest

Use the following diagram for the following two questions.

3. The graph above represents the growth curve for a population. At which stage is the environment resistance the least?
   (a) stage A
   (b) stage B
   (c) stage C
   (d) stage D
   (e) the environmental resistance is the same in all four stages

4. Assume a population in which no individuals leaves or enters the population. In order for stage D to occur the:
   (a) birth rate must equal the death rate
   (b) the biotic potential equals the environmental resistance
   (c) the size of the pre-reproductive group must equal the size of the post-reproductive group
   (d) two of the above are true
   (e) three of the above are true

5. Environmental resistance refers to:
   (a) the ability of the organism to adapt to its environment
   (b) factors in the environment which limit population growth
   (c) the ability of the organism to modify the environment
   (d) factors in the environment which limit the movement of individuals in or out of the population
   (e) the tendency for organisms to defend a particular area against other organisms
6. A country has a population growth rate of 1.4% at this rate, the population will double in about:
   (a) 20 years  
   (b) 40 years  
   (c) 60 years  
   (d) 80 years  
   (e) 100 years

7. In a certain area the crow population is increasing beyond the food supply available, which is most likely to occur first?
   (a) the birth rate will decline  
   (b) immigration  
   (c) emmigration  
   (d) increased mortality

8. A pair of mice are introduced into a cage. An unlimited amount of food is constantly supplied as the size of the population grows. After a period of time the population reaches a stable level and does not appreciably increase or decrease. The level at which the population stabilizes is the result of:
   (a) the amount of food available  
   (b) the size of the enclosure  
   (c) the biotic potential of the group  
   (d) the number of female mice produced  
   (e) the time it takes for the individual to reach adulthood

The following represents the data from three different plant communities. The figure represents the productivity in percent per square meter.

<table>
<thead>
<tr>
<th>Community A</th>
<th>Community B</th>
<th>Community C</th>
</tr>
</thead>
<tbody>
<tr>
<td>Red Clover 98%</td>
<td>Blue Grass 70%</td>
<td>Kentucky Blue Grass 50%</td>
</tr>
<tr>
<td>Sweet Clover 1%</td>
<td>Quack Grass 15%</td>
<td>Canadian Blue Grass 34%</td>
</tr>
<tr>
<td>Dandelion 1%</td>
<td>Crab Grass 10%</td>
<td>Prairie Clover 10%</td>
</tr>
<tr>
<td></td>
<td>Dandelion 5%</td>
<td>Sunflowers 2%</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Violets 1%</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Misc. 3%</td>
</tr>
</tbody>
</table>

9. Which of the following is true of productivity?
   (a) it estimates the amount of light energy that is converted into food energy  
   (b) it determines the amount of animal life an area can support  
   (c) it indicates the major limiting factors for the area  
   (d) two of the above are true  
   (e) three of the above are true

10. The dominant species in community C is:
    (a) Kentucky blue grass  
    (b) Canadian blue grass
(c) prairie clover
(d) sunflowers
(e) there is no dominant species in community C

11. Which community would probably have the least amount of animal life present?
(a) community A
(b) community B
(c) community C
(d) they would all have equal amounts of animal life
(e) there is not enough information to determine the amount of life present

The following represents the interaction between five chickens.

<table>
<thead>
<tr>
<th>Chicken Number</th>
<th>Is Pecked</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>X</td>
</tr>
<tr>
<td>2</td>
<td>X</td>
</tr>
<tr>
<td>3</td>
<td>X</td>
</tr>
<tr>
<td>4</td>
<td>X</td>
</tr>
<tr>
<td>5</td>
<td>X</td>
</tr>
</tbody>
</table>

Thus chicken number 1 can peck chickens 3 and 4. Use this information for the next two questions.

12. Which of the following is true of a peck order of this type?
(a) it reduces the level of competition within the group
(b) once the peck order is determined it is retained in future meetings
(c) peck orders are maintained only during the reproductive season
(d) two of the above are correct
(e) three of the above are correct

13. A pan of chicken feed is placed in the pen and only one chicken can eat at a time. Which chicken would probably eat first, assuming they are all hungry?
(a) chicken number 1
(b) chicken number 2
(c) chicken number 3
(d) chicken number 4
(e) chicken number 5
14. Which of the following curves correctly illustrates the relationship between a predator and its prey?

![Graph options A, B, C, D]

15. Which of the following factors will not be affected by the density of the population?

(a) food supply
(b) waste material accumulation
(c) space
(d) freezing temperature
(e) all of the above

16. Which of the following most closely represents the growth curve of a population if its rate of reproduction is near its biotic potential?

![Graph options a, b, c, d, e]

17. Which of the following is true of territory rights, in animals?

(a) they are formed between members of the same species
(b) they are in operation primarily during the reproductive season
(c) they provide the minimum requirements (food, etc.) for survival
(d) two of the above are correct
(e) three of the above are correct

18. What causes the decrease in a population of organisms that are limited to a closed area where no individuals can enter or leave?

(a) lack of food
(b) accumulation of wastes
(c) over crowding of individuals
(d) two of the above are the causitive factors
(e) three of the above are the causitive factors

19. A population of mice are set up so that mice can leave the pen but no mice can enter it. The population increases. Probably the increase was due to an increase in:

(a) immigration
(b) emigration
(c) mortality (death)
(d) natality (birth)
(e) some factor other than the factors listed above
20. A biologist samples a population and finds that the age distribution of the population can be represented in the following manner:

We would predict:
(a) the population will become extinct
(b) there will be a large increase in the population in the future
(c) the population will remain stable
(d) the population is unstable and may either increase or decrease
(e) the population will show a constant decrease in the future

Use the following key for questions 21 and 22.
(1) Parasitism
(2) Commensalism
(3) Mutualism
(4) Predation
(5) None of the above

21. Certain microscopic animals can be seen attached to the legs of fresh water shrimp. The microscopic animals appear only to get protection and mobility from the shrimp.

22. Termites eat wood but cannot digest it. A certain species of protozoan can digest the wood, but cannot live if they are removed from the digestive tract of the termites.

Use this diagram to answer questions 23 and 24.

23. Which of the following represents an ecotone?
(a) area A
(b) area B
(c) area C
(d) area A and B
(e) areas B and C

24. The variety of animal life would be:
(a) greatest in area A
(b) greatest in area B
(c) greatest in area C
(d) the same in all three areas
(e) there is not sufficient information to make a decision
The following three questions refer to the distribution of vegetation along a slope. Use the diagram below to answer questions 25-27.

25. Which limiting factor shows the greatest continual change as one moves up the slope?
   (a) temperature
   (b) water
   (c) light
   (d) soil nutrients
   (e) humidity

26. Basswood is found growing in all areas of the slope except areas A and B. We might conclude:
   (a) basswoods will grow only in high light intensity
   (b) basswoods show a wide range of tolerance for many factors
   (c) basswoods require a soil with a low humus content
   (d) basswoods require a soil with a high water content
   (e) basswoods are a good indicator (index) species

27. Willows are limited almost exclusively to area B. On the basis of this we might conclude:
   (a) area B represents a sharp and distinct change for at least one limiting factor
   (b) willows could be used for an indicator species for the presence of high water concentration
   (c) the willows are dying out
   (d) two of the above are correct
   (e) three of the above are correct

28. Several birds that normally migrate together are captured in July and placed in a cage. They are exposed to 16 hours of light and 8 hours of darkness each day. In October we might expect these birds to:
   (a) show signs of wanting to migrate
   (b) show increased hostility towards each other
   (c) a tendency to flock together
   (d) two of the above are true
   (e) none of the above are true

29. The eggs of a migratory bird are taken from the nest and hatched in the laboratory. The birds are raised and released six weeks after the last wild member of the species has left the area. The birds follow the same migratory route of their parents. This
indicates:
(a) migration is a learned phenomenon
(b) birds pick their routes by trial and error
(c) the route birds follow is determined by instinct
(d) the adult birds leave signs the young birds can follow
(e) the birds follow the magnetic lines of force of the earth

30. Which of the following statements is true of a predator prey relationship?
(a) there is always more predators than there are prey
(b) most predators kill only to satisfy their food needs
(c) in a natural environment a dynamic equilibrium will exist between a predator and its prey
(d) two of the above are true statements
(e) three of the above are true statements
ECOLOGY TEST UNIT III

Directions:

This test is composed of 33 multiple choice items. Select the most correct response for each question. Record your answer on the answer sheet provided. You will have 50 minutes to complete the test.
1. A BOD sample is taken in May and a second sample is taken in June. The June sample shows a higher reading than the May sample. This could be explained by the fact:
   (a) the plants are producing more oxygen
   (b) there has been an increase in the amount of organic matter in the water
   (c) the organisms living in the water require more oxygen
   (d) oxygen is diffusing into the water from the air
   (e) the light is unable to penetrate to the bottom of the water

2. The biological removal of organic material from water in a sewage plant occurs during:
   (a) primary treatment
   (b) secondary treatment
   (c) tertiary treatment
   (d) all of the above
   (e) two of the above

3. In the slow trickling filter at the sanitary sewer, the actual removal of the organic material is brought about by:
   (a) the rocks
   (b) the living organisms
   (c) the digestor
   (d) the water
   (e) all of the above

4. The major cause of phosphate pollution in order of decreasing degree is:
   (a) agriculture, industry, homes
   (b) industry, agriculture, homes
   (c) homes, agriculture, industry
   (d) agriculture, homes, industry
   (e) homes, industry, agriculture

5. An area of 5000 acres is established as a grassland. If the climate is such that trees could grow, how could the grassland be best maintained?
   (a) it would be impossible to maintain the grassland, as all grasslands eventually become a forest
   (b) cut down the trees
   (c) periodically burn the area
   (d) allow grazing by herbaceous animals
   (e) plow up the area and allow it to undergo succession back to a grassland

6. A roadside area is disturbed, so that all of the vegetation is destroyed. We would predict that the first type of plant life would be:
   (a) annual plants
   (b) biennial plants
(c) perennial plants
(d) 50% annual and 50% perennial
(e) 40% annual, 40% biennial and 20% perennial

The following represents a succession for a given area. Use this information for the next three questions.

Community A → Community B → Community C → Community D

7. A student visits a woodland community and wishes to determine if it is a climax community. If it was climax community:
   (a) the community would be basically a monoculture
   (b) we would expect to find members of the dominant species in each age group
   (c) the soil moisture would be low
   (d) light would be the major limiting factor
   (e) all of the above are true of a monoculture

8. If we wished to maintain the area with plant and animal life like that of community A, it would be:
   (a) necessary to periodically disturb the area
   (b) prevent seeds from community B from being introduced
   (c) necessary to plant the seed of community A
   (d) wait until it had gone through stage D and return to stage A
   (e) impossible to maintain the area permanently as community A

9. Which of the communities is not causing a change in the environment?
   (a) they are all causing major changes in the environment
   (b) only community A is not causing a major change in the environment
   (c) communities A and D are not causing a change in the environment
   (d) only community D is not causing a change in the environment
   (e) none of the communities are causing a change in the environment

10. Which of the following would be true of the animal life in the communities?
    (a) we would expect community A to have the least number of different species
    (b) the kind of species present would differ in each of the communities
    (c) the kinds of species in community D would remain stable, but the amount of each kind might vary
    (d) two of the above are true
    (e) three of the above are true

11. The major climax vegetation for Iowa would be:
    (a) an oak-hickory forest
    (b) coniferous forest
12. The type of climax community which develops is determined by the:
(a) soil type
(b) elevation of the area
(c) life form of the plants
(d) climate
(e) animal life present

13. Some authorities have suggested cities need to develop rapid trans­
portation systems. The value of this would be to:
(a) move people rapidly from the suburbs to the city and back
(b) reduce the number of parking spaces needed
(c) provide low cost transportation
(d) reduce the air pollution problem
(e) make more jobs available to people

Use the following key for the next three questions, to identify the

type of biome.
(a) grassland
(b) deciduous forests
(c) desert
(d) tundra
(e) all of these

14. The yearly rainfall is between 10 and 30 inches.

15. Some of the animals in these biomes obtain their water through
the plants they eat.

16. The woody plants that are present tend to be stunted and sprawling.

17. Which of the following represents the largest amount of air pol­
lution?
(a) hydrocarbons
(b) particulate material such as soot
(c) oxides of nitrogen
(d) oxides of sulfur
(e) carbon monoxide

18. In a sanitary treatment plant of the type found in Perry what per­
cent of the organic material that enters the plant can be removed
before the water leaves the system?
(a) less than 50%
(b) 70-80%
(c) 80-90%
(d) more than 95%
(e) all of the organic material
19. It is necessary to remove the organic materials from the sewage water because:
   (a) it provides too much food for the aquatic life in the river or lake
   (b) it uses oxygen from the water to bring about decay
   (c) it produces undesirable odors
   (d) it provides a health hazard in terms of disease
   (e) it interferes with the photosynthetic activity of the plants

20. The breakdown of organic material into simpler substances is brought about by the action of:
   (a) bacteria
   (b) temperature
   (c) water
   (d) two of the above
   (e) three of the above

The following diagram represents an anaerobic-aerobic lagoon system for the treatment of industrial wastes in water

Plant → Primary → Secondary → Tertiary → River
   (Anaerobic) → Lagoon → Lagoon → Lagoon → (Aerobic)

21. In which lagoon would you expect to find the least amount of oxygen?
   (a) primary lagoon
   (b) secondary lagoon
   (c) tertiary lagoon
   (d) it would be the same for all lagoons
   (e) it is impossible to tell from the information provided

22. If the BOD of material entering the primary lagoon is 1500 mg/liter, the secondary lagoon 150 mg/liter, the tertiary lagoon is 75 gm/liter and the river is 15 gms/liter, what is the total efficiency of the system?
   (a) 99% efficiency
   (b) 95% efficiency
   (c) 86% efficiency
   (d) 90% efficiency
   (e) 97% efficiency

23. Where is the removal of nitrogen and phosphate compounds most efficient?
   (a) primary lagoon
   (b) secondary lagoon
   (c) tertiary lagoon
   (d) it is the same in all three lagoons
   (e) the system is not designed to remove nitrogen and phosphate compounds
24. As a biology student you visit a plant that is building a la­
goon system of this type and you note that one of the lagoons
is built with a large amount of surface area and the depth of
the lagoon is shallow. You would expect this to be the:
(a) primary lagoon
(b) secondary lagoon
(c) teritary lagoon
(d) either the primary or secondary lagoon
(e) either the secondary or teritary lagoon

25. Which of the lagoons is most effective in removing organic
material?
(a) primary lagoon
(b) secondary lagoon
(c) teritary lagoon
(d) they are all equally effective
(e) the system will not function unless all three lagoons
are working

26. Smog will be most dangerous to a person's health:
(a) in the summer time
(b) during the day time
(c) if a thermal inversion occurs
(d) when the wind is blowing
(e) in an area where there is little rainfall

27. Which of the following is true of air pollution?
(a) there has always been some air pollution
(b) the amount of air pollution has steadily increased since
the industrial revolution
(c) death from certain disease has shown a direct correlation
with the amount of air pollution
(d) two of the above are correct
(e) three of the above are correct

28. The life expectancy of a new car is about:
(a) 3-4 years
(b) 4-5 years
(c) 5-6 years
(d) 6-7 years
(e) over 8 years

29. The junked car in the United States represents a potential source
of:
(a) 300,000 pounds of iron
(b) 3 million pounds of iron
(c) 33 million pounds of iron
(d) 3 billion pounds of iron
(e) 33 billion pounds of iron
30. Which of the following is true of bodies of junk cars.
   (a) the cost of recycling them is greater than their current market value
   (b) must have certain things such as the chrome removed before they can be melted down
   (c) has a value of $16-$18 per ton
   (d) two of the above are true
   (e) three of the above are true

31. Of all the pollution problems, the major factor, common to all, that prevents or slows down their solution is:
   (a) lack of trained man power
   (b) lack of knowledge to solve the problem
   (c) the cost of solving the problem
   (d) time needed to solve the problem
   (e) all of the above

32. Which of the following metals is not present, in significant amounts, in an automobile?
   (a) iron
   (b) zinc alloys
   (c) aluminum alloys
   (d) tin
   (e) lead

33. When an automobile is purchased for salvage parts, what parts are most valuable?
   (a) the motor train (engine, transmission, etc.)
   (b) tires
   (c) doors
   (d) windows
   (e) all of these are of about equal value
ECOLOGY - RETENTION TEST

Directions:

This test is composed of 40 multiple choice questions. Select the most correct answer and make the corresponding letter on the answer sheet provided.
1. An ecological niche:
   (a) can contain many different organisms
   (b) is the job an organism has in its community
   (c) is the group of most useful animals in a community
   (d) is where an animal lives

2. On top of a mountain, a biologist notices that all of the trees have branches on the south side of the trunk, but not on the north side. He might conclude that:
   (a) a disease was effecting the trees
   (b) a micro climate existed which favors growth on the south but not the north side
   (c) trees of this species form branches only on one side
   (d) there is not enough light on the north side of the tree
   (e) all of the above are correct

3. A farmer wished to increase the water-retaining capacity of his soil. He might do this most effectively by:
   (a) increasing the amount of humus in the soil
   (b) adding sand to the soil
   (c) packing the soil
   (d) adding fertilizer to the soil
   (e) increase the amount of bacteria in the soil

Use this diagram for questions 4 and 5.

```
        Snakes
         v
  Salamanders  Spiders
             v
       Centipedes  Nematodes (Roundworms)
          v
    Beetles  Springtails
          v
     Fungi  Amebas  Paramecia
                v
          Bacteria
```

4. If all of the snakes were removed, most probably:
   (a) the salamanders would emigrate
   (b) the centipede density would decrease
   (c) the nematode density would increase
   (d) the spider population would be lowered

5. If there were a great increase in fungi, which of the following would lead to dynamic equilibrium of the community?
   (a) an increase in amebas and paramecia
   (b) a decrease in nematodes and spiders
   (c) an increase in beetles and springtails
   (d) an increase in centipedes and nematodes
6. Algae $\rightarrow$ Aquatic Insects $\rightarrow$ Minnows $\rightarrow$ Walleye Pike
We can be sure that if we determined the total weight of all the organisms at each step:
(a) there would be approximately the same weight at each step
(b) the weight of algae would be greater than for any other step
(c) the weight of the walleye pike would be greatest
(d) the weight of the minnows would be greater than the amount of weight of the aquatic insects, but less than the weight of the walleye pike

7. Decomposer organisms are important because:
(a) they convert organic material to humus
(b) they release nutrients from the humus that can be used by plants
(c) they increase the water retaining capacity of the soil
(d) they destroy disease causing organisms
(e) they can remove nutrients from the air that can be used by the plants

8. Which of the following statements is true?
(a) competition is greatest between different species
(b) competition is greatest between members of the same species
(c) the level of competition is the same, regardless of whether it's between members of the same species or members of different species
(d) competition is least when the population size is greatest

9. Which of the following curves correctly illustrates the relationship between a predator and its prey?

10. Which of the following most closely represents the growth curve of a population if its rate of reproduction is near its biotic potential?
11. Which of the following is true of territory rights in animals? 
   (a) they are formed between members of the same species 
   (b) they are in operation primarily during the reproductive season 
   (c) they provide the minimum requirements (food etc.) for survival 
   (d) two of the above are correct 
   (e) three of the above are correct 

12. A biologist samples a population and finds that the age distribution of the population can be represented in the following manner.

   We would predict:
   (a) the population will become extinct 
   (b) there will be a large increase in the population in the future 
   (c) the population will remain stable 
   (d) the population is unstable and may either increase or decrease 
   (e) the population will show a constant decrease in the future 

13. Termites eat wood but cannot digest it. A certain species of protozoan can digest the wood, but cannot live if they are removed from the digestive tract of the termites.
   (a) parasites 
   (b) commensalism 
   (c) mutualism 
   (d) decomposers 
   (e) producers 

Use this diagram to answer questions 14 and 15.

The diagram above represents where two communities meet.
14. Which of the following represents an ecotone?
   (a) area A  
   (b) area B  
   (c) area C  
   (d) areas A and B  

15. The variety of animal life would be:
   (a) greatest in area A  
   (b) greatest in area B  
   (c) greatest in area C  
   (d) the same in all three areas  
   (e) there is not sufficient information to make a decision  

Use this diagram for questions 16 and 17.

16. Basswood is found growing in all areas of the slope except areas A and B. We might conclude:
   (a) basswoods will grow only in high light intensity  
   (b) basswoods show a wide range of tolerance for many factors  
   (c) basswoods require a soil with a low humus content  
   (d) basswoods require a soil with a high water content  
   (e) basswood is a good indicator (index) species  

17. Willows are limited almost exclusively to area B. On the basis of this we might conclude:
   (a) area B represents a sharp and distinct change for at least one limiting factor  
   (b) willows could be used for an indicator species for the presence of high water concentration  
   (c) the willows are dying out  
   (d) two of the above are correct  
   (e) three of the above are correct  

18. A BOD sample is taken in May and a second sample is taken in June. The June sample shows a higher reading than the May sample. This could be explained by the fact:
   (a) the plants are producing more oxygen  
   (b) there has been an increase in the amount of organic matter in the water
(c) the organisms living in the water require more oxygen
(d) oxygen is diffusing into the water from the air
(e) the light is unable to penetrate to the bottom of the water

19. A roadside area is disturbed, so that all of the vegetation is destroyed. We would predict that the first type of plant life would be:
(a) annual plants
(b) biennial plants
(c) perennial plants
(d) 50% annual and 50% perennial
(e) 40% annual, 40% biennial and 20% perennial

The following represents a succession for a given area. Use this information for questions 20 through 22.

Community A → Community B → Community C → Community D (Climax Community)

20. A student visits a woodland community and wishes to determine if it is a climax community. If it was climax community:
(a) the community would be basically a monoculture
(b) we would expect to find members of the dominant species in each age group
(c) the soil moisture would be low
(d) light would be the major limiting factor
(e) all of the above are true of a monoculture

21. If we wished to maintain the area with plant and animal life like that of community A, it would be:
(a) necessary to periodically disturb the areas
(b) prevent seeds from community B from being introduced
(c) necessary to plant the seeds of community A
(d) wait until it had gone through stage D and return to stage A
(e) impossible to maintain the area permanently as community A

22. Which of the communities is not causing a change in the environment?
(a) they are all causing major changes in the environment
(b) only community A is not causing a major change in the environment
(c) communities A and D are not causing a change in the environment
(d) only community D is not causing a change in the environment
(e) none of the communities are causing a change in the environment

23. The type of climax community which develops is determined by the:
(a) soil type  
(b) elevation of the area  
(c) life form of the plants  
(d) climate  
(e) animal life present

24. It is necessary to remove the organic materials from the sewage water because:  
   (a) it provides too much food for the aquatic life in the river or lake  
   (b) it uses oxygen from the water to bring about decay  
   (c) it produces undesirable odors  
   (d) it provides a health hazard in terms of disease  
   (e) it interferes with the photosynthetic activity of the plants

The following diagram represents an anaerobic-aerobic lagoon system for the treatment of industrial wastes in water:

Plant → Primary Lagoon → Secondary Lagoon → Teritary Lagoon → River Lagoon
(Aerobic) (Aerobic) (Aerobic)

Questions 25 and 26 refer to this type of lagoon system.

25. In which lagoon would you expect to find the least amount of oxygen?  
   (a) primary lagoon  
   (b) secondary lagoon  
   (c) teritary lagoon  
   (d) it would be the same for all lagoons  
   (e) it is impossible to tell from the information provided

26. Where is the removal of nitrogen and phosphate compounds most efficient?  
   (a) primary lagoon  
   (b) secondary lagoon  
   (c) teritary lagoon  
   (d) it is the same in all three lagoons  
   (e) the system is not designed to remove nitrogen and phosphate compounds

27. Smog will be most dangerous to a person's health:  
   (a) in the summer time  
   (b) during the day time  
   (c) if a thermal inversion occurs  
   (d) when the wind is blowing  
   (e) in an area where there is little rainfall

28. Which of the following is true of bodies of junk cars?  
   (a) the cost of recycling them is greater than their current market value
(b) must have certain things such as the chrome removed before they can be melted down
(c) has a value of $16-$18 per ton
(d) two of the above are true
(e) three of the above are true

29. Which of the following is not recycled in an ecosystem?
(a) oxygen
(b) water
(c) minerals
(d) energy
(e) none of the above are recycled

30. The following diagram is a skeleton outline of the relationship of the living organisms in a community. Select the answer that correctly identifies the proper sequence.

(a) 1. decomposers 2. carnivores 3. herbivores 4. producers
(b) 1. producers 2. herbivores 3. carnivores 4. decomposers
(c) 1. producers 2. decomposers 3. herbivores 4. carnivores
(d) 1. herbivores 2. carnivores 3. producers 4. decomposers
(e) 1. carnivores 2. producers 3. herbivores 4. decomposers

Use this information for questions 31 through 33.

<table>
<thead>
<tr>
<th>Plant</th>
<th>A</th>
<th>B</th>
<th>C</th>
<th>D</th>
</tr>
</thead>
<tbody>
<tr>
<td>rainfall</td>
<td>20-40&quot;</td>
<td>20-80&quot;</td>
<td>20-45&quot;</td>
<td>5-10&quot;</td>
</tr>
<tr>
<td>light ft/c</td>
<td>1100-1500</td>
<td>900-1800</td>
<td>200-350</td>
<td>900-1700</td>
</tr>
<tr>
<td>nitrogen</td>
<td>30-50 ppm</td>
<td>10-50 ppm</td>
<td>25-60 ppm</td>
<td>10-20 ppm</td>
</tr>
<tr>
<td>phosphorous</td>
<td>10-40 ppm</td>
<td>5-35 ppm</td>
<td>5-30 ppm</td>
<td>5-15 ppm</td>
</tr>
</tbody>
</table>

31. If a given environment had the following conditions, light=1200 foot candles, water=30 inches, available nitrogen=20ppm and phosphate=18ppm, which factor would be the most serious limiting factor for plant A?
(a) water
(b) light
(c) nitrogen
(d) phosphorous
(e) all four factors are equal as limiting factors

32. Which of these plants, based on the above factors, would show the widest range of distribution?
(a) plant A
(b) plant B
(c) plant C
(d) plant D

34. Which of the following statements is true of a climax community?
(a) the type of vegetation will be the same in all climax communities
(b) the type of vegetation will always be a woodland or forest
(c) the type of vegetation will be determined by the climate and soil in a climax community
(d) the type of vegetation will change very slowly in a climax community
(e) the vegetation will be composed of only mature adult plants

The following represents a pyramid of biomass (total weight of the individuals at a particular level). Assume that herbivores have an efficiency of 15% and all carnivores have an efficiency of 20%. Use this information for the following question.

35. If we wished to have a larger population of birds, we could:
(a) use large insects
(b) use larger plants
(c) have the birds eat the plants
(d) use larger birds
(e) all of the above

Use this information for questions 36 and 37.

<table>
<thead>
<tr>
<th></th>
<th>Area A</th>
<th></th>
<th></th>
<th>Area C</th>
</tr>
</thead>
<tbody>
<tr>
<td>Alfalfa</td>
<td>92%</td>
<td>Alfalfa</td>
<td>32%</td>
<td>Blue Grass</td>
</tr>
<tr>
<td>Clover</td>
<td>4%</td>
<td>Blue Grass</td>
<td>54%</td>
<td>Clover</td>
</tr>
<tr>
<td>Dandelion</td>
<td>1%</td>
<td>Clover</td>
<td>3%</td>
<td>Quack Grass</td>
</tr>
<tr>
<td>Quack Grass</td>
<td>3%</td>
<td>Dandelion</td>
<td>3%</td>
<td>Crab Grass</td>
</tr>
<tr>
<td></td>
<td>Quack Grass</td>
<td>8%</td>
<td>Quack Grass</td>
<td>8%</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Sour Dock</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Misc.</td>
</tr>
</tbody>
</table>

36. Which area would probably show the greatest amount of productivity per meter squared?
(a) area A
(b) area B
(c) area C
(d) all three areas would show the same degree of productivity
(e) it is impossible to judge based on the information provided
37. Which of the following has the greatest influence on the community from which the data for area C was calculated?
   (a) blue grass
   (b) clover
   (c) crab grass
   (d) quack grass
   (e) wild phlox

Use the below diagram for question 38.

38. If two different species occupied the same niche in the community, we could predict:
   (a) both species would die out due to the competition
   (b) both species would survive at a level lower than either species would survive along
   (c) species A would probably survive and species B would die out
   (d) species B would probably survive and species A would die out

39. Birds which are basically carnivores are particularly susceptible to DDT. This is due to the fact:
   (a) DDT is not eliminated by most organisms and thus becomes more concentrated as it passes through the food chain to the birds
   (b) birds are more affected by DDT than other animals
   (c) the digestive system of birds allows the DDT to move directly into the blood stream
   (d) birds are less selective in the food they eat and thus are more apt to eat food containing DDT

40. If the human population in a country showed a zero population growth, it would mean:
   (a) there would be a limited amount of food available
   (b) the death rate per thousand would equal the birth rate per thousand
   (c) there would be an equal number of individuals in each age group
   (d) disease would be the major limiting factor on the population growth
   (e) all of the above would be true
ENVIRONMENTAL ATTITUDE SCALE

This questionnaire has been developed to learn more about your feelings in regards to environmental problems. Your opinion is important, so please answer these questions as honestly as you can.

In each case you should read the statement carefully and decide how you feel about that statement. You may think the statement is certainly true, so you might say that you strongly agree with that statement. You might feel the statement is certainly not true. In this case you might say that you strongly disagree with the statement.

In some cases your feeling about the statement may be somewhere between these very strong answers, and you might just agree or disagree. In a few cases you may feel that you don't know enough about the statement to mark any of these or you may not feel one way or the other----you would then mark no opinion.

To make it easier for you, these different possible answers are listed next to the numbers 1, 2, 3, 4 and 5. You should choose the answer YOU believe best describes your feeling and blacken in the corresponding space on the IBM answer sheet.

5. I strongly agree with the statement.
4. I agree with the statement.
3. I have no opinion about the statement.
2. I disagree with the statement.
1. I strongly disagree with the statement.

REMEMBER, THE ONLY CORRECT ANSWER IS THE ONE WHICH ACTUALLY REPRESENTS HOW YOU FEEL ABOUT THE CURRENT ENVIRONMENTAL CRISIS.
1. The time has come for Congress to develop an intensive program to stop the United State's population growth.

2. Persistent pesticides, such as DDT, should be banned from the market.

3. More emphasis should be placed on the development of biological control of pests and less reliance on chemical control.

4. People should use low phosphate soaps and detergents, even if their clothes do not get as white as they do with phosphate products.

5. The federal and state governments should purchase more land and maintain it in its natural condition.

6. People, such as Paul Ehrlich, who predict serious population problems in the near future are incorrect in their analysis.

7. More land should be set aside as wildlife refuges.

8. Road construction and housing developments should be prevented from destroying valuable natural land areas.

9. Most people who use and sell pesticides are more concerned about money than their affects on the environment.

10. It is essential to recycle materials such as paper, metals, etc., even if the cost of recycling is greater than procuring new materials.

11. It is desirable to have wildlife around simply for enjoyment.

12. In the future, the average person will have to get along with fewer conveniences.

13. The ban on open burning has caused more problems than it has solved.


15. A program supported by tax money should be developed to reclaim much of the solid materials that are currently being hauled to the dump grounds.
APPENDIX B. FIELD TRIP EXERCISES
IDENTIFICATION OF COMMON TREES USING A KEY

In working with plants and animals, it is often desirable to be able to identify them. This requires some type of classification. Organisms are grouped together on the basis of similarity or dissimilarity of characteristics. The more closely related are the organisms, the greater is the number of similar characteristics.

A key is a device used to identify the organism as to kind. It is based on the concept of analyzing an organism's characteristics one at a time. A person is asked to look at a certain characteristic. He must then decide if the organism has or lacks this characteristic. On the basis of the choice he makes, he is directed to look at a second characteristic. Again he must make a choice and move on to the next pair of characteristics. If he makes the correct choices throughout the entire key, he arrives at the correct name for the organism. In this exercise you will use a key to help you identify some of the common trees found around Perry.

Objectives:

The student shall be able to:

1. Identify 10 out of 15 common trees found in the Perry area. A list of trees to be studied will be given to the student at the time of the study.

2. Show he can use the key by identifying an unknown tree using the key.

3. Having identified the tree and its common names, use other keys to find its scientific name.

Materials:

1. Key to the common trees of Iowa.
2. Picture key to trees of Iowa.

Procedure:

1. The best way to learn to use a key is to actually identify trees with it. In this exercise you will be working with specimens taken from trees of this area.

Student Activity:

1. Identify the trees as directed by your instructor.

2. Prepare a collection of ten different species of trees. These are to be pressed and mounted on paper as indicated by your instructor.
LIMITING FACTORS

Certain physical factors have pronounced effects upon the type of vegetation which is found in an area. This laboratory exercise will study some of these factors. The six basic factors to be studied are: light intensity, soil moisture, water retaining capacity, humus content, humidity and soil particle size. Some of these factors vary from time to time and need to be measured over a period of time to fully understand their implications.

Objectives:
The student shall be able to:

1. Measure light intensity, humidity, soil moisture, water retaining capacity, humus content and soil particle size.

2. Define each of the above terms.

3. Select statements which indicate the effect of humus on soil aeration, water retaining capacity and soil moisture.

4. Determine the light intensity in an open area, partial shading and heavy shading. Having measured the light in these areas, the student shall calculate the approximate amount at each vegetative layer.

5. Calculate the per cent of each soil particle class and with the use of a table determine the type of soil present.

6. Determine the per cent of humus in the soil.

7. Determine the maximum amount of water a soil can hold.

8. Determine the actual amount of water present.

Materials:

<table>
<thead>
<tr>
<th>Soil Thermometer</th>
<th>Soil Sieves</th>
<th>Mortar and Pestle</th>
</tr>
</thead>
<tbody>
<tr>
<td>Photometer</td>
<td>Plastic Bags</td>
<td>Scales</td>
</tr>
<tr>
<td>Sling Psychrometer</td>
<td>Oven</td>
<td></td>
</tr>
</tbody>
</table>
Procedure:

Three different sites (permanent grassland, woodland, and a cornfield) will be analyzed for the physical factors listed below. Each lab will analyze one site. The data for all labs will be pooled.

Make the following analyses for your particular site. Record your data on the data sheet provided.

1. Temperature. Air and soil thermometers. Record at 4' high, at soil surface, at 1" depth, and at 6" depth (drill or dig a hole for this).


3. Light Intensity. Using a photometer measure the light in a clearing in "average shade" and in heavy shade. Record the time of day.

4. Soil Samples. Using a geotome collect a soil sample (which takes two extractions with the tube) at 0-6", 6-12", 12-18". Make the following analysis:
   (a) mechanical analysis
   (b) soil moisture content
   (c) water retaining capacity
   (d) organic content

5. Miscellaneous Data. Date. Accurate geographical location of quadrat. (State, county, township, range, section, forty or lot). Altitude. Topographical setting.

Preliminary Preparation:

1. For measuring the soil-water content, keep the bags tightly sealed and the sample should be immediately oven-dried. For the other three types of measurement, air dry the soil samples by spreading them out (e.g., on a sheet of heavy cardboard) and exposing them to the air for 24 hours.

2. All measurements are weights (to nearest tenth of a gram), finally expressed as per cents (to nearest tenth).

Mechanical Analysis:

Pulverize the soil with a mortar and pestle. Sift through soil sieves after weighing. Express each of the six classes as per cent, to total 100.

<table>
<thead>
<tr>
<th>Soil Class</th>
<th>Mesh No.</th>
<th>Minimum Particle Diameter (mm.)</th>
</tr>
</thead>
<tbody>
<tr>
<td>I Gravel</td>
<td>18</td>
<td>1.0</td>
</tr>
<tr>
<td>II Course Sand</td>
<td>35</td>
<td>0.5</td>
</tr>
</tbody>
</table>
III Medium Sand 60 0.25
IV Fine Sand 140 0.1
V Very Fine Sand 300 0.05
VI Silt and Clay
(Clay is under 0.005)

Soil Moisture:

Weights: a - air dry; o - oven dry; w - wet; s - soil; c - can

\[
\frac{\text{Wet soil} - \text{oven dried}}{\text{Dry soil}} \times 100 = \% \text{ of soil moisture}
\]

Water Retaining Capacity (W.R.C.)

\[
\frac{\text{Wet soil} - \text{air dried soil}}{\text{Air dried soil}} = 100
\]

Student Activity:

1. What per cent of available light falls on the floor of a woodland?

2. Define humus, water retaining capacity and soil moisture.

3. Which temperature would show the greatest amount of fluctuation? Explain how these temperatures may effect normal plant growth.

4. How does soil particle size effect the water retaining capacity of the soil?

5. Of what value is humus to good soil composition?

6. What factors effect the humidity in an area? Why is humidity an important factor in plant growth?

7. Explain why soil moisture may vary from time to time but water retaining capacity does not vary.

8. How does the slope of the ground effect the soil temperature?

9. Compare the three sites for each of the physical factors listed above.
A PRODUCTIVITY STUDY OF HERBACEOUS PLANTS

In any ecosystem there is a loss of useful energy. Consequently, energy must constantly be added to the system. The only source of energy available to the biotic portion of the ecosystem is light energy. The conversion of light energy into a form available to living organisms is achieved by the photosynthetic activity of the producer organisms.

The ability to convert light energy into chemical energy and store it as food is called productivity. Productivity can be defined as the amount of dry food material produced per unit area per unit time.

This laboratory exercise is designed to compare the productivity of areas, having different types of vegetation. The areas studied will include an area currently under agricultural cultivation, a disturbed area and an area showing climax vegetation.

Objectives:
The student shall be able to:

1. Define or select statements which define: (a) community (b) monoculture

2. Distinguish between an agricultural community and a natural community in terms of total productivity and degree of diversity.

3. List examples of diseases affecting monocultures in the immediate area.

4. Predict which communities may suffer the most serious loss of productivity when infected by a single disease organism.

5. Pick the dominant species in each area.

6. Compute the productivity per square meter for a given area.
7. Compute the productivity per species, to a maximum of five species per given area.

8. Compare the productivity of the areas sampled and list them in descending order of their productivity.

9. Write a one page paper as to the different degrees of productivity and suggest possible explanations.

Materials:

<table>
<thead>
<tr>
<th>meter stick</th>
<th>stakes</th>
<th>string</th>
<th>scissors</th>
</tr>
</thead>
<tbody>
<tr>
<td>paper sacks</td>
<td>scales</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Procedure:

1. Select the areas to be studied. In an experimental study, several of these areas would be selected randomly to ensure achieving a representative sample. For the purpose of this exercise, select one sample which is representative of the vegetation present.

2. Mark off an area which represents one-fourth of a square meter. This can be accomplished by constructing a square 50 cm x 50 cm. Enclose this area with the string and stakes provided.

3. Cut all of the vegetation at soil level and place it in the sack provided.

4. The rest of the laboratory work will be done indoors. Determine the total weight of the sack plus the plant material.

5. Determine the weight of the sack.

6. Subtract the weight of the sack from the total weight determined in step four. The remaining weight represents the weight of the plant material or the productivity per one-fourth meter. Convert this to grams per meter square, by multiplying by four. In most studies the plant material would first be dried to remove the water in the tissue. For the purpose of this study, this will not be necessary.

7. Separate the plants into piles on the basis of the species present. If there are more than five species present, place all of those which occur in the least amount together into one pile and label as miscellaneous.

8. Weigh each species of plant present and determine the per cent of the total productivity each species contributes.
\[
\text{Weight of Species} \times 100 = \text{Productivity per species}
\]
\[
\text{Total weight of all species}
\]

**Student Activity:**

1. Describe each area sampled.

2. Determine the total productivity of the plant material in gms/m\(^2\).

3. Identify and record the weight of plant material by species.

<table>
<thead>
<tr>
<th>Weight of plant material by species</th>
</tr>
</thead>
<tbody>
<tr>
<td>Species</td>
</tr>
<tr>
<td>Weight</td>
</tr>
</tbody>
</table>

4. Determine the total productivity by species.

<table>
<thead>
<tr>
<th>Per cent of productivity by species</th>
</tr>
</thead>
<tbody>
<tr>
<td>Species</td>
</tr>
<tr>
<td>Weight</td>
</tr>
</tbody>
</table>

5. Define the terms community and monoculture.

6. Compare a natural community to an agricultural community in terms of: (a) number of different species found in each community (b) total productivity

7. If a community is composed of a single species of producer organism, what advantages may result? What disadvantages?

8. Is the amount of light energy that is fixed as food the same in all communities?

9. What physical limiting factors may have been operating in the communities studied?
HABITAT STUDY

Birds represent an interesting group of animals. Each species is suited to a specific habitat. They are adapted to fill a particular niche within this habitat. Specialized bills, feet, coloration, nesting habits and mating behavior are a few of the characteristics which allow a bird to fit a particular niche.

This exercise will provide an opportunity for the study of a particular habitat and several of the species of birds found in it.

Objectives:
The student shall be able to:
1. Define habitat and niche.
2. To correlate bill and/or feet with the type of food eaten by the birds.
3. To identify some possible ways one species is isolated from the other species found within the same habitat.

Materials:
1. Binoculars
3. Mist nets and necessary banding equipment.

Procedure:
1. Describe the habitat being studied.
2. Identify the birds found in this area from the list provided by the instructor. Note where these birds are most commonly found.
3. Erect the mist nets at three different locations.
4. Band any bird caught in the net.
5. Observe the birds prior to their release for such characteristics
as size, type of bill and feet and coloration.

**Student Activity:**

1. Construct the following chart:

<table>
<thead>
<tr>
<th>Date</th>
<th>Locality</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Weather conditions</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Description of the habitat</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Bird</th>
<th>Common name</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Age</th>
<th>Sex</th>
<th>Band No.</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Bill Type</th>
<th>Feet Type</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Coloration Pattern</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
</tr>
</tbody>
</table>

2. A basic principle of ecology states that one and only one species will occupy a given niche. On the basis of your observation, how many different niches are occupied by birds in this habitat?

3. If the above statement is correct, what factors do you think might separate the various species observed?

4. What possible niche does each species occupy?

5. Explain how the following birds are adapted for their particular niche.

<table>
<thead>
<tr>
<th>Screech Owl</th>
<th>Red Tailed Hawk</th>
<th>Mallard Duck</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sandpiper</td>
<td>Redheaded Woodpecker</td>
<td></td>
</tr>
</tbody>
</table>
CHANGES IN VEGETATION RELATED TO PHYSICAL FACTORS

An analysis of the vegetation on a slope often reveals that the species composition at the bottom of the slope is considerably different than that at the top of the slope. These differences reflect variations in the physical factors pertaining to plant growth.

In this exercise, the change in vegetation that occurs starting at the edge of the Raccoon River to the top of the hill in Sportsman Park will be examined. Students will be asked to determine what physical factors are involved in these changes.

Objectives:
The student shall be able to:

1. Construct a transect along a slope and identify the woody species of plants present.

2. Define the term ecotone and pick an example to illustrate this concept.

3. Prepare a diagram showing the vegetation present along the transect. This shall include:
   (a) species of woody plants present
   (b) layering effect if present
   (c) any distinct changes in vegetation

4. List the major physical factors effecting each zone.

5. Pick the dominant species in each zone.

6. Define the term "indicator species" and pick those plants which serve as indicator species.

Materials:

1. String
2. Stakes
3. Compass
4. Keys and picture of woody plants
5. Diagram of the area
6. Meter stick
7. Light meter
8. Geotome
Procedure:

1. Starting at the bottom of the slope, run a string up the slope. Your instructor will give you instructions on how to use a compass so as to construct a straight line.

2. Run a second string 4 meters to one side and parallel to the first. This will delimit the study area. Each string will be marked off into 10 meter segments.

3. Student will work in pairs. Each pair will be assigned to one or more 4 x 10 meter square segments. Each student pair should:
   (a) identify the woody species present
   (b) make a frequency count of each species present
   (c) tabulate each species present as to height on the following basis:

   (1) 0-10ft.
   (2) 11-20ft.
   (3) 21-30ft.
   (4) 31-40ft.
   (5) 41 and over

4. Observe the herbaceous plants present and note such things as amount of ground cover, variety of plants present and height of the plants.

5. Take light readings throughout the transect. Also, make one reading in the open area to determine the total available radiation for the day.

6. Using the geotome, make observations concerning the type of soil along the slope gradient. Pay particular attention to such things as soil type, humus and water content.

Student Activity:

1. Using the diagram provided, sketch the distribution of wood species. Make your sketch approximately to scale. If some of the trees are 60 ft. tall and some only 10 ft. tall, indicate this on your drawing. Also, indicate any layering effect.

2. Indicate any zone of vegetation you note.

3. Are the zones sharply defined or do they gradually merge into another zone? What would you expect this to mean in terms of the physical factors?

4. When a zone has more than one species of plant life, one or more species generally have a greater influence on the area than the other plants. These are called the dominant species. What plants do you feel could be the dominant species in the area studied?
5. Sometimes a plant is associated with a given set of characteristics. This plant may or may not be the dominant species. In any case, when a plant indicates a particular set of physical characteristics, it is called an indicator species. What plant or plants do you feel could be indicator species in the area studied?

6. Discuss the significance of the statement, that a good indicator species should have a narrow range of tolerance for one or more physical factors.

7. What physical factors do you feel were most important in causing the diversity of vegetation in this area?

8. Calculate the percentage of total light available at breast high and ground level in each of the zones.
ECOLOGICAL SUCCESSION IN ROADSIDE DITCHES

Ecological succession has been defined as "the orderly process of community change; it is the sequence of communities which replaces one another in a given area." (Odum, 1959 p. 257) The concept that a given area may support several different types of communities over a period of time, is a basic concept of ecology. Of equal importance is the concept that these communities follow some predictable order.

It would be desirable to observe one area over a period of time and see the various types of communities that occur. However, this might take from a few years to several thousand years. An alternate method is to view several areas showing different stages of succession and compare the communities found there. It is necessary to make the assumption that a single area would show each of these stages if given enough time.

In this exercise, roadside ditches will be studied. These areas have at one time had nearly all of their vegetation removed. The type of vegetation that is found in progressively older ditches represents examples of ecological succession. The species of plants that are found may vary because of man's influence, i.e. seeding the ditches, nearby crop land, etc. Nevertheless, the process is similar to that which occurs in nature.

Objectives:

The student shall be able to:

1. Define or select statements which define:
   (a) succession
   (b) seral stage
   (c) climax community
   (d) annual plant
   (e) perennial plant
   (f) biennial plant
2. List at least three physical factors which may be different between the various communities studied.

3. Describe the type of plants found in a ditch as to how long it takes the plant to grow and produce seed.

4. Write a one page paper describing what changes have occurred in the communities observed in terms of type of plants present, and explain what factors have been instrumental in bringing about these changes.

5. Given the types of plant community present in a particular area, predict what the next possible community might appear next.

6. Select statements which indicate the characteristic of a climax community.

Materials:

1. String
2. Meter stick
3. Nails
4. Guides for identifying plants
5. Plant press

Procedure:

1. Mark off a plot, as indicated by your instructor, 50 cm. x 50 cm. (one-fourth of a meter squared).

2. Identify the plants present, using the materials provided by your instructor. Those plants which cannot be readily identified in the field can be pressed and taken back to the laboratory for later identification.

3. Determine the frequency of each species.

4. Classify each plant as to annual, biennial or perennial.

5. Using the geotome, observe the soil and note any apparent characteristics of the soil which might effect the plant life present.

6. Note the general appearance of each site visited.

Student Activity:

1. Compile a chart for the area visited as indicated on the following page.
2. What physical factors seem to change the most between the three sites observed?

3. What characteristics of the plants found at site A made them suited for life there?

4. Discuss the degree of diversity of plant life in the three areas. Where is it the greatest? the least?

5. Where do you find the greatest number of annual plants?

6. Which of the areas represents the most harsh environment?

7. In which areas are the physical factors being changed the most?

8. What information do you need to know if you wished to determine the oldest community visited was in a stage of climax?

<table>
<thead>
<tr>
<th>Name of plant</th>
<th>Area A</th>
<th>Area B</th>
<th>Area C</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>f</td>
<td>l.s.</td>
<td>f</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Name of plant</th>
<th>Area A</th>
<th>Area B</th>
<th>Area C</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>f</td>
<td>l.s.</td>
<td>f</td>
</tr>
</tbody>
</table>
A SEWAGE PLANT - AN ECOSYSTEM

The treatment of sewage represents a major problem for any city. In years past, when the population was small, the raw sewage could be dumped directly into the rivers and lakes. The natural biological processes associated with these bodies of water could take care of the problem. As the population has increased, the amount of sewage has increased until the lakes and streams can no longer handle the problem. The result has been the pollution of these bodies of water. The alternative to this method has been the treatment of the sewage prior to dumping it into the water.

There are several methods of treating sewage. One of these is the slow trickling filter. Such a system may be viewed as a small ecosystem. In this case, the mini ecosystem is being used to treat a problem within a larger ecosystem.

In this laboratory exercise, the sewage plant at Perry, Iowa, will be analyzed in terms of the component parts of such a system, their function and finally an evaluation of their effectiveness.

Objectives:
The student shall be able to:

1. Distinguish between primary and secondary treatment in terms of:
   (a) method of treatment
   (b) materials being removed

2. List two possible useful products that can be produced by the system.

3. List three types of organisms associated with the trickling system.

4. List the possible pollutants remaining in the water leaving the system.
5. Select statements which identify the systems efficiency in removing the solid waste materials.

6. Identify the sources of energy in the system.

7. Write a paragraph suggesting how water could be conserved.

8. Write a paragraph suggesting how any possible pollutants remaining might be treated.

9. Identify the biotic members of the system.

10. Identify the abiotic elements of the system.

11. Identify where energy is lost from the system.

12. Identify where inorganic materials are lost from the system.

Materials:

1. Diagram of the area
2. Kits to test for:
   (a) nitrite-nitrate concentration
   (b) ammonia concentration
   (c) phosphate concentration

Procedure:

1. A diagram of the system has been provided. For each of the following, identify the function of the structure and explain how this function is performed:
   (a) bar screen
   (b) aerator
   (c) commontator
   (d) clearifiers
   (e) digestor
   (f) slow flow trickling filters
   (g) fast flow trickling filters
   (h) final filter

2. Secure a sample of the water after it has passed through the system. Test this for the presence of:
   (a) nitrite-nitrate
   (b) ammonia
   (c) phosphate
   (d) dissolved oxygen
Student Activity:

1. How much material enters the system on an average day? Of the total amount, what per cent is solids?

2. Of the total amount of solids that enters, what per centage is removed?

3. Why is it necessary to remove the solid materials?

4. What products are produced by the digestor? Do they have any value?

5. In the digestor the solid materials are broken down into simpler substances. What causes this breakdown?

6. What materials are removed by the trickling filters? What is added?

7. What type of organisms are responsible for the removing of these materials, in the trickling filter?

8. What is the purpose of the rocks in the trickling filter?

Dr. Roger Landers, ecologist at Iowa State University, has referred to a system of this type as an ecosystem. Questions 9-15 are based on this concept.

9. An ecosystem requires a constant source of energy. Where does energy enter this system?

10. There are two major parts of ecosystem; a biotic or living portion and an abiotic, or physical portion. Identify the abiotic and biotic portions of this system.

11. The living portion of an ecosystem is composed of producer organisms, consumer organisms, and decomposer organisms. Identify these three groups in this system.

12. In an ecosystem, the total weight of the producer organism is greater than the weight of the consumer organism. However, in this system this would not necessarily be true. Why? Does this violate the principle of energy flow?

13. Where does the inorganic material enter the system?

14. Where does energy leave the system?

15. Where does the inorganic material leave the system?

16. What problems occur in the operation of the system? Discuss this in terms of operation and pollutants remaining in the water.
17. Assume that there is a critical shortage in the supply of water for the city of Perry. As an engineer, you are asked to help solve this problem. What possible solutions would you suggest? Consider this question from the possibility that you can construct new facilities and from the point of view you must utilize only those present.

18. You have identified certain pollutants remaining in the water that enters the Raccoon River. The State Department of Health has criticized this situation. What possible alternatives are available to you?
AUTOMOBILE SALVAGE - A BIG PROBLEM

The U. S. Bureau of Mines in its report *Automobile Disposal A National Problem* stated, "when an automobile has outlived its usefulness as a transportation vehicle it becomes an esthetic problem - but it also becomes a valuable source of material. In a sense it becomes a mine from which valuable metallic and nonmetallic materials can be obtained." It is evident that this potential source is not presently being utilized.

The nation is faced with an ever increasing number of car bodies littering the landscape. But more important, the resources necessary to build these cars are being depleted. Recycling is not just an esthetic problem, it is a means of conserving some of the nation's exhaustible resources.

This exercise will deal with the problems of automobile salvage and disposal.

Objectives:

The student shall be able to:

1. List four types of metal found in a car and give one example of where these metals are found on a car.

2. Identify the parts of an automobile that are most commonly salvaged for resale.

3. List at least two problems confronting the operator of a salvage yard in disposing of car bodies.

4. Calculate the tons of metal that could be recycled per year at the local level and at the national level.

5. List two methods by which car bodies can be processed prior to shipping them to the steel mills.

6. List three sources of cars that enter a salvage lot.
7. Select the statement which indicates the number of cars that are junked each year.

8. Write a one page paper suggesting possible solutions to the problems of auto salvage and disposal.

Materials:

1. Pencil
2. Paper

Procedure:

1. The information necessary for the completion of this exercise will be gained primarily by interviewing the operator of an auto salvage yard.

2. View the automobiles in the yard as to age, place of damage and portion of the car remaining after all the useable parts have been salvaged.

Student Activity:

1. What are the four major metals found in a car? Give an example of where each of these might be found on a car.

2. When an automobile is purchased for salvage, what parts are in most demand?

3. Eventually all parts wear out. What happens to such parts as the motor, rear end and other such parts?

4. After the reusable parts have been removed from the car there remains the car body. These are often left standing. Discuss this idea in terms of:
   (a) of preparing the car bodies for the processing plant
   (b) transportation of the bodies to the processing plant
   (c) how the car bodies must be processed before they can be sold to the steel mills

5. List three sources where an auto salvage dealer might obtain cars.

6. Automobile manufacturers make the statement, "cars are safer today than they have ever been." A common complaint of the consumer is, "cars are more poorly constructed today than they were 20 years ago." On the basis of what you have seen and the interview, evaluate these two statements.

7. What is the life expectancy of a new car?
8. What changes in production could the automobile manufacturer make that would help solve the problem?

9. Assume a car contains 3700 pounds of ferrous metal (some form of iron), 120 pounds of zinc alloys, 50 pounds of aluminum alloys, 50 pounds of copper and copper alloys and 24 pounds of lead. How many pounds of each element could be recycled:
   (a) at the local level
   (b) at the national level, using a conservative estimate, 9 million cars being junked per year