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ABSTRACT

The purpose of this study was to statistically evaluate the influence of student placement at reading level by means of an informal reading inventory in one kind of elementary science materials. The materials were used in 21 fifth grade classrooms in four Oregon school districts. The classes were divided into three treatment groups which were distributed among the schools. Treatment 1 consisted of students who read at one of five levels as determined by an individual formal reading inventory. Treatment 2 students read at one of five levels as determined by a group informal reading inventory. Treatment 3 students read at only the middle level of the five levels supplied by the publishers. Analysis of variance revealed no significant differences in achievement on criterion tests items among the treatment groups. The results indicate that the informal reading inventory will place students 1.3 years lower in the materials used in this study than would the Metropolitan Reading Achievement tests. Data on teacher rating indicated that teacher effectiveness was a valid area for further research. (BR)

AN ABSTRACT OF THE THESIS OF

DONALD ROGER DAUGS for the DOCTOR OF PHILOSOPHY
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Title: EVALUATION OF THE INFLUENCE OF MULTI-LEVEL READING MATERIALS ON THE ACHIEVEMENT OF FIFTH GRADE ELEMENTARY SCIENCE PUPILS WHEN PLACED AT READING LEVEL BY AN INFORMAL READING INVENTORY

Abstract approved: Stanley Williamson
Dr. Stanley Williamson

The purpose of this study was to statistically evaluate the influence of student placement at reading level by means of an informal reading inventory in one kind of elementary science materials. The materials were written at five levels of reading difficulty to better meet the reading ability spread found in the intermediate grades. The significance of student placement on achievement gain was evaluated by an analysis of variance. Groups were also equated with respect to reading level and teacher rating by an analysis of covariance.

Population

The materials were used in 21 fifth grade classrooms in four Oregon school districts. The classes were divided into three treatment groups which were distributed among the schools.

Treatment Groups

Treatment 1. Students read at one of five levels as determined by an individual informal reading inventory.

Treatment 2. Students read at one of five levels as determined by a group informal reading inventory.

Treatment 3. Students read at only the middle (C) level of the five levels supplied by the publishers.

Hypotheses Tested

(1) There is a significant difference in achievement on criterion test items among classes of fifth grade students who study material written at one or five reading levels when students are placed at respective reading level by an informal reading inventory administered by an individual having thorough training in the use of informal reading inventories.

(2) There is a significant difference in achievement on criterion test items among classes of fifth grade students who study material written at one or five reading levels when students are placed at respective reading level by a group informal reading inventory administered by the classroom teacher.

Results

(1) Analysis of variance revealed no significant differences

among the three treatment groups.

The results indicate that the informal reading inventory will place students 1.3 years lower in the materials used in this study than would the Metropolitan Reading Achievement tests. Additional research must be undertaken before it can be concluded that there is not a significant advantage in using the multi-level materials under study. The teacher effectiveness and guessing on the pretest variables need to be more adequately controlled. Data on teacher rating indicated that teacher effectiveness was a valid area for further research.

Evaluation of the Influence of Multi-Level Reading Materials on the Achievement of Fifth Grade Elementary Science Pupils When Placed at Reading Level by an Informal Reading Inventory

by

Donald Roger Daugs

A THESIS

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Typed by Mary Jo Stratton for Donald Roger Daugs

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The road to becoming an educator began in 1957 while in Germany as a guest of the United States Army. During this time the writer had the opportunity to teach a Sunday School class of teenagers. The comment of a young man in that class to the effect, "I wish our regular school classes were like this" made the decision for me to teach. Since that time contact with students and the optimism of young minds has been a great stimulus to continue in education. The confidence and love displayed by the writer's students have provided an impetus for progress. This same confidence and love is extended by this student in heartfelt thanks to the following:

To my wife and five daughters who have run the race together.

To Dr. Stanley Williamson who has been an inspiration and example these past years and who made possible the opportunity to study under him.

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To the committee who has shared valuable time in producing this study.

D. R. D.

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I. INTRODUCTION

Comments from teachers at all grade levels indicate that many of their pupils are unable to read assigned materials. It is apparent that there is a relationship between ability to read and academic achievement.

One of the major objectives of recent science curricula has been scientific literacy for all students. A major facet of the objective of scientific literacy is the ability to read and interpret the common literature of science. Effort in such science curriculum preparation has been directed toward giving students concrete experience through which they build a conceptual framework from which generalization can be developed. Given these experiences a student should be able to read and interpret the common literature of science as if he had made the investigation himself.

The more recent high school science curricula are basically developed around one textbook, making the false assumption that the experiences required for all levels of reading ability can be served out of the same textbook. Other curricula offer no experience in reading at all. The goal of scientific literacy for all students can not

possibly be attained "out of the same textbook." The fact that many students drop out before reaching high school and that most of those going on to high school generally take only one year of science may indicate that the burden of scientific literacy should fall on the elementary school.

Individual differences in reading ability must be taken into consideration in teaching. These differences can be better met by the production of materials that are stimulating, variable, and flexible. The materials must arouse interest and stimulate the student to make good use of them. The materials need not be organized in such a fashion that all students have access to identical materials. All students need not progress at the same rate.

When using variable and flexible materials the teacher becomes a consultant, rather than a purveyor of information. The pupil is the active agent in the classroom. The teachers who decry that many of their pupils are unable to read the textbooks are aware of the individual differences in students and can to some extent identify the pupils' reading needs; however, these teachers seldom have access to the materials necessary to meet these needs. Conformity to a standard based on "the textbook" is the norm for behavior of all students. This becomes increasingly the case as one progresses from K through 12. Multi-level materials are a necessity to remedy this situation.

As cultural differences, in addition to individual differences,

become more apparent, the revealed variability within the population seems to indicate that the one textbook concept is becoming increasingly inadequate. The solution seems to be related to providing relevant materials that pupils can use for self-directed learning. Success is an excellent motivator. If pupils were provided materials they could read successfully and understand, measurable gains in achievement should result.

The objectives of the multi-level materials under study include the following: to arouse curiosity in students, to stimulate creativeness, to provide for acquisition of skills of inquiry, and to provide for acquisition of knowledge of science. Since it is not possible to reliably measure all of these objectives, this study is limited to an evaluation of the materials from the standpoint of achievement, i. e., knowledge of science.

The production of materials written at different levels of readability does not insure that the student will be properly placed by his teacher. It is one thing to know that a pupil can not read a textbook, but a much more difficult thing to select a level of material that can be used with an individual for effective instruction. If it can be shown that proper placement in use of multi-level materials effects a significant difference in achievement gain, then publishers can be encouraged to produce such materials.

Statement of the Problem

The purpose of this study is to objectively investigate the degree to which reading level, as determined by an individual informal reading inventory (IRI)[1] based on the five reading levels of The Earth's Atmosphere Laboratory[2], or as determined by a group informal reading inventory, influences achievement gain scores on a criterion test[3] designed specifically for these materials.

A basic objective of this research is to determine whether placement of students by means of (1) an individual informal reading inventory administered by a person trained in the reading field or (2) by a group informal reading inventory administered by the classroom teacher, influences achievement gain significantly.

It should be noted that the study is designed so that the manner in which most teachers use the materials will be reflected in the results. All teachers would have a minimum of in-service instruction in use of the materials. Experience level of the teacher could have been controlled by inserting the same science teacher into a number of classrooms; however, this is considered beyond the scope of this study. Random assignment of classrooms to treatment will compensate for variability in teacher background.

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[1] See page 6.
[2] See page 11.
[3] See Appendix VI.

Definition of Terms

Student: Those fifth grade students participating in this study.

Trained informal reading inventory administrator: For the purpose of this study this will be limited to this researcher. Generally an individual having training and experience in the psychology and use of an informal reading inventory.

Classroom teacher: Those teachers participating in this study.

Achievement gain: The difference between posttest and pretest scores on the criterion test.

Minimum of in-service instruction: In-service instruction consisted of less than one hour spent on philosophy and organization of materials.

Participant: Those classroom teachers participating in this study.

Hypotheses Identified and Tested

(1) There is a significant difference in achievement on criterion test items among classes of fifth grade students who study materials written at one or five reading levels when students are placed at respective reading level by an informal reading inventory administered by an individual having thorough training in the use of informal reading inventories.

(2) There is a significant difference in achievement on criterion test items among classes of fifth grade students who study materials written at one or five reading levels when students are placed at respective reading level by a group informal reading inventory administered by the classroom teacher.

The Informal Reading Inventory[4]

Introduction

The informal reading inventory is a device that evaluates readiness for continued individual instruction in reading. Every subject matter teacher is a reading teacher, consequently all teachers should be concerned with readiness for reading in a given subject matter area. This is particularly true in science with its specialized vocabulary.

The informal reading inventory provides four basic types of information. These are: (1) the highest level at which a pupil can read with complete understanding, (2) the highest level at which instruction can be initiated, (3) the level at which the language becomes baffling, and (4) the highest level at which the student can comprehend. Additional information of a diagnostic nature also results from the use of an informal reading inventory. The latter is not or primary interest

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[4]See Appendix III.

in this study.

Definition of Terms and Criterion for Evaluating Performance on an Informal Reading Inventory (Marksheffel, 1966; Betts, 1946)

Basal or Independent Reading Level. The highest reading level at which an individual can read with full understanding and be free of mechanical difficulties.

(1) A word recognition score of 99 to 100%.

(2) A minimum comprehension score of at least 90% based on factual, vocabulary and inferential type questions.

(3) Free from all tensions such as finger-pointing, scowling, twisting in chair, vocalizing.

Instructional Reading Level. The highest reading level at which an individual can be profitably instructed free of symptoms of difficulty.

(1) A word recognition score of 95% or better.

(2) A minimum comprehension score of 75%.

(3) Free of all tensions.

Frustration Reading Level. The reading level at which an individual finds material incomprehensible and is upset emotionally by having attempted to read it.

(1) A word recognition score of 90% or less.

(2) A comprehension score of 50% or less.

(3) The pupil is tense as indicated by finger-pointing, squirming, vocalizing, etc.

Probable Capacity Level. The highest reading level at which an individual can understand material read to him.

(1) Hearing comprehension of 75% or more.

(2) A vocabulary on a similar level to the author's words.

(3) Ability to anticipate answers.

Abbreviations Commonly Used.

WR: word recognition

IRI: informal reading inventory

Procedure for Using Test

(1) Readiness Period

(a) Explain test to student.

(b) Establish rapport.

(2) Oral Reading at Sight

(a) Set limited purpose for reading.

(b) Student reads orally at sight while errors in word recognition are noted by the test administrator.

(c) Student is asked questions from the comprehension part of the test.

(3) Silent Reading

(a) Student is given a sample of material at the same level.

(b) Student is given a purpose for reading and is advised to ask for help in pronunciation if needed.

(c) Student is asked comprehension questions about the material.

(4) Oral Rereading

(a) Student is given a reason to reread orally part of the selection read silently to check on his work recognition.

(5) The procedure in steps (1) to (4) are repeated until the frustration level in reading is reached.

(6) Probable Reading Capacity (not used in this study)

(a) The selection is read aloud to the student.

(b) Comprehension questions are asked the student.

(c) Repeat until the student is at a level beyond which he has less than 75% comprehension.

Advantages of an Informal Reading Inventory

(1) Selection of test material from the instructional materials contributes to validity.

(2) Size of type, length of line and vocabulary are under constant control, thus contributing to reliability.

(3) Both the achievement level and the specific needs may be analyzed in one operation.

(4) Any classroom text materials can be used to construct this type of test.

(5) Cost of the test is negligible.

Group Informal Reading Inventory

The group IRI is used primarily as a quick screening device to determine which students can not read assigned materials. Students are provided with a selection to read silently. After reading the students respond to a set of questions similar to those used in an individual IRI. If the student can answer 70% of the questions it can be assumed that the student can read the assigned materials. If the score is 50% or less the student will be frustrated by the materials.

Metropolitan Achievement Tests: Reading

The word knowledge (vocabulary and word recognition) subtest consists of 55 items and has a time allotment of 14 minutes. The reading subtest (paragraph meaning and comprehension) has 44 items and a time allotment of 25 minutes. These Metropolitan Tests are generally regarded as valid and reliable for the purpose intended by the test constructors. In the case of the reading subtest the intent for the test was to reflect the instruction in reading (emphasis this researcher's) at each grade level and also reflect reading situations occurring in all other curriculum areas. Corrected split-half reliability coefficients are in the .90's at every battery level.

The word knowledge subtest consists of a representative sample of the words used in widely circulated reading series which show effective discrimination between students of good and poor vocabulary.

The unique concepts and vocabulary of science and mathematics are noticeably lacking in both subtests. Reliability of such an instrument as means to place students at reading level in a specific subject matter area is questionable. The split-half reliability coefficients are spuriously high due to the fact that the subtests are timed. A split-half reliability coefficient should not be used with a time test.

A valid use of such tests is to interpret the average score made by some group of students. The grade equivalent score is useful in comparing the mean score for a classroom or a school system with a national or state norm.

Organization of SRA Materials

The Earth's Atmosphere Laboratory, published by Science Research Associates, is designed primarily to meet individual reading needs so that a teacher can allow students to progress at their own rates. The materials are arranged around five central concepts about atmosphere. Each concept is developed at five different reading levels, and the associated activities are at three to five levels of sophistication. Materials call for interaction with classmates, but a student could use the materials without the assistance of the teacher.

Reference to Figure 1 will aid in the understanding of the description of materials which follows.

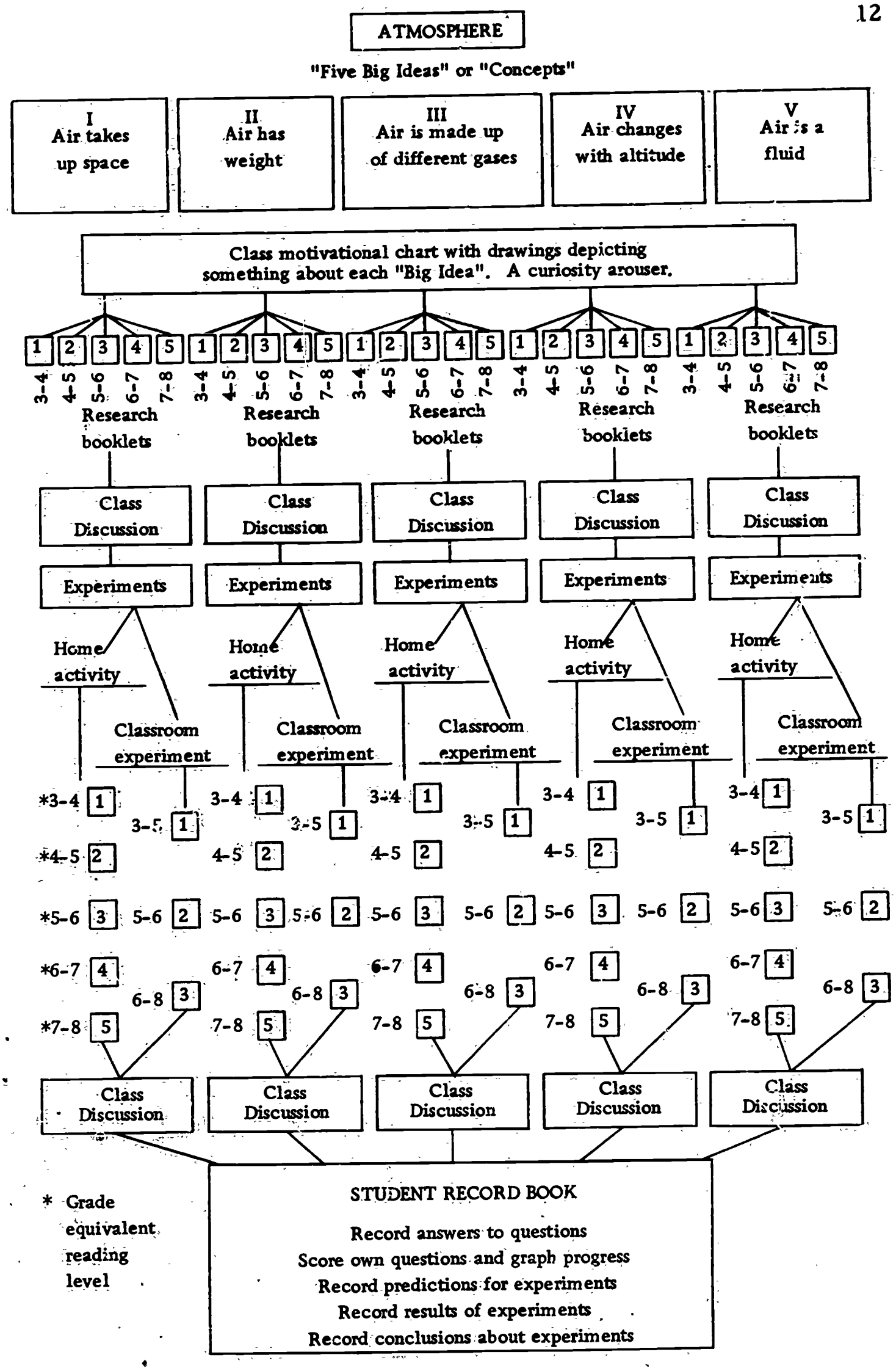

Figure 1. Schematic Organization of "Learnings in Science" Laboratory

Laboratory Contents

One-level Picture Chart. This 24 inch x 30 inch chart is designed to promote thinking about the topic of atmosphere. It has five large drawings, one for each of the big ideas about atmosphere. Teachers are encouraged to use this chart as a motivational tool to help pupils want to learn about the concepts.

Student Record Book. Each student is provided with a record book consisting of three principal parts: (1) A one-reading level article which is read by the teacher as a model of the articles which the student will read. Its purpose is to instruct about how to use the information. (2) Pages on which the students record answers to questions, write out predictions, list materials for experiments and record results. (3) A chart on an instructional page shows them how to figure the percentage right on responses to comprehension checks on reading selections. There is also a graph on which the students plot their percentage scores and keep a record of progress when using laboratory materials.

Research Booklets. The research booklets are the reading selections. Five concepts about atmosphere are treated by a total of ten authors. At each of five reading levels five different authors each wrote on one "big idea." The levels of difficulty as stated by the publisher range from grade three to grade eight. Each selection within a "big idea" is a unique point of view as a result of varied

authorship. This means that the various research booklets have some content in common with the other four and some content which is unique for the selection. Class discussion and experimentation was intended to integrate individual reading selections in a manner such that the total experience of the class would contain most of the elements of the "big idea."

The reading ability grade-equivalent of research booklet reading level A was three to four as determined by Fryback's use of the Spache formula. Levels B through E were determined by Fryback using the SRA "reading ease calculator" (Fryback, 1965). For the use of an informal reading inventory it was required only that the material used be ranked in order of difficulty. Table I summarizes the ranking of the SRA materials.

Table I. Reading level ranking for learnings in science research booklets.

Booklet reading level	Readability grade equivalent	Number of words
A	3-4	325-425
B	4-5	475-525
C	5-6	650-750
D	6-7	850-950
E	7-8	1050-1150

Two sets of multiple choice questions at the conclusion of each reading selection asked the student to recall what he had read and to use what he had learned in a new situation. This was followed by two kinds

of experiments -- one, a home activity designed as an individual experience, perhaps requiring the help of some member of the student's family; second, a class experiment designed as a small group experience calling for mutual cooperation of pupils. Both types of experiments are open-ended.

Self-Evaluation. Answers to the objective questions which follow the reading selections are found on the "key cards." Additionally, "key model booklets" contain discussions about the predictions and results of the experiments. Students are instructed to use these key cards to score and evaluate their own work on each of the "big ideas." The student's self-evaluation is recorded in the student record book previously described.

Teacher Handbook. The teacher's handbook contains instructions for the teachers regarding use of the materials and organization of the laboratory. It also contains a discussion of the general organizational philosophy of the materials.

Teachers' Instructional Aid Booklet. The main function of this booklet is to aid teachers in directing class discussion. It contains suggested questions which the teacher can use to stimulate class discussion. Questions are included which are unique to reading level. In this way the lower level readers who often do not participate in class discussion may be the only ones knowing the answer to a specific question. This procedure also fills gaps in materials at any one

reading level.

Assumptions

(1) Materials in The Earth's Atmosphere Laboratory are properly ranked in order of reading difficulty.

(2) Classroom teachers will follow prescribed directions.

(3) Elementary science teachers with limited science backgrounds can handle the materials in the manner recommended by the authors.

(4) The criterion test measures achievement gain with respect to knowledge of science.

(5) The informal reading inventory places students at proper reading level.

(6) Systematic instruction involving reading should be provided through materials that are well below the level of readability at which the learner is frustrated.

(7) Symptoms of reading difficulty increase in direct proportion to the increase in the difficulty of the material (Betts, 1946).

(8) Symptoms of reading difficulty may be used as a basis for estimating reading achievement (Betts, 1946).

(9) Independent reading should be done in materials in which the learner is free of both mechanical errors and errors of comprehension.

(10) Instruction in reading should be done in materials which

challenge the pupil, but do not frustrate him.

Limitations

(1) This study will be limited to those fifth grade classes in which administrators and teachers are willing to cooperate with the researcher.

(2) The placement of students at proper reading level is limited by reliability of the informal reading inventory.

(3) A higher level of professional competence is required to administer this type of test than to administer standardized achievement tests. Validity of the test is largely determined by the skill of the IRI administrator.

(4) Validity of the inventory is in part dependent on the materials being at the reading levels indicated. If the materials are not ranked in order of increasing difficulty, the informal inventory will not be valid.

(5) The ability to establish rapport may influence the results of the inventory.

(6) Cost in time may be a factor for use of an informal reading inventory with all students.

Organization of the Remainder of the Study

The need for individualized instruction and materials of ranked

difficulty is elaborated upon in the review of literature. Justification for use of an informal reading inventory for placement of students at reading level is also documented in chapter II.

Chapter III includes the experimental design and outlines the procedure followed in establishing the study in classrooms. Information on the informal reading inventory, the criterion test, and teacher evaluation is presented. Also included in the third chapter is a schematic representation of the statistical devices used in analysis of the data.

Chapter IV is a presentation and interpretation of the data. This is followed in Chapter V by a summary of results, conclusions drawn from this study, and recommendations.

II. REVIEW OF LITERATURE

Need for Materials of Ranked Difficulty

Teachers at all grade levels comment that many of their students cannot read assigned materials. This is due to both the nature of the reader and the nature of the materials being read. Smith and Dechant (1961, p. 363-364) summarize research on the readability of science texts at the elementary and high school levels as follows:

(1) Reading levels of many (of the texts) are too advanced for students for whom they are written.
(2) There are wide differences between levels of reading difficulty of the easiest and most difficult science texts.
(3) In some texts whose average level of reading difficulty seems satisfactory, there are passages that would be difficult for even some college students.
(4) Many texts contain words -- other than technical key words -- that could be replaced with easier synonyms.

From this summary, it can be concluded that not all pupils will be able to read text materials. In an unpublished study done by this writer, over 50% of the junior and senior high students participating read at a level which indicated that they could not read the texts. The study also indicated a high correlation between science text reading level and past grades in science.

Another very similar summary (Smith, 1963, p. 216) comments on work done by Mallinson and co-workers. Smith states:

(1) The reading difficulty of many textbooks in science is too advanced for the students for whom they are written.
(2) The difference between the levels of reading difficulty of the easiest and the most difficult textbook in any area

of science are significant.

(3) In some textbooks of science whose average level of reading difficulty seems satisfactory there are passages that would be difficult for some college students.

(4) Many textbooks of science contain non-technical words that could be replaced with easier synonyms.

(5) The levels of reading difficulty within the textbooks vary greatly. The earlier passages in the textbook did not seem to be consistently lower in level of reading difficulty than the later passages.

Newport (1965) indicated that of nine continuous series textbooks used in elementary science only a few approach the grade level for which they are intended. Mallinson (1950) found similar results at an earlier date, indicating that in the period 1950 to 1965 little progress had been made in bringing material more in line with grade level of difficulty. Even if texts were consistent internally and written at a given grade level, one would still be confronted with the problem of student variability at grade level.

Numerous references express the need to recognize the wide range of reading abilities within a classroom. Strang (1961) indicates that the scatter in reading scores of a given chronological age may extend over the entire range of a reading test. Marksheffel (1966) reports that the range between bottom and top reading levels will average six to nine grades at the high school level.

> With such variations as these to be found in the average classroom, it is of course unwise and unfair to demand the same results within a given length of time from all the pupils of the group. The relative simplicity, however, of giving a single assignment to an entire class, the apparent economic and administrative necessity of maintaining fairly large classes for each teacher, the

> reluctance of many teachers to experiment with innovations which seem to require more extended planning, and the seductively business-like precision which seems to pervade a sharply graded school system, have all combined to preserve the delusion that all pupils in a given grade are capable of uniform achievement, with the more vicious fallacy that the teacher is impartially "treating them all alike" by demanding the same daily tasks of all. As a matter of fact, a uniform requirement means only half-work for part of the class, and impossible effort for another part. Thus the teacher who tries to strike a fair average in the assignment is really unfair to the brighter pupils by depriving them of any challenge to capacity efforts, and equally unfair to the slow pupils by depriving them of any opportunity for genuine mastery, and corresponding educational growth. Some teachers, realizing the plight of the latter group, direct their main teaching efforts at the slow pupils, and justify their course by declaring that the "bright ones will learn anyhow." Others, with equal logic but less compassion, allow the stronger pupils to absorb the chief attention and set the pace, on the theory that those who cannot meet such a standard should drop back into a grade where they can do the work. In reality none of these three plans is fair or democratic, in the sense of granting to all pupils equal opportunities for the best educational progress of which they are individually capable (Thomas, 1927, p. 351-352).

In a 1969 conference on evaluation conducted at Oregon State University by Dr. Albert Eiss, discussion of the above problem centered around the information depicted in Figure 2 and Figure 3. Given a set course of study a familiar bell-shaped curve will result in regard to quantity of material mastered and time spent on materials. It was proposed by this researcher that the two graphs in Figures 2 and 3 be combined to give a more accurate view of the situation. The resulting three-dimensional representation is presented in Figure 4. Any point on the dome-shaped surface could represent a student in the classroom.

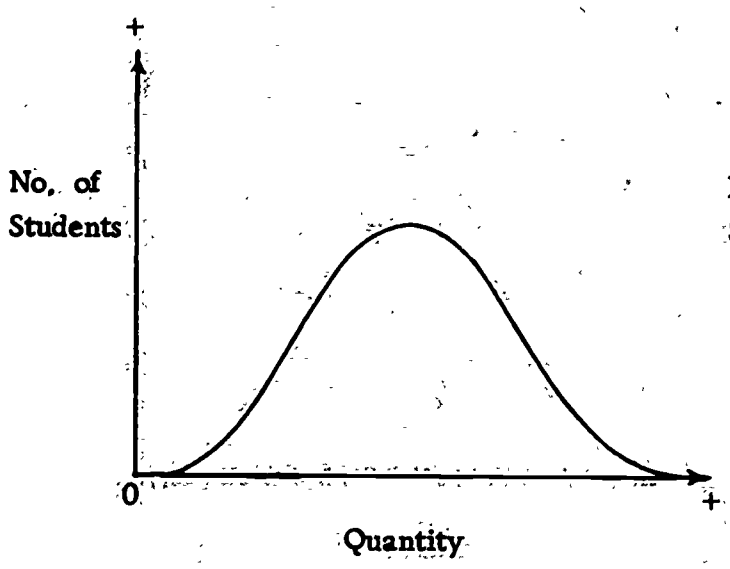

Figure 2. Given a Set Course of Study, Quantity of Material Mastered by Students.

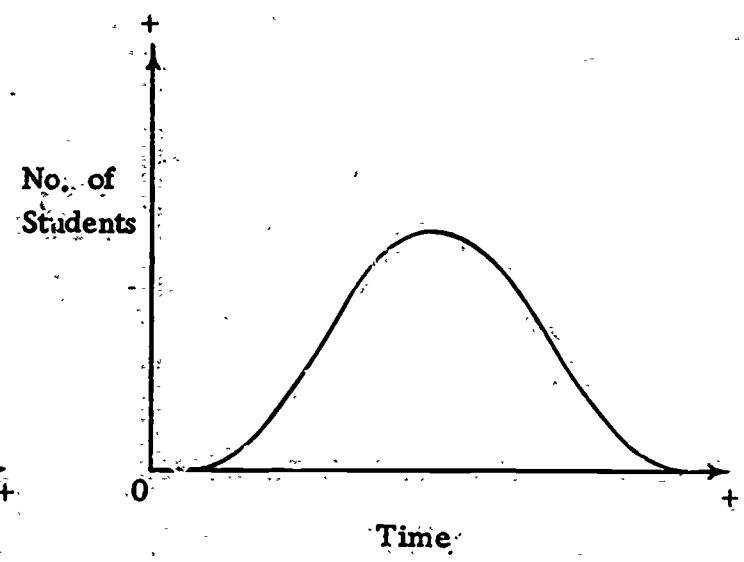

Figure 3. Given a Set Course of Study, Time Spent on Materials by Students.

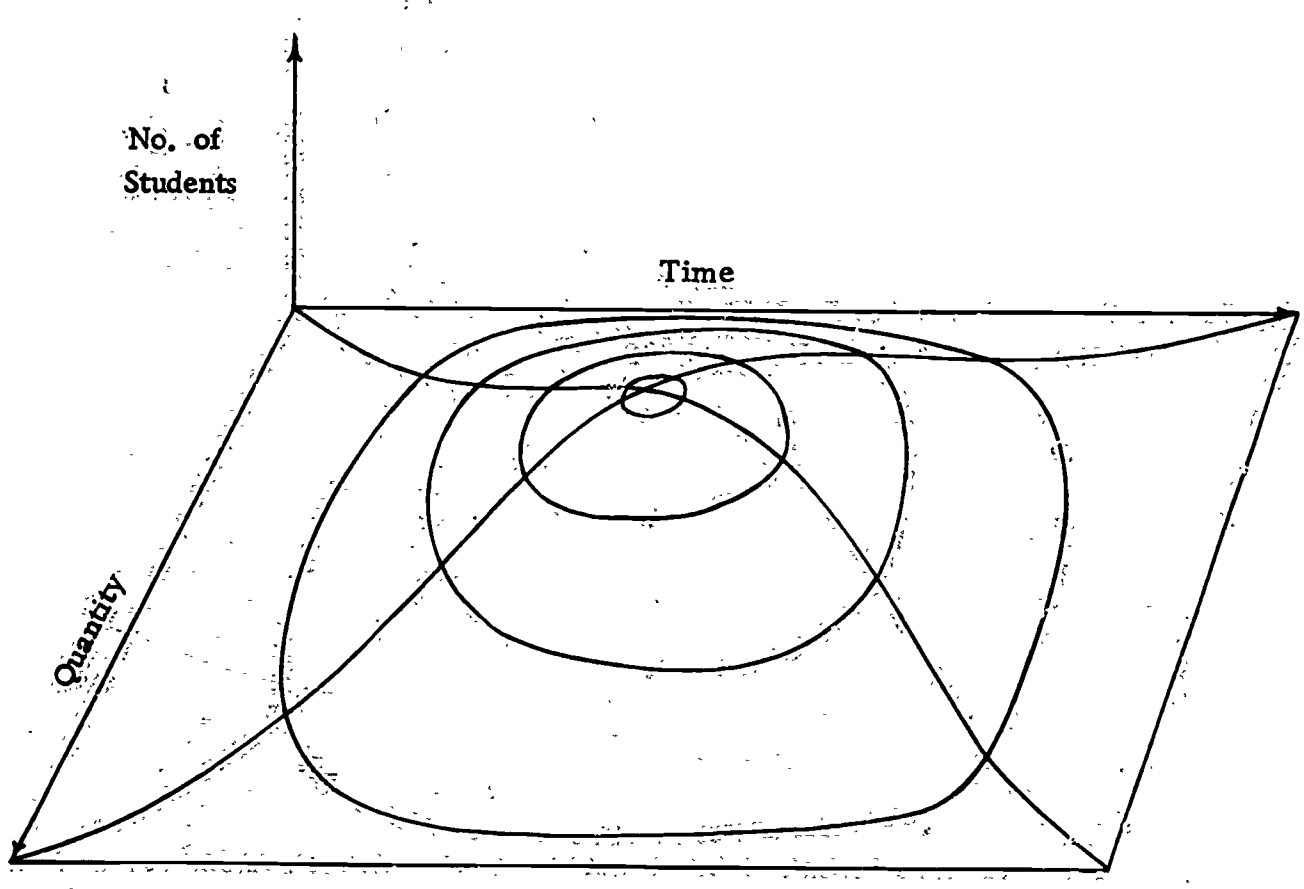

Figure 4. A Three-dimensional Representation of Student Achievement.

Typically the largest number of students would master an average amount of material in an average amount of time. Other students may master a small amount of material in a short time while others will require a long period of time to master the same amount of material. Other students will master a large amount of material in a short time while some students may require a long period of time to master the same large amount of material.

Efforts to produce a diversity of materials at the elementary level in science have resulted in production of large numbers of pamphlet texts. By using such unit-type pamphlets from different publishers, instructional materials can be supplied at different levels of difficulty for a given topic. Mallinson (1955) cautions teachers in regard to use of these materials at the grade level indicated by the publishers. Most are at a level too difficult for the grade level indicated.

Often not recognized by the classroom teacher and textbook writers is the need to provide challenging materials to the student who is reading above his grade level. Certainly the challenge is there for the teacher to meet these individual differences, but the burden of supplying materials at various levels of reading difficulty should not fall solely on the teacher. Research evidence is needed to verify the assumption that provision for individual differences in reading ability is profitable for the student. If research shows that the student will

benefit from this type of instruction, the materials will be produced. Many good teachers attempt to meet these needs at present; however, what is really needed is a greater effort on the part of publishers to produce multi-level materials.

An obstacle to the development of materials at different reading levels has been cost to the publisher.

> Many persons have suggested that three levels of the same textbook should be prepared for every course... Thus the same basic areas would be covered, but the level of presentation and understanding would be differentiated for the students. In theory this is a fine plan. But publication of a single textbook now involves an investment of $75,000 or more (Mallinson, 1957, p. 151).

Few subject matter area teachers have realized that it is one of their primary responsibilities to teach reading. Often the science teacher indicates that it is the reading teacher's problem to solve all problems in reading. The subject matter teacher must realize that students at all ability levels can be helped in their academic achievement by providing materials that are challenging, but readable. There is no better motivation than success.

The Philadelphia Reading Program is an example of an effort to put reading instruction in proper perspective.

> As the program developed, the reading teachers spent more and more of their time helping the teachers of regular classes to improve the reading instruction in all subjects. In accord with the developmental concept of reading, several senior high schools have introduced courses in advanced reading and study skills for college preparatory students and courses in developmental reading for all students, in addition to the already existing courses in remedial work for retarded readers. At

least three senior high schools have organized in-service training programs involving all the members of the professional staff, including counselors, librarians, and department heads. These programs have the triple purpose of (1) improving reading skills by means of instruction in the various content areas, (2) improving achievement in the content areas by means of instruction in appropriate reading and study skills, and (3) improving general school adjustment by helping students experience the satisfactions that accompany greater scholastic success. Bibliographies and study guides for the professional staff have been prepared and distributed, special faculty meetings have been planned, and expert consultant service has been secured (Strang, 1961, p. 36).

This brief description of an evolving reading program illustrates three important trends: toward continuity in reading instruction from kindergarten to college; toward integration of reading instruction with the teaching of every subject; and toward development of a comprehensive, whole-school program which serves the needs of students representing a wide range of reading potential and proficiency. This program also accents the importance of providing for the continuous growth of teachers, administrators, counselors, librarians, and the reading specialists themselves (Strang, 1961, p. 37).

Need for Individualized Instruction

Experimental evidence on individualized instruction in science is meager. O'Toole (1967) concluded that an individualized method of instruction was not superior in achievement of science content and overall problem solving ability in a study involving 81 fifth grade pupils.

Morningstar (1965) reports a plan for individualized instruction being used in Aspen, Colorado, schools. The instructional program was initially individualized in the mathematics, reading, and to a

lesser degree science, areas, grades kindergarten-six. This program was so successful that plans were made to initiate a similar program at junior and senior high levels. Evaluation was not in terms of the group's achievement, but rather in terms of an individual's ability. Justification for this program was given as follows:

> A survey of the school population and its academic achievement indicated that with the immense range of ability it was unrealistic to get achievement standards by grade levels for all children. Individual differences were not being accounted for under the plan. Consequently, there were many students who were frustrated either by having to meet standards too rapidly or because they could not move ahead. Also, students were moving ahead to the next level before they had mastered the necessary skills or work habits (Morningstar, 1965, p. 3).

Fryback (1965) investigated the achievement gain of fifth grade science pupils using science materials written at five levels of reading difficulty. Twenty-nine fifth grade classes were divided into the following treatment groups:

(1) Group 1 read only at C level, discussed materials, and worked the experiments included with the C level materials.

(2) Group 2 used materials at levels A, C, and E, discussed materials and worked the experiments included with each level of material.

(3) Group 3 used materials at all five levels (A, B, C, D, E), discussed materials and worked the experiments included with each level of material.

(4) Group 4 used all five levels of materials (A, B, C, D, E)

and worked the experiments included with each level of material, but did not discuss the materials.

(5) Group 5 used all five levels of material (A, B, C, D, E) with discussion, but did not do experiments.

(6) Group 6 did not see any of The Earth's Atmosphere Laboratory materials, but were given the pretest-posttest and the reading achievement tests. This was a control group.

Pupils were assigned to reading level by use of either the Metropolitan Achievement Tests (Reading) or the California Reading Achievement Tests. The reading levels of the materials were assumed by the researcher to be at the grade levels stated by the publisher. Achievement was measured by a pretest-posttest constructed by the author. In consideration for validity, questions were well distributed among reading levels and concepts covered. The criterion test reliability coefficient score was reported as .88 as determined by the split-half method on the posttest scores of the students in treatment group three.

Fryback concluded that the study showed clearly that achievement gain scores as measured by the criterion test were not influenced significantly by the fact that materials were written at grade-equivalent reading levels. The validity of this conclusion was based on the assumption that students were properly placed at reading level.

Placement of Students at Reading Level

Schiffman (1963) found that the grade level of standardized tests averaged 1.26 grade levels over the instructional level as determined by informal evaluations. He found furthermore that the average readability level of content texts (history, science, social studies) averaged 3.24 grade levels over the instructional level as determined by informal evaluations. This was an exceptionally well done study by a researcher who is highly regarded in the reading field.

Betts (1946, p. 441) found

> that not one of several standardized reading tests designed for use at the fifth grade level was adequate for determining the achievement levels of pupils at upper or lower ends of the distribution. Although ten percent of the class did not exhibit desirable reading behavior on first grade materials, some of the tests graded these pupils no lower than second, third, or fourth grade level. In general, standardized tests may be expected to rate those pupils from one to four grades above their manifest achievement levels. While this is not an all-out indictment of achievement tests in reading, it is a caution to those who attempt to use standardized test data as a sole criterion for appraising achievement level.

Marksheffel (1966, p. 87) reports that:

> Records of students receiving help in reading at the Oregon State University Reading Clinic during the past eight years are in agreement with Betts' findings, which showed that standardized tests of reading tend to place a student from one to four grade levels above his actual instructional reading level.

If the preceding statements of reading authorities can be accepted as being reasonably accurate (or valid) then Fryback's use of the standardized tests to place pupils at their respective reading levels

placed many pupils at a reading level above their ability, i.e., at a frustration level. This fact in itself justifies repeating the Fryback study with an attempt being made at more accurately placing students at their respective reading levels.

The use of an informal reading inventory for placing pupils at their appropriate reading level has definite value in correct placement of each student. Abrams (1963, p. 116-118) indicates that to correctly place a pupil

> we must appraise (1) how well his current achievement in reading compares with his intelligence level; (2) how his performance in reading matches up with the performance of other children his age; (3) what level of material he can be expected to read on his own and where he will most profit from instruction (not to mention where he will be frustrated by the complexity of the material); and (4) how well he can evluate his own performance and be aware of his own deficiencies.
>
> For a considerable number of years now it has become generally accepted that the answers to most of the questions stated above can best be elicited by the intelligent use of informal inventories.

Summary

The need for materials written at a student's ability level is generally recognized. These materials have been slow to appear on the educational scene, due in part to the wide range in abilities within a classroom, and in part to publishers' costs to produce the required materials.

If individualized instruction is to be effective, then students must

be properly placed at ability level. The informal reading inventory is recognized as a useful instrument in proper placement of students at reading ability level.

III. THE STUDY

This investigation was designed to determine the relationship between mean class gain scores on a criterion test as developed by Fryback (1965) in classrooms where students were placed at reading level in The Earth's Atmosphere Laboratory by an individual informal reading inventory, by a group informal reading inventory, or were placed at grade level only.

Experimental Design

The experimental design was set up to utilize seven fifth grade classes in each of three treatment groups. Treatment group one consisted of students reading at their appropriate level, as determined by an individual informal reading inventory, in one of the five levels of the research booklets. Treatment group two consisted of students reading at their appropriate level, as determined by a group informal reading inventory, in one of the five levels of the research booklets. Treatment group three read only the middle (C) level of the five levels supplied in a laboratory. The (C) materials were designated as fifth grade materials by the publishers. All students discussed the materials and carried out the experiments.

More teachers had volunteered to participate in the study than funds were available for. As a result of the surplus of participants, four categories were developed for matching classrooms with

treatments. These were: treatment group one, treatment group two, treatment group three, and alternate. Two schools, which had three classrooms each, offering to participate in the study requested that all three treatments be used in their building. These were assigned by drawing labels from a box. The labels were numbered 1, 2, and 3 corresponding to treatment numbers. The remaining possible participants were then assigned to the four possible categories by drawing labels for each classroom marked 1, 2, 3, and alternate, until each treatment group had seven participants.

Within each treatment group all students were placed in one of six reading level categories: A- (below the level of the material), A (lowest), B, C, D, and E (highest) as discussed on page 13 and shown in Table I.

An analysis of variance technique was applied to the criterion test gain scores to determine significances of achievement. The influence of treatments and reading levels on achievement gain scores was determined for significance at the .05 (or better) level.

Significance of treatment and reading level on achievement gain scores was also determined for groups of questions within the total criterion test. These small groups of questions fell into one of three categories as described on page 37.

School Contacts

During the summer of 1969 initial contacts were made through school administrative officers. Arrangements were made to meet with interested fifth grade teachers and their principals early in the 1969-70 school year. During this initial contact with the fifth grade teachers the philosophy of the Learnings in Science Laboratories was discussed, teachers were shown samples of the laboratory materials, and a brief outline of the study was presented (Appendix I). These meetings were completed by mid-September, 1969.

Teachers were notified by mail of the assignment to treatment group (Appendix II). Individual informal reading inventories (Appendix III) were given by this researcher between mid-September and the end of October. Group informal reading inventories (Appendix IV) were given by the classroom teachers in November. All students were given the Metropolitan Achievement Tests (Reading) by this researcher the last two weeks of November. A short delay in classroom use of the materials occurred due to late arrival of the laboratories. Rather than start use of materials two weeks before Christmas vacation, some teachers elected to start right after vacation.

Prior to the giving of the pretest each teacher was visited individually. At this meeting the following materials were distributed: (1) special written instructions (Appendix V), (2) criterion tests (Appendix VI) with answer sheets, (3) student reading level assignments

as determined by the informal reading inventories, (4) Learnings in Science Laboratories, and (5) a student record book for each student. Questions raised by the teachers were answered, but they were not given an instructional workshop in use of the materials. The research was intended to get a measurement of the results as they would probably appear when used by most teachers. Students in all three groups were made aware that they were participating in a special research project. It was hoped that this would balance the Hawthorne effect.

Student Population

The 21 fifth grade classrooms used in the study were distributed among four Oregon school districts. The participating districts were as follows: Corvallis School District #509J, Crowfoot School District #89C, Lebanon School District #16C, and Philomath School District #17J.

A total of 441 students were involved in the study. The delay of up to one and one-half months between administration of the informal reading inventories and the start of classroom use of the laboratories was neglected in the placement of students at reading level. Table II shows distribution of students assigned to different reading groups. Rather than group students from grade level 0.0 to 3.9 at reading level A, as did Fryback, this researcher categorized students below the

level of the materials, i. e., below 3. 0, as A-.

Table II. Number of students assigned in different reading groups based on IRI results.

Reading level	Grade-equivalent reading level of the materials	Grade-equivalent reading level of the student	Total students
A-	---	0-2.9	59
A	3-4	3.0-3.9	72
B	4-5	4.0-4.9	84
C	5-6	5.0-5.9	178
D	6-7	6.0-6.9	23
E	7-8	7.0-7.9*	25

*The highest level of the informal reading inventory. Some students at reading level E could have handled material at a higher level.

Table III shows the distribution of the student population with respect to treatment. Also included are the mean class scores on the Metropolitan Achievement Tests. This Metropolitan score represents the mean of the mean of the two subtest scores on the Metropolitan Achievement Test. The subtests referred to above were word knowledge and reading. Fryback used the mean of the two subtest scores to place students at reading level. On the basis of the Metropolitan Test scores the treatment groups were considered equivalent with respect to general reading ability.

The range of reading ability was from non-readers to those reading above the level of the tests, i. e., above tenth grade level. Provision was made for those students below the lowest level of the materials by placing them at level A (the lowest level) and then

alternately including and excluding them in the treatment of the data.

Table III. Mean grade-equivalent reading scores for three treatments.

Treatment	Mean grade-equivalent reading score	Total students
1	6.0	156
2	5.8	144
3	5.9	141

The Informal Reading Inventory

The informal reading inventory was developed by this researcher in May, 1969. The inventory was constructed from the five reading levels of The Earth's Atmosphere Laboratory. In this way the unique vocabulary and concepts of the materials used in this study were included in the determination of reading level.

Two representative samples of material from each level of material were selected. Care was exercised in selecting samples that were not predicated on preceding material. Ten questions were developed for each reading sample selected. The questions were of three types. About one-third were based on vocabulary, one-third tested knowledge of facts, and one-third were based on generalizations of inferences.

To better assure that the questions were written in a language the students could understand, the IRI was given to students during the summer of 1969. These were children who would be entering fifth

grade in the fall.

These same children were given the Metropolitan Reading Tests to determine whether the expected differences in placement would result.

Criterion Test

The criterion test (Appendix VI) was the same criterion test as used in the Fryback study (Fryback, p. 81-93). Test items originated from one of three sources: (1) directly from the questions printed at the end of the reading selections; (2) directly from the reading materials; and (3) inferential questions related to the reading materials.

Questions were well distributed among the five big ideas, the five reading levels, and the special categories of questions used in the analysis. Tables IV and V show how well this concern for validity has been met. The column on the right in Table IV indicates the number of questions out of a total of 60 which a student reading at any one level finds unique to all other reading levels. Answers to these questions could have been learned through discussion.

Questions unique to reading level consisted of factual recall and conceptual understanding or application type questions. The questions common to all reading levels consisted of 12 fact and three concept type questions. Answers for conceptual-none questions were not found in any of the materials but could be inferred (or generalized)

Table IV. Number of questions for each big idea.

Big idea	Number of questions
I Air takes up space	12
II Air has weight	12
III Air is made up of different gases	12
IV Air changes with altitude	14
V Air is a fluid	10
Total	60

Table V. Number of questions at each reading level by categories of questions.

Reading level	Unique to reading levels	Common to all levels	Conceptual-none		Unique to other levels
A	6	15	18		21
B	5	15	18		22
C	4	15	18		23
D	6	15	18		21
E	6	15	18		21
Total	27	15	18	=	60

from concepts or facts learned by using the materials.

The criterion test was given first as a pretest just prior to classroom introduction of the Laboratory. The posttest was given at the conclusion of the study. Emphasis was placed on the need to refrain from guessing on test items. Students were instructed (see Appendix V) to leave items blank on the answer sheet if they did not know the answer or if there were unfamiliar words in items on the pretest. Many students filled in all blanks. On this basis students were divided into guessers and non-guessers for different treatments of the gain score data. Students were also instructed to not guess on posttest items (see Appendix V).

Students were instructed to ask the teacher about words that posed difficulty on the posttest. It was hoped that this would benefit the reader with word recognition difficulties.

Test Reliability

The test reliability coefficient was determined by the split-half method on the posttest scores of student number 7 and 14 in each of the 21 classrooms. The reliability coefficient of the extended test was .86 as determined by the Spearman-Brown formula (Wood, 1960). Fryback (1965) reported a reliability of .88 for the extended test, but did not report coefficients for the subtests.

This researcher found coefficients of .81, .63, and .36

respectively for the questions unique to reading level, questions common to all levels, and questions not found in any of the materials. The .36 value corresponds to teacher participant comments that their pupils are unable to make the inferences and generalizations necessary to answer questions of this type.

Analysis

The gain score data were submitted to an analysis of variance and analysis of covariance program. This program was composed in cooperation with the Oregon State University Computer Center under the direction of Dr. David Niess. Tables VI and VIII depict the schematic of the techniques applied to the data.

Table VI. Schematic of analysis of significance of mean gain scores.

Source of variation	D.F.	S.S.	$M.S._1$	F	and repeat for $M.S._2$, $M.S._3$, $M.S._4$
Treatments					
Error					
Total					

where:

$M.S._1$ = mean square of criterion test total gain score.

$M.S._2$ = mean square of criterion test gain scores for questions unique to reading level.

$M.S._3$ = mean square of criterion test gain scores for questions

common to all reading levels.

$M.S._4$ = mean square of criterion test gain scores for conceptual questions not found in any of the reading materials.

Table VII. Analysis of covariance: covariate = reading level.

Source of variation	D.F.	$M.S._1$	F	and repeat with $M.S._2$
Treatments				
Error				
Total				

where:

$M.S._1$ and $M.S._2$ are as indicated above.

Findings Not Related to Hypotheses

Teacher Evaluation

Teacher effectiveness in relation to this study was determined by means of a rating scale consisting of six categories for evaluation. The areas evaluated were as follows: (1) materials administration, (2) evidence of following directions, (3) ability to motivate students, (4) use of experiments, (5) evidence of completion of student workbook, and (6) enthusiasm at the end of the study. Judgements in each category were made by this researcher on a ten point scale. Classroom visitation by this researcher and discussions with teachers served as a basis for the judgements made. Teachers were rated throughout the

course of the study.

The following criteria were used as guides in evaluating the teachers:

(1) Materials administration.

(a) ease with which adjustment was made to use of the Laboratory.

(b) evidence of planning ahead with respect to needs for experiment materials.

(c) evidence of student understanding of how materials were to be used.

(d) evidence that treatment group C participants were remaining within the framework of C level materials.

(2) Evidence of following directions.

(a) proportion of students answering all items on the pre-test.

(b) procedure followed to introduce new concepts and vocabulary.

(c) conformity to time schedule recommended by publishers.

(d) evidence that students completed all areas in student record book.

(3) Ability to motivate students.

(a) subjective assessment of student enthusiasm for the various activities involved in use of the materials.

These judgements were made on the basis of observation and discussion with students.

(4) Use of experiments.

(a) evidence that home and classroom experiments were performed.

(b) evidence that materials needed for experiments were adequate, and were provided on time.

(5) Evidence of completion of student workbook.

(a) examination of the student workbooks throughout the study.

(6) Enthusiasm at the end of the study.

(a) subjective evaluation by this researcher of participants' general feeling toward the material.

(b) participants' plans to use this unit again.

(c) interest in procuring additional multi-level materials.

IV. PRESENTATION AND INTERPRETATION OF DATA

The study was designed to determine if student achievement gain scores were significantly affected when students: (1) used material as directed at five levels of difficulty when placed at reading level by an individual informal reading inventory; (2) used materials as directed at five levels of difficulty when placed at reading level by a group informal reading inventory; (3) used materials as directed at one level only (fifth grade level).

Metropolitan Reading Achievement Tests were given to all students. These data were used as a measure of general reading ability and to equate treatment groups. The means for the three treatments as indicated in Table VIII did not differ significantly. It was hoped that the mean Metropolitan scores for the three treatments would be similar to results obtained by Fryback. Fryback's tests were given three months earlier in the school year than those of this study. Even with this added time increment all treatments in the Fryback study scored lower than treatment groups in this study.

Table VIII. Grade-equivalent Metropolitan Reading Achievement Test scores.

Treatment group	Mean grade-equivalent reading score	Number of classrooms	Total students
1	6.0	7	156
2	5.8	7	144
3	5.9	7	141
Fryback 1	5.2 (5.5)	5	117
Fryback 3	5.1 (5.4)	5	129

Scores on the Metropolitan test in this study compared favorably with the Fryback study scores if the lower of the two subtest scores in this study were used as the Metropolitan score. Actually this would be a more sound practice than using the mean of two subtests for student placement in a study such as this, as it is the lower of the two abilities tested that should be the limiting factor in student performance. Comparisons between the Fryback study and this study are limited by the apparent inequality of groups.

Table IX shows that 20.5 percent of the pupils in treatment one and 18.7 percent of the pupils in treatment two were below the lowest level of the materials. Additionally, 69.9 percent and 73.5 percent of treatments one and two respectively were below grade level (fifth grade), i.e., the IRI placed this percentage of students below the grade level placement recommended for level C by the publishers.

The study by Fryback did not show this skewed distribution due to the fact that the test used for student placement was standardized for grade level. Table X further clarifies this relationship. The years difference in student placement, had the Metropolitan test been used in this study, are as predicted for use of an informal reading inventory (see page 28, Chapter II).

In both treatments one and two the mean years difference between the IRI grade placement and the Metropolitan score decreased as reading level increased. Table XI shows how consistent this pattern

Table IX. Number of students at each difficulty level by treatment.

Treatment	Level of difficulty	Number of students	% of total students within treatment	% of students below grade level
1	A-	32	20.5	69.9
Students placed	A	34	21.8	
at reading level	B	43	27.6	
by individual	C	13	8.3	
reading inventory	D	17	10.9	
	E	17	10.9	
2	A-	27	18.7	73.5
Students placed	A	38	25.4	
at reading level	B	41	29.4	
by group informal	C	24	16.7	
reading inventory	D	6	4.2	
	E	8	5.6	
3	C	141	100%	?*
All students at same level				

*Data are not sufficient to determine what percentage of students in treatment group three are below grade level.

is for both treatments. The correlation coefficient for mean years difference in placement vs. reading level was -.77. This coefficient is significant at the .01 level.

Mean Gain Score Data

Table XII shows the mean gain score for each treatment and for classes within treatments. These scores represent the mean points gained between pretest and posttest. The least variance occurs in treatment one, where students were placed by the individual informal reading inventory.

Table X. Years difference between Metropolitan placement and instructional level as determined by the informal reading inventory.

Treatment	Classroom	Mean years difference between Metropolitan placement and instructional level
1 Students placed at reading level by individual informal reading inventory	1	1.6
	2	0.8
	3	1.3
	4	0.8
	5	1.9
	6	1.6
	7	
		Mean = 1.3
2 Students placed at reading level by group informal reading inventory	1	0.9
	2	1.4
	3	1.5
	4	0.9
	5	1.6
	6	1.6
	7	1.5
		Mean = 1.3

Table XI. Mean years difference between Metropolitan scores and instructional level by reading level.

Treatment	Reading level	Mean years difference between Metropolitan score and instructional level
1 Students placed at reading level by individual informal reading inventory	A-	2.13
	A	2.09
	B	1.33
	C	0.62
	D	0.24
	E	-0.35
2 Students placed at reading level by group informal reading inventory	A-	1.63
	A	1.83
	B	1.49
	C	0.71
	D	0.67
	E	-0.25

Table XII. Class and treatment total mean gain scores.

Treatment	Class	Class mean gain score	Mean treatment gain score
1	1	9.05	11.79
Students placed at	2	11.45	
reading level by an	3	12.17	
individual informal	4	12.85	
reading inventory	5	10.88	
	6	10.23	
	7	15.91	
2	1	11.94	13.08
Students placed at	2	7.40	
reading level by a	3	7.59	
group informal	4	22.80	
reading inventory	5	15.10	
	6	14.00	
	7	9.83	
3	1	8.06	10.33
All students at same	2	10.00	
level	3	16.19	
	4	8.55	
	5	14.88	
	6	6.16	
	7	6.85	
Fryback 1	1	6.0	8.7
Students placed at one	2	9.6	
of five reading levels by	3	12.4	
a standardized reading	4	9.8	
test	5	5.8	
Fryback 3	1	6.5	8.1
All students at same	2	6.3	
level	3	13.7	
	4	10.1	
	5	4.8	

Factors Influencing Mean Gain Score

One of the major factors responsible for the range in gain scores may have been the influence of the teacher. Teachers were rated on a ten point scale during the course of the study in six categories as indicated in Table XIII. Though these ratings are highly subjective judgements, they do show a high degree of correlation with the mean gain score for the classroom (see Table XII). The correlation coefficient for mean gain vs. teacher rating was .53, which was significant at the .01 level. Unquestionably the good teacher will do a better job with one level of materials than the poor teacher with five levels of materials.

Of the ten classrooms with a total gain score of 11.0 or greater, nine teachers had a rating of 8.0 or greater. The remaining classroom had a teacher rating of 7.9. This may have reflected influence of a student teacher on this researcher's judgements. The classrooms with the lowest teacher ratings also included the classrooms with the lowest gain scores.

Another possible factor influencing the mean gain scores was the number of students reading below the lowest level of the materials, and in treatment three, the unidentified students reading below level C of the materials. It can be inferred from treatments one and two (see Table IX) that nearly 70 percent of the students in treatment three could not profitably read the materials.

Table XIII. Teacher ratings (10 point scale).

Treatment	Classroom	Materials administration ability	Following directions	Ability to motivate students	Use of experiments	Evidence of completion of student record book	Enthusiasm at end of study	Total	Average
1	1	8	8	7	4	5	8	40	6.6
	2	9	9	9	9	8	9	53	8.8
	3	9	6	8	8	8	9	48	8.0
	4	9	9	8	8	7	9	50	8.3
	5	9	8	4	6	5	7	39	6.5
	6	10	8	9	8	5	9	49	8.1
	7	10	10	9	9	8	9	54	9.0
2	1	9	9	8	8	5	9	48	8.0
	2	4	2	4	4	4	2	20	3.3
	3	1	2	4	3	3	3	16	2.6
	4	9	9	8	8	6	9	49	8.1
	5	9	6	8	8	8	9	48	8.0
	6	9	9	7	7	7	8	47	7.9
	7	7	4	4	6	6	5	32	5.3
3	1	6	7	7	4	6	6	36	6.0
	2	2	2	4	4	3	3	18	3.0
	3	9	9	9	8	8	9	52	8.6
	4	9	8	7	7	6	8	45	7.5
	5	9	9	8	8	6	9	49	8.2
	6	9	8	3	4	5	9	38	6.3
	7	9	8	8	9	8	9	51	8.5

Table XIV shows the mean gain scores for treatments one and two when students below the level of the materials (A-) are excluded from the study. The mean score for treatment one is raised appreciably, indicating that students were placed more nearly at reading level than in treatment two.

Table XIV. Mean gain scores for treatments 1 and 2 excluding students below the level of the materials.

Treatment	Classroom	Mean total gain score	Mean treatment gain score
1	1	9.20	12.65
Students placed at reading	2	12.32	
level by means of an indi-	3	12.10	
vidual informal reading	4	13.00	
inventory	5	13.44	
	6	11.95	
	7	15.95	
2	1	11.80	13.32
Students placed at reading	2	7.11	
level by means of a group	3	6.23	
informal reading in-	4	24.84	
ventory	5	15.71	
	6	14.00	
	7	10.27	
3	1	8.06	10.33
All students at the	2	10.00	
same level	3	16.19	
	4	8.55	
	5	14.88	
	6	6.16	
	7	6.85	

When the total gain scores are examined by reading level, the gain for students below the lowest level of the materials (A-) is

considerably smaller than the gain for the other reading levels. This is not true of treatment two.

Fryback indicated (p. 50) that the mean gain scores for reading level would typically increase as reading level increased. This researcher found gain scores for the reading levels A through E to vary, but not increase with increase in reading level. The pattern of gain found in Table XV for treatment one is the type of pattern this researcher would expect if students were well placed, i. e., students below the level of the materials with a lower gain than all other levels and gain uniform for the reading levels. Treatment two does not fit this pattern.

Table XV. Mean gain scores for reading levels.

Treatment	Reading level					
	A-	A	B	C	D	E
All three treatments	10.08	12.00	12.93	11.06	16.65	11.28
Treatment 1	8.44	12.24	12.16	13.62	14.12	12.47
Treatment 2	12.04	11.79	13.73	13.96	23.83	8.75
Treatment 3	0	0	0	10.33	0	0

The assumption that the teachers would follow directions was not valid for all participants. It was strongly emphasized that teachers should instruct pupils to not guess on pretest items. This emphasis was both verbal and written (see Appendix V). Some classrooms evidenced students who answered all items on the pretest indicating that proper instructions had not been given. Generally the classrooms

with the largest number of students completing all items on the pretest were the classrooms with the lowest total mean gain scores as shown in Table XVI. Students were arbitrarily categorized as non-guessers it they left six or more items blank on the pretest. The outstanding example of non-guessers was classroom four in treatment two with 96% non-guessers and a total mean gain score of 22.8. The general pattern of rank vs. mean total gain score is very apparent in both treatments two and three. It is also of interest to note the general relationship of this ranking to teacher rating.

Table XVI. Ranking of classrooms within treatments by percent of class not guessing on the pretest.

Treatment	Rank	Classroom	Percent non-guessers	Mean total gain score	Teacher rating
1	1	7	86	15.9	9.0
	2	1	58	9.0	6.6
	3	4	40	12.8	8.3
	4	5	36	10.9	6.5
	5	2	30	11.4	8.8
	6	6	19	10.2	8.1
	7	3	12	12.2	8.0
2	1	4	96	22.8	8.1
	2	5	45	15.1	8.0
	3	1	44	11.9	8.0
	4	7	43	9.8	5.3
	5	6	24	14.0	7.9
	6	3	0	7.4	2.6
	7	2	0	7.6	3.3
3	1	3	72	16.2	8.6
	2	5	46	14.9	8.2
	3	2	41	10.0	3.0
	4	6	31	6.2	6.3
	5	1	22	8.1	6.0
	6	4	20	8.6	7.5
	7	7	15	6.8	8.5

As stated earlier, students were instructed to leave items on the pretest blank if they were unsure of the answers. Many students answered all items. Students who left less than six items blank were categorized as guessers. As indicated in Table XVII the mean treatment gain score for all treatments was greater for the non-guessers than for the guessers.

Table XVII. Influence of guessing on the pretest on the mean treatment gain score.

Treatment	Mean gain score excluding guessers	Mean gain score excluding non-guessers
1	15.16	9.61
2	16.08	9.88
3	15.14	7.69

Analysis of Significance

Analysis of Variance

Class mean gain scores were used as observations in the analysis of variance technique applied to the data. Gain scores were not found to be significantly different in any of the categories of questions considered by this researcher. These results were essentially the same as the findings of Fryback. On the basis of analysis of variance only, the hypotheses would be rejected. F scores are reported in Table XVIII to give an indication of the influence of excluding students below the lowest level of the material and the consideration of

non-guessers. In all question categories except that for the inferential type questions the influence of excluding students below the level of the materials and considering only non-guessers was to increase the F score. The sub-category for inferential type questions did not fit this pattern, and as reported earlier had a very low reliability coefficient.

Table XVIII. Analysis of variance results for all three treatments.

Criterion test question category	Student category	Significance	F
Total gain	All students	ns	0.7295
	Exclude A-	ns	0.8137
	Non-guessers	ns	0.9558
Questions unique to reading level	All students	ns	0.9013
	Exclude A-	ns	0.9821
	Non-guessers	ns	1.2199
Questions common to all reading levels	All students	ns	0.1270
	Exclude A-	ns	0.1685
	Non-guessers	ns	0.2158
Inferential type questions	All students	ns	0.6832
	Exclude A-	ns	0.6417
	Non-guessers	ns	0.2688

When treatment three gain scores are compared with the gain scores of treatments one and two, the gains are greater in every case for treatments one and two. Table XIX illustrates this comparison for all categories of students considered and for all types of questions. Though not significant, these differences are consistently in favor of the multi-level material.

The magnitude of these differences between mean gains in treatment three and the gains of treatments one and two was most

Table XIX. A comparison of gain scores in treatment three with gain scores from treatments one and two.

Question category	Student category	+ or - comparison of mean gain for treatment 3 with treatment 1 gain	+ or - comparison of mean gain for treatment 3 with treatment 2 gain
Total gain	All students	+	+
	Exclude A-	+	+
	Non-guessers	+	+
Questions unique to reading level	All students	+	+
	Exclude A-	+	+
	Non-guessers	+	+
Questions common to all reading levels	All students	+	+
	Exclude A-	+	+
	Non-guessers	+	+
Inferential type questions	All students	+	+
	Exclude A-	+	+
	Non-guessers	+	+

evident for the total mean gain scores and the gain scores for questions unique to reading level. Figures 5 and 6 depict visually the magnitude of these differences.

Analysis of Covariance

From the foregoing discussion it appeared that teacher rating was relevant to achievement gain. In the analysis of covariance technique applied to the data the performance of treatment groups was handled as if the groups were equal with respect to teacher rating.

The data were subjected to a single-classification analysis of covariance to test the following hypotheses:

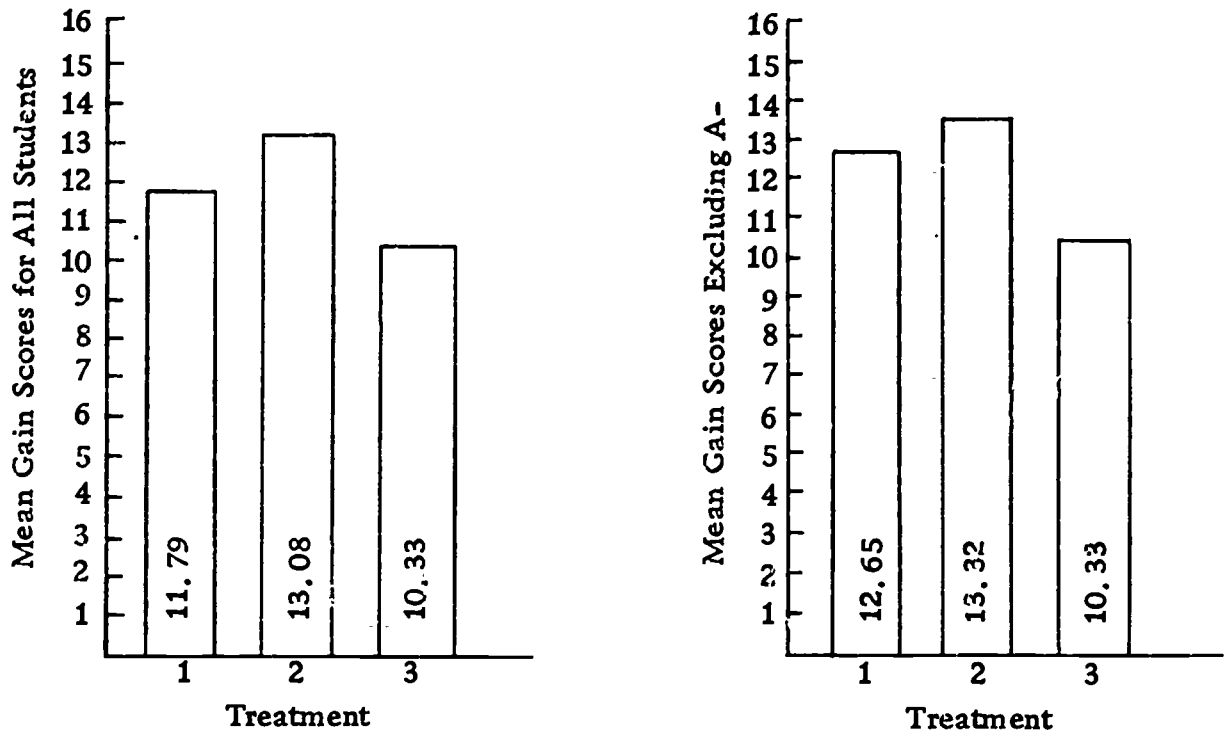

Figure 5. Total Mean Gain Scores on Criterion Test Items.

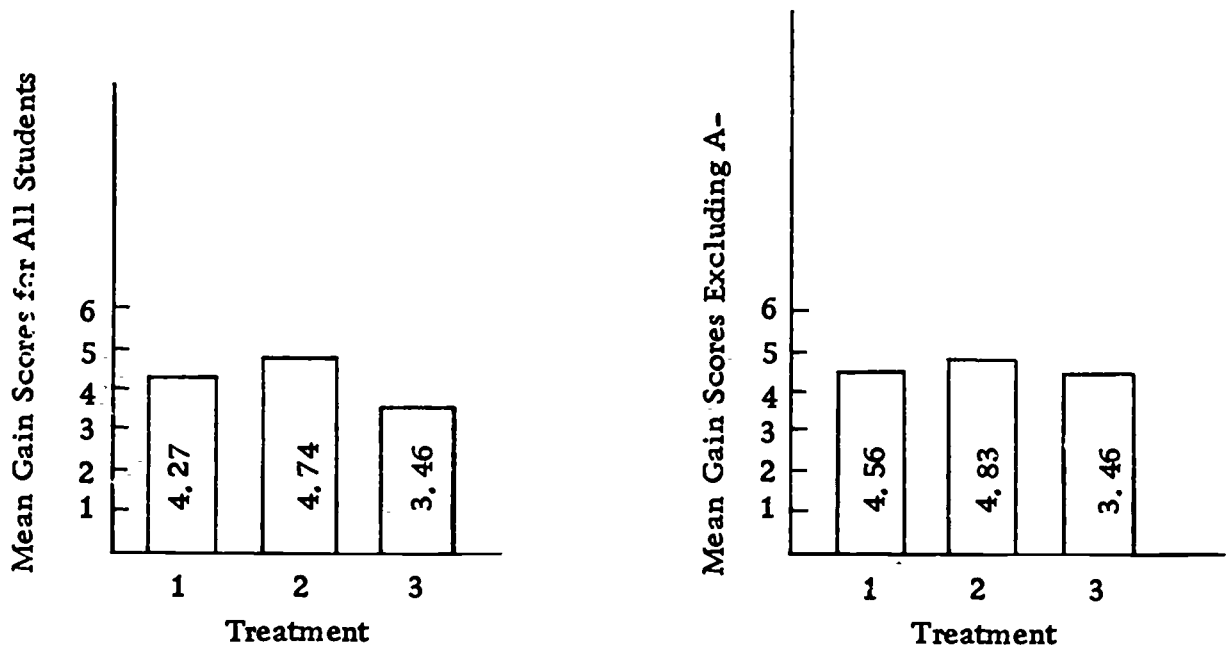

Figure 6. Mean Gain Scores on Questions Unique to Reading Level.

(1) There is a significant difference in achievement on criterion test items among classes of fifth grade students who study materials written at one or five reading levels when placed at respective reading level by an informal reading inventory administered by an individual having thorough training in the use of informal reading inventories, when initial differences between the groups have been statistically adjusted with respect to teacher rating.

(2) There is a significant difference in achievement on criterion test items among classes of fifth grade students who study material written at one or five reading levels when placed at respective reading level by a group informal reading inventory administered by the classroom teacher, when initial differences between the groups have been statistically adjusted with respect to teacher rating.

The analysis of covariance, with teacher rating as the covariate, resulted in an F ratio of 2.304, which was not significant. On this basis, the above stated hypotheses would be rejected. The resulting adjusted mean gain scores were of interest, and are reported in Table XX.

Table XX. Total gain scores and teacher rating means as adjusted for analysis of covariance involving all three treatments.

Treatment	Classrooms	Mean teacher rating	Mean gain score	Adjusted mean gain score
1	7	7.9	11.79	10.57
2	7	6.2	12.67	13.76
3	7	6.9	10.10	10.22

Correlation between teacher rating and mean gain was .53. Teacher rating was least variable in group one and most variable in group two. This is evidenced in the changes in adjusted mean gain scores in Table XX. To further analyze this relationship the analysis of covariance procedure was applied to only treatments one and two. Results are reported in Table XXI.

Table XXI. Analysis of covariance for treatments one and two, with teacher rating as the covariate.

Source	Degrees of freedom	Sum of squares	Mean square	F
Treatment	1	35.154816	35.154816	4.938*
Error	11	78.319400	7.119945	
Total	12	113.474215		

*Significant at the .05 level.

By inspection of the criterion means in Table XXII it can be determined that treatment two is superior to treatment one. This difference is significant at the .05 level. An analysis of covariance with reading level as covariate for all three treatments and for just treatments one and two produced no significant results. The factor most likely influencing the significant difference between treatments one and two is the gain score of classroom four in treatment two. As indicated in Table XVI, classroom four in treatment two had a mean achievement gain of 22.8. This was 6.6 points greater than the next highest classroom in the entire study, and nearly double any score

obtained in the Fryback study. Associated with the 22.8 gain score was a 96% non-guess score. The influence of guessing on the pretest was a major weakness of this study, and a probable factor in superiority of treatment group two.

Table XXII. Total gain scores and teacher rating means as adjusted for analysis of covariance involving treatments one and two.

Treatment	Class-rooms	Mean teacher rating	Mean gain	Adjusted mean gain
1	7	7.9	12.08	10.60
2	7	6.2	12.67	14.15

With only four of the 21 classrooms in the study having over 50 percent non-guessers, the influence of this factor may have been sufficient to invalidate the results of this study. Coupled with teacher rating, pretest guessing constitutes a great weakness of this study and also of the earlier Fryback study.

Other Data

Time Spent on Materials

A correlation of .18 was found to exist between time spent on the materials and mean gain score. This value was not significant. It was concluded that time spent on the materials was not a major factor influencing mean gain score. The correlation between teacher rating and time spent on materials was .48, this coefficient was not

significant.

Comparison With the Fryback Study

It was hoped that the mean Metropolitan scores for the study would be equivalent to those of the Fryback study, so that inferences could be made about the placement of students by means of the Metropolitan test. As reported in Table VIII, the Metropolitan scores for this study were higher than for the Fryback study, but not significantly so.

In an attempt to determine if a significant difference existed between performance of treatment groups one and two in this study and treatments one, two and three in the Fryback study, an analysis of covariance technique was applied to the data with reading level the covariate. Mean gain was handled by reading level within treatment rather than by classroom as previously done. This resulted in six observations each for treatments one and two, and only five observations for the Fryback study due to the inclusion of all pupils below the level of materials in level A of the Fryback study. Using reading level as the covariate statistically equated the possibly unequal groups with respect to reading level. This analysis produced results significant at the .01 level as reported in Table XXIII. Inspection of the adjusted mean gain scores in Table XXIV indicated that this difference was in favor of the results of this study. This significance can not be

Table XXIII. Analysis of covariance of treatments one and two of this study and treatments one, two and three of the Fryback study, with reading level the covariate.

Source	Degrees of freedom	Mean square	F
Treatment	2	98.885884	9.336*
Error	13	10.591539	
Total	15		

*Significant at the .01 level.

Table XXIV. Adjusted mean gain scores by reading level within treatments.

Treatment	Observations	Mean reading level	Mean gain score	Adjusted mean gain
1	6	4.17	12.18	12.34
2	6	4.17	14.02	14.18
*Fryback 1, 2, 3	5	5.00	6.23	5.84

*page 50, Fryback.

attributed to the fact that the Metropolitan tests would have placed students approximately 1.3 years higher than the informal reading inventory. If this were so, treatment three in this study would have performed at a lower level than it did.

This researcher attributes the difference to introduction of vocabulary and concepts prior to students reading the materials (see Appendix V) as opposed to the procedure outlined by the publisher, i.e., vocabulary and concepts are discussed after reading.

V. SUMMARY, CONCLUSIONS, AND RECOMMENDATIONS

Summary of Results

The first four statements below treat the hypotheses tested. The other statements are based upon other relevant evidence produced in the study.

(1) Analysis of variance revealed no significant differences in mean gain scores among treatments involving classes which used science materials written at one or at five different reading levels, when students are placed at reading level by an individual informal reading inventory.

(2) Analysis of variance revealed no significant differences in mean gain scores among treatments involving classes which used science materials written at one or at five different reading levels, when students are placed at reading level by means of a group informal reading inventory.

(3) Analysis of covariance with teacher rating as covariate revealed treatment two to be superior to treatment one at the .05 level.

(4) Analysis of covariance with reading level as covariate revealed no significant differences in mean gain scores among the three treatments.

(5) About 20% of the students were below the lowest level of

the materials.

(6) About 70% of the students were below grade level (fifth grade).

(7) There were 1.3 mean years difference between the Metropolitan reading scores and the instructional reading level as determined by the informal reading inventories.

(8) Difference between the Metropolitan scores and instructional level decreased as reading level increased.

(9) Gain scores for treatment one were most typical of type of gain expected for reading levels. The gain was low for students below the level of the materials and uniform for all levels A through E.

(10) The assumption that teachers would follow directions was not a valid assumption.

(11) Guessing on the pretest was strongly related to teacher rating.

(12) Students in all treatment groups in this study performed significantly better, as measured by achievement gain, than students in comparable treatment groups in the Fryback study.

Conclusions

The information produced by this study is limited by the assumptions stated earlier: (1) materials are ranked in order of reading difficulty, (2) classroom teachers will follow prescribed directions,

(3) elementary teachers with limited science backgrounds can handle the materials in the manner recommended, (4) instruction in reading should be done in materials which challenge the pupil but do not frustrate him, (5) the informal reading inventory places students at reading level.

Teacher Rating

Classrooms in treatment group three, where only one level of material was used, that had high teacher ratings evidenced greater achievement gain than classrooms in the multi-level groups which had low teacher ratings. Unquestionably the good teacher with one level of material will do a better job than the poor teacher with five levels of material.

When treatments were equated statistically with respect to teacher rating, using analysis of covariance with teacher rating as the covariate, treatment group two was found to be significantly superior to treatment one. It cannot be concluded that the group informal reading inventory is superior to the individual informal reading inventory in placing students at reading level, but rather that some other variable produced this result. Analysis of covariance with reading level as covariate indicated that superiority of group two was not a result of differences in reading level. Classroom four in treatment two had an atypically high gain score. The results of this

one classroom greatly influenced the results of treatment group two. Teacher rating for this classroom was high, but not sufficient to produce the extremely high gain score. Classroom observation did not reveal any outstanding procedures of discussion or experiment use that might account for the high gain. Classroom observation did indicate that students were very sensitive to teacher directions. No effort was made by the students to complete the student workbook. They were not instructed to do so. Directions regarding guessing on the pretest were apparently explicit. Ninety-six percent of the students in this classroom were categorized as non-guessers. It can be concluded that the factor of guessing on the pretest strongly influenced mean gain scores.

Teachers were able to use the materials without workshop instruction. The exception to this statement was in that some teachers did not plan ahead for the experiments. This was not due to any deficiency of the materials, but rather to the planning and organizational abilities of the teacher and to enthusiasm for the study. Enthusiasm for the study was more important than science background of the teacher. Many non-science oriented teachers did outstanding jobs during the study.

Evidence from classroom observations indicated that at least four participating teachers were making only a minimal effort to follow directions. The assumption that teachers would follow directions was not a valid assumption in these cases. No effort was made

on the part of this researcher to influence this situation after the materials were initially introduced in the classroom.

The Criterion Test

This study revealed some distinct weaknesses of the criterion test. Reliability of the subtests was not previously reported. The low reliability of two subtests of the criterion test, as revealed in this study, limited the usefulness of the test in analysis of the data. Reliability, coupled with influence of guessing on the pretest points to the need for a stronger criterion instrument. In respect to both reliability and influence of guessing on the pretest, the criterion test should have been no weaker than in the Fryback study.

Reading Level

With the large percentage of students below the lowest level of the materials and the very large percentage of students below the grade level recommended for grade placement (fifth grade) of the materials, it can be concluded that the materials are at a stated grade level that is too low. Evidence from the informal inventories supported the assumption that the reading levels were ranked in order of difficulty. The Metropolitan scores conformed closely with the grade equivalent reading levels designated by the publishers for the five reading levels; however, the informal inventories indicated that the

grade level placement of these materials should be raised one grade. They should be placed in sixth grade classrooms rather than fifth grade classrooms. This would result in more students at the higher reading levels and fewer students below the lowest level of the materials.

Relationship to the Fryback Study

This evaluation has built upon the Fryback study, particularly in the area of student placement at reading level. The fact that all treatments in this study performed significantly better than comparable groups in the Fryback study cannot be attributed to superior placement of students. The major difference between procedures in these two studies was in regard to introduction of new vocabulary and concepts. New vocabulary and concepts were introduced prior to student reading in this study. This procedure was reversed in the Fryback study. Those participants in this study who did not show evidence of following instructions in regard to introduction of concepts and vocabulary were generally found in classrooms with low gain scores. These low gain scores were similar to gain scores found in the Fryback study. It can therefore be concluded that introduction of new concepts and vocabulary prior to student reading favorably influenced achievement gain.

Recommendations

This study has defined areas in which additional research on the multi-level approach is needed. It is recommended that the study be repeated with the following changes:

(1) Employ a more detailed procedure to evaluate teacher influence. Categories used in this study were appropriate as evidenced by high correlation with achievement gain. These categories should be elaborated upon and a more definitive instrument should be developed for evaluation of teacher influence.

(2) The type of criterion test used in this study is weak in that it is at only one reading level and in that the multiple choice type questions invite guessing. A different type of criterion test should be used to measure achievement gain. It is recommended that a criterion test involving the Cloze procedure (Bormuth, 1967) be developed for the purpose of measuring achievement gain. A different test should be used for each reading level and should be taken from the actual materials used, as was the informal reading inventory. This procedure would decrease the influence of guessing. Documentation of the validity of the Cloze procedure as a measure of achievement gain would need to be provided from existing literature.

(3) Investigate the relationship of pupil performance on the Cloze tests to instructional reading level as determined by an informal reading inventory. This data does not exist at present and could lead to a much more economical procedure for student placement at reading level. The informal reading inventory is expensive in time, while the Cloze procedure requires far less time. If a significant relationship between student placement at instructional reading level and student pretest performance on a Cloze test can be established, a great savings in time can be facilitated by using the Cloze test for student placement at reading level in subject matter reading materials. This would have great potential for classroom application.

(4) The materials under study should be centered around sixth grade students rather than fifth grade. This would result in a larger number of students at the higher reading levels and fewer students below the lowest level of the materials.

With the high interest on the part of teachers and administrators in multi-level materials and indications that positive gains are produced by their use, the above research should be undertaken at once.

Many participants expressed a desire to have enough multi-level topics for an entire year's work in science. Publishers should be encouraged to meet these desires by improving existing materials and

to produce additional materials. For the convenience of the teacher it is recommended that the publishers of multi-level materials include the equipment needed for experiments in kits that accompany the Laboratories.

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APPENDICES

APPENDIX I

The Problem

This study will objectively investigate the degree to which reading level, as determined by an informal reading inventory based on five levels of one kind of science materials (SRA Earth's Atmosphere Laboratory) influences achievement gain scores on a criterion test designed specifically for these materials. The influence of the IRI administrator will also be investigated.

Method

The experimental design will be set up to use 21 fifth grade classes. Pupils in seven of the classrooms will be assigned to reading level by an IRI administered by this researcher (treatment group 1), pupils in seven other classrooms will be assigned to reading level by a group IRI administered by the classroom teacher (treatment group 2), and pupils in seven other classrooms will have materials at only fifth grade reading level (treatment group 3).

A criterion pretest and posttest designed by Fryback will be used to measure achievement.

Materials

The tests and SRA materials will be supplied to the participating classrooms. The SRA Laboratories will remain in the classroom as complimentary sets. The materials needed for experiments can be

obtained by the pupils and teachers with little or no cost if not already in the classroom.

Involvement

Participating teachers will be randomly assigned to treatment groups. During the first nine weeks of the school year informal reading inventories based on the five levels of reading materials will be given by this researcher in the classrooms assigned to treatment group 1. Also during the period group informal inventories will be given by the classroom teachers in classrooms assigned to treatment group 2.

Prior to use of the SRA materials all classrooms will have the Metropolitan Reading Tests administered by this researcher. This is a 39 minute test.

The classroom teachers will administer the criterion pretest before starting to use the SRA materials.

The SRA Earth's Atmosphere Laboratory should involve 43 sessions of 35-40 minutes. It is hoped that this can be accomplished during the second nine week period. Upon completion of the SRA unit the criterion posttest will be administered by the classroom teachers.

Laboratory Contents

One-level Picture Chart. This 24 inch x 30 inch chart is designed to promote thinking about the topic of atmosphere. It has five large drawings, one for each of the big ideas about atmosphere. Teachers

are encouraged to use this chart as a motivational tool to help pupils want to learn about the concepts.

Student Record Book. Each student is provided with a record book consisting of three principal parts: (1) A one-reading level article which is read by the teacher as a model of the articles which the student will read. Its purpose is to instruct about how to use the information. (2) Pages on which the students record answers to questions, write out predictions, list materials for experiments and record results. (3) A chart on an instructional page shows them how to figure the percentage right on responses to comprehension check on reading selections. There is also a graph on which the students plot their percentage scores and keep a record of progress when using laboratory materials.

Research Booklets. The research booklets are the reading selections. Five concepts about atmosphere are treated by a total of ten authors. At each of five reading levels five different authors each wrote on one "big idea." The levels of difficulty range from grade three to grade eight. Each selection within a "big idea" is a unique point of view as a result of varied authorship. This means that the various research booklets have some content in common with the other four and some content which is unique for the selection. Class discussion and experimentation was intended to integrate individual reading selections in a manner such that the total experience of the

class would contain most of the elements of the "big idea."

The reading ability grade-equivalent of research booklet reading level A was three-four as determined by Fryback's use of the Spache formula. Levels B through E were determined by Fryback using the SRA "reading ease calculator" (Fryback, p. 13). For the use of an informal reading inventory it was required only that the materials used by ranked in order of difficulty.

Two sets of multiple choice questions at the conclusion of each reading selection ask the student to recall what he has read and to use what he has learned in a new situation. This is followed by two kinds of experiments. One, a home activity designed as an individual experience, perhaps requiring the help of some member of the student's family. Second, a class experiment designed as a small group experience calling for mutual cooperation of pupils. Both types of experiments are open-ended.

Self-evaluation. Answers to the objective questions which follow the reading selections are found on the "key cards." Additionally, "key model booklets" contain discussions about the predictions and results of the experiments. Students are instructed to use these key cards to score and evaluate their own work on each of the "big ideas." The students self-evaluation is recorded in the student record book previously described.

Teacher Handbook. The teachers handbook contains instructions

for the teachers regarding use of the materials and organization of the laboratory. It also contains a discussion of the general organizational philosophy of the materials.

Teachers Instructional Aid Booklet. The main function of this booklet is to aid teachers in directing class discussion. It contains suggested questions which the teacher can use to stimulate class discussion. Questions are included which are unique to reading level. In this way the lower level readers who often do not participate in class discussion may be the only ones knowing the answer to a specific question. This procedure also fills gaps in materials at any one reading level.

APPENDIX II

Treatment 1

Principal's Name

Attention: Participant

Dear Study Participant:

All preliminary contacts with teachers and administrators have been completed. Interest in the study has exceeded expectations.

You have been assigned to treatment group 1. This group will use materials at five levels of difficulty and will be placed at reading level by an individual informal reading inventory administered by this researcher.

If this assignment to treatment group is unacceptable for any reason, or if you will be unable to use the SRA materials the second nine weeks, please notify me immediately. Call 487-4196 collect. If I have not been notified by October 15, it will be assumed that the assignment to treatment group is satisfactory.

You will be contacted shortly to arrange for administration of the IRI.

Sincerely,

Donald R. Daugs

DRD/wld

Treatment 2

Principal's Name

Attention: Participant

Dear Study Participant:

All preliminary contacts with teachers and administrators have been completed. Interest in the study has exceeded expectations.

You have been assigned to treatment group 2. This group will use materials at five levels of difficulty and will be placed at reading level by a group informal reading inventory administered by you. The student responses will be corrected by this researcher.

If this assignment to treatment group is unacceptable for any reason or if you will be unable to use the SRA materials the second nine weeks, please notify me immediately. Call 487-4196 collect.

You will be contacted shortly to arrange for administration of the group IRI.

Sincerely,

Donald R. Daugs

DRD/wld

Treatment 3

Principal's Name

Attention: Participant

Dear Study Participant:

All preliminary contacts with administrators and teachers have been completed. Interest in the study has exceeded expectations.

You have been assigned to treatment group 3, which will be the control group, receiving only SRA materials at the fifth grade level. If this is unacceptable to you for any reason, or if you will be unable to use the SRA unit the second nine weeks, please notify me immediately. Call collect 487-4196. If not notified by October 8, it will be assumed that the assignment to treatment group is satisfactory.

Next contact with teachers in treatment group 3 will be to administer the Metropolitan Reading Test after completion of the informal reading inventories in the other treatment groups.

Sincerely,

Donald R. Daugs

DRD/wld

Alternate

Principal's Name

Attention: Participant

Dear Study Participant:

All preliminary contacts with administrators and teachers have been completed. Interest in the study has exceeded expectations. Twenty-seven teachers have expressed a desire to participate in the study. Sufficient funds for only 21 classrooms are available. Teachers were randomly assigned to treatment groups 1, 2, 3, or to an alternate group. You have been assigned to the alternate group and will be called upon in the event that any of the teachers assigned to treatment groups 1, 2, or 3 are unable to participate.

Your cooperation is appreciated.

Sincerely,

Donald R. Daugs

DRD/wld

APPENDIX III

AN INFORMAL READING INVENTORY

(SRA, The Earth's Atmosphere Laboratory, 1964)

by

Donald R. Daugs

Fish Out of Water

Level A Comprehension_____

Oral: pp. 1-2 (219 words) 1-A Word Recognition_____

Motivation: This selection is about the air we breathe. As you read it see if you can discover what air is made of.

"Someday you might visit the moon. The minute you step from your rocket ship, you will be a fish out of water. Why? A fish lives in water. You live in air. You live at the bottom of an ocean of air. This ocean of air is the earth's atmosphere. As far as we know, the moon has no atmosphere, so you could not live there unless you wore a space suit.

Our ocean of air is made up of certain gases; and gases, like everything else in the world, are made up of tiny bits of stuff called molecules. They are so tiny you can never see one at a time. In a gas, the molecules are always moving very fast. Often one molecule bumps into another molecule. Then it bounces off in a new direction.

How do we know that air is really there? You cannot smell any of the gases that make up air. You can smell cookies baking. And you might smell the odor of paint or of burning leaves. Your nose is sure to tell you when odors of these things are mixed with the gases of the air. But you cannot smell air itself. You cannot see or taste air either. The gases that make up air have no color, odor, or flavor" (reprinted by permission of the publisher).

Comprehension Check:

(F) 1. What ocean do we live at the bottom of? (the ocean of air)

(I) 2. Could a fish live on the moon? (No, there is no water.)

(V) 3. What name is given to the earth's ocean of air? (atmosphere)

(I) 4. Why can an astronaut live in a space suit on the moon? (He takes his air with him in the suit.)

(F) 5. What is our atmosphere made of? (gases, molecules)

(V) 6. What name do we give to the stuff that makes up the air? (gas, gases)

(V) 7. What is a molecule? (a tiny bit of stuff)

(I) 8. If the molecules in a gas are moving very fast, then why can't we feel them hit us? (They are too small to feel.)

(I) 9. How do we know air is really there? (You can see what it does, e.g., fill balloons and tires, feel it blow, etc.)

(F) 10. What kinds of things can you smell when mixed with the gases of the air? (odor of paint, burning leaves, etc.)

Fish Out of Water

Level A

Comprehension_____

Silent: pp. 2-3 (276 words) 1-A

Word Recognition_____

Motivation: Read and find out how you can tell for sure air is really there.

"You cannot see, smell, or taste air, but it is all around you. Here is one way to show someone that air takes up space and fills places people often think are empty.

Take some soil. Look at it closely. Can you see that it is in small pieces? Can you see spaces between these pieces? Now put enough soil into a drinking glass to cover the bottom of the glass. Pour water slowly into the glass. Then let the dirt settle. Watch closely. What do you see rising in the water? Where does the air in the bubbles come from? Could you show that the air came from the tiny spaces between the small pieces of soil and not from the water? Your home activity also will help you show that air fills many places that seem empty.

You can see many things that air can do. Air is very useful. Just ask your dad about this the next time he has a flat tire. And what fun would you have playing basketball if there were no air in the ball?

What makes a basketball seem hard? Remember that air is made up of many fast-moving gas molecules. When you fill a basketball, you put more and more of these moving molecules into it. Inside the ball, these gas molecules become crowded very close together.

When they are so crowded, more molecules bump into each other more often. More molecules also hit against the inside wall of the basketball and push against it. As more and more molecules are added, they push more and more. The push of all these molecules is called pressure" (reprinted by permission of the publisher).

Comprehension Check:

(F) 1. Why do people often think spaces filled by air are empty? (Air is colorless, odorless, and tasteless. You can't always feel it.)

(F) 2. What fills the spaces in soil? (air)

(I) 3. Why does water push air out of the spaces in soil? (Water is heavier. Air will float up to the top.)

(I) 4. How do you know the air bubbles do not come from the water when you pour water into a glass containing soil? (If water alone is poured into the glass there would be no bubbles.)

(F) 5. How can air be useful? (to hold up tires, to fill basketballs, to fly kites, etc.)

(F) 6. What is air made of? (fast-moving gas molecules)

(F) 7. How could you get gas molecules to bump into each other more often? (Crowd them together, as in a ball; move air faster.)

(V) 8. What is the push of all the molecules of air against the inside of a ball called? (pressure)

(I) 9. If you make the pressure in a tire more it might "blow out," but what would happen to a sealed can if you took all the air out of it? (It would collapse.)

(I) 10. If the can in question 9 collapsed, what would be true about the pressure on the inside of the can as compared to the outside of the can? (The pressure would be greater on the outside if the can collapsed.)

ORR: Read the last paragraph of the material you were instructed to read before. (49 words)

A 5700-Trillion-Ton Ocean

Level B

Comprehension_____

Oral: pp. 1-2 (204 words) 2-B

Word Recognition_____

Motivation: As you read the first part of this selection see if you could prove that air has weight.

"If you scooped up a can full of air, how much would you have? Could you weigh the air in the can?

Air takes up space. We know this because balloons and tires get larger when they are filled with air. But does the air make them heavier?

Does a balloon full of air feel heavier than one that is not? It might not, for a small change in weight is hard to sense. But if you lifted a tire that had gone flat and then lifted it again after it had been filled with air, the added weight would probably surprise you.

Like all forms of matter, air takes up space and has weight. All the objects in the universe not only attract but are attracted by all the other objects. The attraction of objects for one another depends on the amount of matter the objects contain and how far apart they are. We call this attraction gravity.

When you jump into the ocean of air around you, gravity draws you back with a pull that is equal to your weight. We express gravity in terms of the weight of the object that is being attracted to the center of the earth" (reprinted by permission of the publisher).

Comprehension Check:

(F) 1. How do we kmow air takes up space? (It makes tires and balls larger when they are filled with air.)

(F) 2. Which would weight more, a balloon full of air or an empty balloon? Why? (The balloon full of air because air has weight; it goes down to the ground.)

(I) 3. Which would be heavier, a can full of water or a can full of air. Why? (A can full of water, because water is heavier than air.)

(V) 4. What is matter? (Anything that takes up space and has weight; the stuff things are made of; any material thing.)

(V) 5. What does attraction mean? (to pull together, or to pull toward you)

(V) 6. What name do we give to the attraction objects have for each other? (gravity)

(I) 7. Which would have the more attraction for the earth, a flat tire of a tire full of air? (a full tire)

(I) 8. Which would be attracted to the earth with the greater force, a balloon filled with air ten feet above the ground, or a balloon with the same amount of air 1000 feet above the ground? Why? (The balloon ten feet above the ground, because the attraction for objects is less when they are far apart.)

(V) 9. What is weight? (the pull of gravity on an object)

(I) 10. How would your weight on the moon compare to your weight on earth? You would weight less on the moon because the moon is smaller than the earth so there would be less gravity.)

A 5700-Trillion-Ton Ocean

Level B

Comprehension_____

Silent: pp. 2-3 (228 words) 2-B

Word Recognition_____

Motivation: Read to determine how much air weighs.

"The earth attracts all the gas molecules in the air. This attraction is the total weight of the atmosphere. If you marked off a single square inch of ground at sea level and weighed all the molecules from the bottom to the top of the atmosphere above the square inch, you would find their weight totaled 14.7 pounds. The push that the weight of the atmosphere exerts against a surface is called air pressure.

The estimated weight of all the air around the earth is 5700 trillion tons. Did you think the air could weigh so much?

At sea level a cube of air 10 feet by 10 feet by 10 feet, or 1000 cubic feet, would weigh 81 pounds. If you find how many times 1000 cubic feet of air will fit into your classroom, you can figure out what the weight of the air in your classroom would be at sea level. You can find the total sea-level weight of air in a room another way: one cubic foot of air weighs about 1.3 ounces, or .081 pound.

The weight of a cubic foot of air can change. Gas molecules move faster as they get warmer, and some of the molecules will move out of the cubic foot of space. How does this affect the weight of a volume of air that gets warmer? colder?" (reprinted by permission

of the publisher).

Comprehension Check:

(F) 1. Why does the earth attract all the gas molecules in the air? (They are matter; they have weight.)

(V) 2. What is a square inch? (a square, one inch on a side)

(V) 3. What is sea level? (the level of the ocean)

(F) 4. About how many pounds would the air above a square inch of land surface at sea level weigh? (14.7 pounds)

(I) 5. Why does a bathroom scale read zero if air above it has weight? (The pressure of the air against the bottom of the scale is equal to the pressure on the top of the scale.)

(V) 6. What is an estimate? (an approximation, a very good guess based on information available)

(V) 7. What is a cube? (a solid three-dimensional figure with equal sides; a block)

(F) 8. How much would all the air surrounding the earth weigh? (5700 trillion tons)

(V) 9. What name do we give to how much a container will hold? (volume)

(I) 10. If some of the molecules of air move out of a container when the air is heated, how will this affect the weight of the air in the container? (It will weigh less.)

ORR: Read the section that tells about how we determine air pressure. (74 words)

Our Mixed-Up Air

Level C Comprehension_____

Oral: pp. 1-2 (350 words) 3-C Word Recognition_____

Motivation: As you read see if you remember what gases make up the atmosphere.

"As the earth turns and winds blow, the gases in the atmosphere are continually being mixed, so that any sample of air is a mixture that contains most of them. If this mixing action stopped for some reason, and if the gases settled in layers according to their weight, the bottom layer would be xenon, and then would come krypton, ozone, carbon dioxide, argon, neon, oxygen, nitrogen, helium, and, at the very top, hydrogen.

In the drawing on page 2 you will notice that nitrogen and oxygen together make up about 99 percent of the total atmosphere. Are these two gases important to us? Indeed they are. The living things of the earth could not exist in their present form if they didn't have oxygen. And oxygen from the air is constantly combining with various materials to form new materials.

For thousands of years man has used fire to cook his food, to give him light, and to keep himself warm. Yet it was less than 200 years ago that we found out what really happens when things burn. Joseph Priestley, the English scientist who discovered oxygen, thought that a mysterious gas he called phlogiston excaped from things as they burned. After all, it was easy to see that when a stick burned it

became just a pile of ashes.

But at about the same time, a careful French experimenter by the name of Antoine Lavoisier weighed a sample of mercury and sealed it, along with a known weight of air, in a closed container. After heating the container, he found that there was no loss of weight. The oxygen from the air had combined with the mercury. The oxygen was gone and a new substance, mercuric oxide, had been formed; its weight equaled the weight of the mercury plus the weight of the oxygen. The same thing happens when wood or coal burns. Oxygen from the air combines with the carbon in these fuels to form carbon dioxide; nothing is lost or destroyed. Your home activity and the classroom experiment will help you understand how things burn" (reprinted by permission of the publisher).

Comprehension Check:

(I) 1. What kind of experiment could you think of using a balloon to show that different gases have different weights? (A balloon could be filled with hydrogen or helium and it would rise, but if filled with a heavier gas it would fall.)

(F) 2. Name four gases that are found in air. (xenon, keypton, ozone, carbon dioxide, neon, oxygen, nitrogen, helium, hydrogen)

(F) 3. What two gases make up 99 percent of the air? (oxygen and nitrogen)

(F) 4. What gas in the air is needed by living things? (oxygen)

(F) 5. What man discovered oxygen? (Joseph Priestley)

(V) 6. What is phlogiston? (A mysterious gas that Priestley thought escaped from things that burned.)

(I) 7. If wood were burned in a closed container would the air in the container weigh more or less if phlogiston were released. (more)

(F) 8. What kind of matter burns in most fuels ? (carbon)

(F) 9. What gas is formed when fuels burn ? (carbon dioxide)

(I) 10. What two kinds of matter molecules would be combined to form carbon dioxide ? (carbon, oxygen)

Our Mixed-Up Air

Level C Comprehension_____

Silent: pp. 2-3 (281 words) 3-C Word Recognition_____

Motivation: Read to find out why we can call our air "mixed-up."

"We must always be careful to prevent accidents due to fire. If your clothes should catch fire, knowing how to put out the flames can save your life. Quickly wrap yourself in a blanket if one is handy, or roll up in a rug, or roll on the ground. How does this put out the fire? We say it smothers the flame. What happens is that oxygen is kept away from the flame, and fire will not burn unless oxygen is present.

We can also smother flames with carbon dioxide. Carbon dioxide is a heavy gas, and when used under pressure in a fire extinguisher it settles down over a fire and crowds out the oxygen.

When oxygen combines with other substances, the process is called oxidation. Fire is an example of rapid oxidation--large amounts of heat and light are given off rapidly. Rust forms when oxygen combines with iron. This is an example of slow oxidation. There is no light, and heat is given off very slowly. The difference between these forms of oxidation is that one combination takes place slowly and the other rapidly.

Did you know that molecules of nitrogen are taken out of the air by bacteria (tiny living cells) that live in the soil? They change the gas into forms that growing plants can use in making new cells.

Nitrogen dilutes, or thins out, the oxygen in the air. This is important, for if we were to breathe in too much oxygen, our bodies would produce too much energy too fast. The cells of the body would drown or smother in their own waste products" (reprinted by permission of the publisher).

Comprehension Check:

(F) 1. How do you put out flames if your clothes catch fire? (Wrap yourself in a rug or blanket, or roll on the ground.)

(F) 2. How does this put out the fire? (It keeps the oxygen away and fire will not burn without oxygen.)

(I) 3. How does water put out a fire? (It keeps the oxygen away by wetting the material burning. It also might cool the burning material.)

(V) 4. What does it mean to smother something? (to completely cover it so that it can't get any air)

(F) 5. What gas is used to smother a flame? (carbon dioxide)

(I) 6. If carbon dioxide is given off when a substance burns, why doesn't the fire put itself out? (The carbon dioxide mixes with the air.)

(V) 7. What is the process called when oxygen combines with other substances? (oxidation)

(F) 8. What is an example of slow oxidation? (rusting)

(V) 9. What are bacteria? (tiny living cells found in soil)

(I) 10. Bacteria take nitrogen out of the air. What would happen to us if the bacteria took all of the nitrogen out of the air? (We would die because the nitrogen in the air is needed to dilute the oxygen in the air. If we get too much oxygen our cells would smother in waste products.)

ORR: Read the paragraph that tells about oxygen combining with other substances. (71 words)

Why is Air Like a Rubber Band?

Level D Comprehension_____

Oral: pp. 1-2 (320 words) 5-D Word Recognition_____

Motivation: Read to obtain an understanding of why air moves.

"Once in a while you must outpush the wind in order to open a door. And now and then a gust of air may slip into your room and mess up a stack of papers. Since your room is always filled with air, why does more outside air rush in sometimes?

Air is always moving. Up-and-down air currents and surface winds flow through the atmosphere in much the same way that currents of water flow through the oceans. Looking out the window, you might see dust blowing down a street, leaves dancing up and down on the branch, or a small whirlwind of leaves and dust skimming across a pasture.

Can you see the moving air that causes all this activity? Of course not. If you observe carefully, though, you can determine the direction from which the wind is blowing. Does the air in the whirlwind behave like the air passing through the trees? Are the clouds in the sky and the dust in the street moving in the same direction? Air moves because it is a fluid.

Air has no definite shape or volume. And the gas molecules that make up the air yield to any force tending to change their position. If you inflate a balloon with air, you can force it into different shapes.

You can squeeze the balloon and make it shorter, or you can stretch it and make it longer. Could you squeeze a balloon filled with water into different shapes? Yes, but you could not change the volume of liquid in the balloon by squeezing it. Nor would a quart of water increase to a quart and a half if you stretched the balloon. What would happen if you filled the balloon with concrete and allowed it to harden? Could you force the balloon into other shapes or sizes? Air and water are both fluids whose molecules move freely when a force is applied" (reprinted by permission of the publisher).

Comprehension Check:

(V) 1. What is a gust of air? (a sudden push)

(I) 2. Why would air blow into a room if it is already filled with air? (The pressure on the outside must be greater than the pressure on the inside; it can move and make room for more air.)

(V) 3. What is an air current? (a stream of flowing air; flowing of air)

(F) 4. Why can't you see the air that causes the wind? (It is a colorless mixture of gases.)

(I) 5. How can you determine which direction a wind is blowing? (smoke, leaves, dust, etc., wet finger)

(I) 6. If a fluid takes the shape of the container, which would hold more fluid, a cube with a volume of one cubic foot, or a globe with a volume of two cubic feet? Why? (The globe; it has one cubic foot more space.)

(F) 7. What two types of matter are fluids? (liquids and gases)

(V) 8. What is a liquid? (a type of matter that has a definite volume, but not a definite shape; water, juice or milk)

(I) 9. Why couldn't a balloon filled with concrete be classed as a fluid? (The concrete has a definite shape; fluids are pliable; it is solid.)

(V) 10. What is a force? (a pressure or push that is exerted or applied to something)

Why is Air Like a Rubber Band?

Level D Comprehension_____

Silent: pp. 2-3 (313 words) 5-D Word Recognition_____

Motivation: As you read this determine what kind of home freezer would save the most on bills.

"Like all fluids, air flows from a high-pressure area to a low-pressure area. When you open the door of a refrigerator, you can feel cold air rushing over your feet. Why? The warm, less dense air in the room weighs less than the cold, dense air from the refrigerator. As the cold air flows out, gravity pulls it near the floor. And since the cold air is heavier than the warm air in the room, it exerts pressure on the warm air and pushes it up. Have you ever wondered why the open-top freezers in grocery stores remain cold? The greater density and weight of the cold air inside the box keeps the warm air from flowing in. The cold air cannot escape because there is no area of lower pressure for the heavier air to flow into. Air movements are caused by changes in air pressure. In your home activity you will work with the properties of moving fluids.

In the 1700's a scientist named Daniel Bernoulli made an important discovery about fluids. He found that the higher the speed of a flowing gas or liquid, the lower its pressure. This is now called Bernoulli's law.

You can check this if you wish. Stick a pin through a cardboard and hold it over the end of a spool as shown in the drawing. Blow

through the hole at the other end of the spool. The cardboard will remain in place after you release your hold. With the aid of the picture, could you explain to someone else why this happens? Does the diameter of the stream of air decrease? If you blow an airstream midway between two apples suspended in air, the apples will move toward each other and collide. Can you explain why? Does the air around the apples exert more, or less, pressure than the stream of air flowing between them?" (reprinted by permission of the publisher).

Comprehension Check:

(V) 1. What is a fluid? (a liquid or gas; something that can make room for more)

(F) 2. Does air flow from a low-pressure area to a high-pressure area or from a high-pressure area to a low-pressure area? (from a high-pressure area to a low-pressure area)

(V) 3. What does it mean to be "less dense?" (The air is not packed as close together.)

(I) 4. Why is there usually a small door on the freezer compartment inside a refrigerator? (to keep the more dense cold air inside the freezer compartment)

(I) 5. On a calm evening where would it be cooler, in a valley or on top of the hills around the valley? Why? (in the valley, because the cool air is more dense and will settle to the bottom of the valley)

(F) 6. What causes air to move? (changes in air pressure)

(F) 7. About when did Bernoulli make discoveries about moving streams of fluids? (1700's)

(F) 8. What is Bernoulli's law? (The higher the speed of a flowing gas or liquid the lower its pressure.)

(V) 9. What does the word diameter mean? (the distance across it)

(I) 10. Why would two apples suspended in air move together if you blow a stream of air between them? (The air pressure between the apples would be lower than on the other side, so the higher air pressure would push the apples together.)

ORR: Read the last paragraph. (114 words)

Shells in an Ocean of Air

Level E Comprehension_____

Oral: p. 2 (254 words) 4-E Word Recognition_____

Motivation: Read to find out why air pressure changes with altitude.

Air pressure changes at different altitudes and decreases as altitude increases. The air is less dense, or less compressed, as you go higher, and there is less air above you to produce pressure.

You feel the change of air pressure when you go up a mountain or travel in a plane. At the higher altitudes the air inside your body pushes on the inside of your eardrum with a pressure that is greater than that of the less dense upper air pushing on the outisde of your eardrum. If you yawn, the denser air on the inside of your eardrum can escape, and your ear feels comfortable. As you come down to a lower altitude, which side of your eardrum is subjected to the greater pressure? Why? Air pressure at an altitude of nine miles is about one-eighth of that at sea level. What would the air pressure be at that altitude?

Beyond nine miles the air pressure continues to decrease. At an altitude of about 60 miles, the gas molecules are much farther apart. They are about a million times less dense than at the surface of the earth. At this altitude, atmospheric pressure hardly exists.

The atmosphere surrounding the earth is classified by layers called atmospheric shells. The most common way of identifying each

shell is by the average air temperature within the shell; yet there is no well-defined line between shells. Their boundaries change from season to season as different areas of the earth absorb different amounts of heat from the sun" (reprinted by permission of the publisher).

Comprehension Check:

(V) 1. What is altitude? (distance above the ground)

(V) 2. What does compressed mean? (more dense, squeezed together)

(F) 3. What happens to air pressure as you go to high altitude? (The air pressure decreases.)

(I) 4. Which side of your eardrum is subjected to the greatest pressure as you come down a mountain? (the outside)

(I) 5. If the air pressure at an altitude of nine miles is one-eighth of that at sea level, how would you find out what the pressure is in pounds per square inch? (Divide 14.7 by eight.)

(F) 6. How high would we need to go before there was hardly any atmosphere? (about 60 miles)

(I) 7. Why can't birds fly 60 miles high? (There is not enough air for them to breathe. There isn't enough air for them to fly.)

(V) 8. What is an atmospheric shell? (a layer of air)

(V) 9. What is a boundary? (the edge of a layer, a border)

(I) 10. Would the boundary of an atmospheric shell go up or down if the air became warmer? (Up; the warm air spreads out and rises causing the shell to become larger.)

Shells in an Ocean of Air

Level E

Comprehension_____

Silent: pp. 2-3 (350 words) 4-E

Word Recognition_____

Motivation: As you read note the names given to the shells of the earth's atmosphere.

"Meteorologists (another name for weathermen) use rockets, planes, balloons, and satellites to explore the temperature and conditions of the upper air. They have named four shells of the atmosphere, and they are constantly seeking more information about each. Nearest the earth is the troposphere, extending upward to about ten miles. The entire surface of the earth lies within this shell. If you check the altitudes marked on a map, you will see that the top of Mount Everest--the earth's highest mountain--lies below this height.

The top of the troposphere is sometimes called the tropopause. This is where the troposphere begins to blend into the next atmospheric shell, the stratosphere. The air temperature within the stratosphere is fairly constant, but it begins to rise at the upper limit--at an altitude of about 50 miles. At the top, where it begins to blend into the next atmospheric level, there is a sharp increase in air temperature.

The two upper shells of air are the ionosphere, extending up to 500 miles, and the exosphere, the outer layer, which extends up from 500 miles above the earth. In the upper part of the ionosphere the temperature of the gas can be as much as several thousand degrees,

and gas molecules are great distances apart.

The exosphere is really the beginning of outer space. Air pressure is nonexistent, and gas molecules travel at such high speeds that some reach a velocity of slightly more than seven miles per second, the speed necessary to escape the gravitational pull of the earth. Those molecules that escape drift endlessly in space.

Man has always tried to understand the heavens. Primitive people thought that the gods sent warmth and rain from the sky. The Greeks and Romans thought the aurora borealis was a sign of bad luck; the American Indians thought it was a glow from the fires of the northern medicine men. And even in the 1700's, when astronomers announced that meteors were chunks of matter from outer space, there were some scholars who were unwilling to accept this as a fact"

(reprinted by permission of the publisher).

Comprehension Check:

(V) 1. What is another name for weathermen? (meteorologists)

(F) 2. How many shells of the atmosphere have meteorologists named? (four)

(V) 3. What is the troposphere? (the lowest shell of the earth's atmosphere)

(V) 4. What is the boundary between the troposphere and the stratosphere called? (the tropopause)

(I) 5. Why might the air become warmer at the top of the stratosphere? (There must be some gas at the top of the stratosphere that reacts with sunlight.)

(V) 6. What does the prefix exo mean? (outer or outside)

(I) 7. If the temperature is as high as several thousand degrees in the ionosphere why aren't the satellites melted when they pass through this shell? (The molecules of air are great distances apart.)

(F) 8. What layer is the beginning of outer space? (the exosphere)

(F) 9. How fast must a particle go to escape the earth's gravitational pull? (seven miles per second; 25,000 miles per hour)

(I) 10. Is space empty? Why? (No, there are particles of matter widely scattered in space, such as the molecules that escape from the earth.)

ORR: Read the last paragraph. (81 words)

APPENDIX IV

GROUP INFORMAL READING INVENTORY

(SRA, The Earth's Atmosphere Laboratory, 1964)

by

Donald R. Daugs

Instructions to Teacher:

Inform the students that they are to read selections from some special science materials that will be used in class. Some of the selections will be more difficult than others. Encourage the pupils to read the selections carefully.

After they have read a one-level selection give them the questions related to that level. Answers should be brief, but complete enough to let this researcher know that the student knows the correct answer. Pupils' answers to these items will determine what level of materials a pupil will use during the study.

Place all answer sheets in the correct level packet. All sheets will be corrected by this researcher.

Fish Out of Water

Level A

Motivation: This selection is about the air we breathe. As you read is see if you can discover what air is made of.

"Someday you might visit the moon. The minute you step from your rocket ship, you will be a fish out of water. Why? A fish lives in water. You live in air. You live at the bottom of an ocean of air. This ocean of air is the earth's atmosphere. As far as we know, the moon has no atmosphere, so you could not live there unless you wore a space suit.

Our ocean of air is made up of certain gases; and gases, like everything else in the world, are made up of tiny bits of stuff called molecules. They are so tiny you can never see one at a time. In a gas, the molecules are always moving very fast. Often one molecule bumps into another molecule. Then it bounces off in a new direction.

How do we know that air is really there? You cannot smell any of the gases that make up air. You can smell cookies baking. And you might smell the odor of paint or of burning leaves. Your nose is sure to tell you when odors of these things are mixed with the gases of the air. But you cannot smell air itself. You cannot see or taste air either. The gases that make up air have no color, odor, or flavor" (reprinted by permission of the publisher).

Student's Name _____

Teacher _____

Comprehension Check:

1. What ocean do we live at the bottom of?

2. Could a fish live on the moon? Why?

3. What name is given to the earth's ocean of air?

4. Why can an astronaut live in a space suit on the moon?

5. What is our atmosphere made of?

6. What name do we give to the stuff that makes up the air?

7. What is a molecule?

8. If the molecules in a gas are moving very fast, then why can't we feel them hit us?

9. How do we know air is really there?

10. What kinds of things can you smell when mixed with the gases of the air?

A 5700-Trillion-Ton Ocean

Level B

Motivation: As you read the first part of this selection see if you could prove that air has weight.

"If you scooped up a can full of air, how much air would you have? Could you weigh the air in the can?

Air takes up space. We know this because balloons and tires get larger when they are filled with air. But does the air make them heavier?

Does a balloon full of air feel heavier than one that is not? It might not, for a small change in weight is hard to sense. But if you lifted a tire that had gone flat and then lifted it again after it had been filled with air, the added weight would probably surprise you.

Like all forms of matter, air takes up space and has weight. All the objects in the universe not only attract but are attracted by all the other objects. The attraction of objects for one another depends on the amount of matter the objects contain and how far apart they are. We call this attraction gravity.

When you jump into the ocean of air around you, gravity draws you back with a pull that is equal to your weight. We express gravity in terms of the weight of the object that is being attracted to the center of the earth" (reprinted by permission of the publisher).

Student's Name _____

Teacher _____

Comprehension Check:

1. How do we know air takes up space?

2. Which would weigh more, a balloon full of air or an empty balloon? Why?

3. Which would be heavier, a can full of water or a can full of air? Why?

4. What is matter?

5. What does attraction mean?

6. What name do we give to the attraction objects have for each other?

7. Which would have the more attraction for the earth, a flat tire or a tire full of air?

8. Which would be attracted to the earth with the greater force, a balloon filled with air ten feet above the ground, or a balloon with the same amount of air 1000 feet above the ground?

9. What is weight?

10. How would your weight on the moon compare to your weight on earth?

Our Mixed-Up Air

Level C

Motivation: Read to find out why we can call our air "mixed-up."

"We must always be careful to prevent accidents due to fire. If your clothes should catch fire, knowing how to put out the flames can save your life. Quickly wrap yourself in a blanket if one is handy, or roll up in a rug, or roll on the ground. How does this put out the fire? We say it smothers the flame. What happens is that oxygen is kept away from the flame, and fire will not burn unless oxygen is present.

We can also smother flames with carbon dioxide. Carbon dioxide is a heavy gas, and when used under pressure in a fire extinguisher it settles down over a fire and crowds out the oxygen.

When oxygen combines with other substances, the process is called oxidation. Fire is an example of rapid oxidation--large amounts of heat and light are given off rapidly. Rust forms when oxygen combines with iron. This is an example of slow oxidation. There is no light, and heat is given off very slowly. The difference between these forms of oxidation is that one combination takes place slowly and the other rapidly.

Did you know that molecules of nitrogen are taken out of the air by bacteria (tiny living cells) that live in the soil? They change the gas into forms that growing plants can use in making new cells. Nitrogen dilutes, or thins out, the oxygen in the air. This is

important, for if we were to breathe in too much oxygen, our bodies would produce too much energy too fast. The cells of the body would drown or smother in their own waste products" (reprinted by permission of the publisher).

Student's Name _____

Teacher _____

Comprehension Check:

1. How do you put out flames if your clothes catch fire?

2. How does this put out the fire?

3. How does water put out a fire?

4. What does it mean to smother something?

5. What gas is used to smother a flame?

6. If carbon dioxide is given off when a substance burns, why doesn't the fire put itself out?

7. What is the process called when oxygen combines with other substances?

8. What is an example of slow oxidation?

9. What are bacteria?

10. Bacteria take nitrogen out of the air. What would happen to us if the bacteria took all of the nitrogen out of the air?

Why is Air Like a Rubber Band?

Level D

Motivation: Read to obtain an understanding of why air moves.

"Once in a while you must outpush the wind in order to open a door. And now and then a gust of air may whip into your room and mess up a stack of papers. Since your room is always filled with air, why does more outside air rush in sometimes?

Air is always moving. Up-and-down air currents and surface winds flow through the atmosphere in much the same way that currents of water flow through the oceans. Looking out the window, you might see dust blowing down a street, leaves dancing up and down on the branch, or a small whirlwind of leaves and dust skimming across a pasture.

Can you see the moving air that causes all this activity? Of course not. If you observe carefully, though, you can determine the direction from which the wind is blowing. Does the air in the whirlwind behave like the air passing through the trees? Are the clouds in the sky and the dust in the street moving in the same directions? Air moves because it is a fluid.

Air has no definite shape or volume. And the gas molecules that make up the air yield to any force tending to change their position. If you inflate a balloon with air, you can force it into different shapes. You can squeeze the balloon and make it shorter, or you can stretch it

and make it longer. Could you squeeze a balloon filled with water into different shapes? Yes, but you could not change the volume of liquid in the balloon by squeezing it. Nor would a quart of water increase to a quart and a half if you stretched the balloon. What would happen if you filled the balloon with concrete and allowed it to harden? Could you force the balloon into other shapes or sizes? Air and water are both fluids whose molecules move freely when a force is applied" (reprinted by permission of the publisher).

Student's Name _____

Teacher _____

Comprehension Check:

1. What is a gust of air?

2. Why would air blow into a room if it is already filled with air?

3. What is an air current?

4. Why can't you see the air that causes the wind?

5. How can you determine which direction a wind is blowing?

6. If a fluid takes the shape of the container, which would hold more fluid, a cube with a volume of one cubic foot, or a globe with a volume of two cubic feet? Why?

7. What two types of matter are fluids?

8. What is a liquid?

9. Why couldn't a balloon filled with concrete be classed as a fluid?

10. What is a force?

Shells in an Ocean of Air

Level E

Motivation: Read to find out why air pressure changes with altitude.

"Air pressure changes at different altitudes and decreases as altitude increases. The air is less dense, or less compressed, as you go higher, and there is less air above you to produce pressure.

You feel the change of air pressure when you go up a mountain or travel in a plane. At the higher altitudes the air inside your body pushes on the inside of your eardrum with a pressure that is greater than that of the less dense upper air pushing on the outside of your eardrum. If you yawn, the denser air on the inside of your eardrum can escape, and your ear feels comfortable. As you come down to a lower altitude, which side of your eardrum is subjected to the greater pressure? Why? Air pressure at an altitude of nine miles is about one-eighth of that at sea level. What would the air pressure be at that altitude?

Beyond nine miles the air pressure continues to decrease. At an altitude of about 60 miles, the gas molecules are much farther apart. They are about a million times less dense than at the surface of the earth. At this altitude, atmospheric pressure hardly exists.

The atmosphere surrounding the earth is classified by layers called atmospheric shells. The most common way of identifying each shell if by the average air temperature within the shell; yet there is no

well-defined line between shells. Their boundaries change from season to season as different areas of the earth absorb different amounts of heat from the sun" (reprinted by permission of the publisher).

Student's Name _____

Teacher _____

Comprehension Check:

1. What is altitude?

2. What does compressed mean?

3. What happens to air pressure as you go to high altitude?

4. Which side of your eardrum is subjected to the greatest pressure as you come down a mountain?

5. If the air pressure at an altitude of nine miles is one-eighth of that at sea level, how would you find out what the pressure is in pounds per square inch?

6. How high would we need to go before there was hardly any atmosphere?

7. Why can't birds fly 60 miles high?

8. What is an atmospheric shell?

9. What is a boundary?

10. Would the boundary of an atmospheric shell go up or down if the air became warmer? Why?

APPENDIX V

Suggestions for Participating Teachers:

Students are to be encouraged to explore topics in greater detail than found in the SRA materials. Books listed under "You Might Also Like to Read" and other related materials should be made available to the students if possible.

Pages 36-39 of the "Teacher's Instructional Aid Booklet" contain a listing of materials needed for experiments. If these are not available in the building it is suggested that students bring them from home.

The "Teacher's Handbook" contains most of the answers to questions you will have concerning use of the materials. It is suggested that you follow the procedure as found on pp. 11-13 of the "Teacher's Handbook" to introduce the materials to the students.

Students are to be assigned to the reading level indicated by preliminary testing done by this researcher, and will remain at that level for the duration of the study. It is necessary that each student understand the system by which the booklets are coded, i.e., the letter and number of bars on the edge of the booklet. When this is understood any level of material may be located in each of the "Big Ideas" without removing it from the Laboratory box.

General instructions found on pp. 14-19 of the "Teacher's Handbook" will be found valuable. Suggested time allotments will be found on pp. 21-22. In addition to the steps recommended for working in a laboratory, p. 21, it is requested that each teacher select a number of vocabulary words and concepts from each big idea and introduce them to the class PRIOR to their reading the selection. This time period can be used as an excellent motivation tool. Write some of the new vocabulary on the board, pronounce the words correctly and use them in sentences. If this is not done prior to the students reading the

materials, the student will tend to skip that word or concept in his reading. Note that this is a major variation from the procedure recommended on p. 17 of the "Teacher's Handbook."

The time allotments suggested on pp. 21-22 of the "Teacher's Handbook" should be very helpful. Please keep a record of time spent in use of these materials.

Place new students who come into your classroom during the study at a level you consider appropriate. The data from these students will not be used. Also note any pupils who are absent more than five days during the study.

Thank you for your cooperation, and good luck.

Instructions for Pretest:

All marks are to be made on the answer sheet. Have the pupils fill in their name, the date, school, their sex, and the instructor's name on the answer sheet.

The pretest should be given just prior to starting the SRA unit. The score from this test and the posttest will be used to measure the achievement gain.

After completion of the pretest, place the answer sheets in the envelope provided and mail them to me. Carefully store the test booklets. They will be used again at the end of the study.

It is suggested that about 40 minutes be allowed for the taking of the pretest.

Instructions for the Student:

This test will determine how much you know about the earth's atmosphere before we use the SRA materials. Read each question carefully. If you do not know the answer or if there are unfamiliar words in the question, leave that item blank on the answer sheet. Do not make wild guesses.

Instructions for Posttest:

All marks are to be made on the answer sheet. Have the pupils fill in their name, the date, school, their sex, and the instructor's name on the answer sheet.

The posttest should be given upon completion of the SRA materials. Place the completed answer sheets in the envelopes provided. I will pick them up. An answer key is provided. You may wish to correct your class's responses for your own evaluation.

Instructions for the Student:

This test will determine how much you have learned about the earth's atmosphere. Read each question carefully. If you do not know the answer to an item, do not guess.

APPENDIX VI

Criterion Test

(used by permission of William Fryback)

1. Which of the following would not cause a weather balloon filled with helium to fall back to the earth's surface?

   A. Heating the helium
   B. Cooling the helium
   C. Compressing the helium
   D. Releasing the helium

2. What would happen to a half-filled balloon if it were left on a warm radiator?

   A. It would get larger
   B. It would gradually get smaller
   C. It would melt
   D. Nothing would happen

3. Equal amounts of air were put into two balloons. One balloon was placed in a refrigerator; the other balloon was held over a pan of boiling water. Later the two balloons were compared.

   Which of the following describe the balloon that was placed in the refrigerator?

   A. Heavier
   B. Lighter than the other balloon
   C. Smaller than the other balloon
   D. Larger than the other balloon

4. The earth's atmosphere is made of

   A. Ice crystals
   B. Water vapor
   C. Pure oxygen
   D. A mixture of gases

5. The term "dense air" means the molecules in the air are

   A. Mixed with water vapor
   B. Warm
   C. Far apart
   D. Close together

6. Which of the following is not a good example of how air can do work?

   A. Sailboat
   B. Windmill
   C. Air conditioner
   D. Parachute

7. Which of the following statements is false?

   The air ocean is made up of gases that are

   A. colorless
   B. weightless
   C. odorless
   D. tasteless

8. When molecules in the air are heated they will

   A. increase in size
   B. move faster
   C. decrease in size
   D. move slower

9. If you have a shovel made of iron, you probably oil it before packing it away. Oiling the iron shovel will help prevent

   A. rotting
   B. rusting
   C. dehydration
   D. freezing

10. At which of the following altitudes would you expect your heart to beat the fastest?

    A. 10 feet
    B. 100 feet
    C. 1,000 feet
    D. 10,000 feet

11. In a sample of air from your classroom, you would not expect to find

    A. water vapor
    B. chlorine gas
    C. dust particles
    D. helium gas

12. If cold air suddenly entered a heated room, it would

A. decrease the number of molecules in the room
B. decrease the air pressure
C. force the warm air up
D. immediately rise to the ceiling

13. When molecules in air push against a surface the result is called

A. weight
B. density
C. pressure
D. gravity

14. When a glass of ice water is placed in a warm room for a few minutes, drops of water appear on the outside of the glass.

This water comes from the

A. air
B. ice
C. glass
D. water in the glass

15. Suppose you were holding your finger over a drinking straw half full of water so that the water remained in the straw. If you were quickly flown to the top of a high mountain in a helicopter

A. all the water would stay in the straw
B. the water would be pushed up higher into the straw
C. some of the water would drip out of the straw
D. no water would remain in the straw

16. A stream of air has less sideways pressure when it is

A. moving slowly
B. moving fast
C. cooled
D. heated

17. When you drink a coke through a straw

A. air pressure pushes the coke up the straw
B. the coke rises because it is expanding
C. the weight of the coke pushes it up the straw
D. the temperature of your mouth warms the coke and makes it rise

18. If you open a bottle of cold air in a warm room and want the cold air to stay in the bottle, you should keep the bottle

A. right side up
B. upside down
C. on its side
D. in your hand

19. The gas which makes up about 79 percent of our atmosphere is

A. helium
B. oxygen
C. carbon dioxide
D. nitrogen

20. You could probably wash your hands in boiling water on the top of a high mountain. This is because the boiling-point of water depends on the

A. temperature of the air
B. amount of water
C. density of water
D. amount of air pressure

21. Why does air push (exert pressure) in all directions, but a solid pushes (exerts pressure) only downward?

Molecules in air

A. are heavier than those of a solid
B. move more freely in all directions
C. are warmer than those of a solid
D. weigh less than those of a solid

22. If an empty water glass were turned upside down and pushed down into a bucket of water, the glass would

A. have air in it
B. have nothing in it
C. fill with water
D. break because of the pressure

23. One way to make the molecules in air move faster is to

A. heat the air
B. cool the air
C. dry out the air
D. humidify the air

24. Carbon dioxide is useful for fighting small fires because it

A. takes up more space than oxygen
B. is colder than oxygen
C. is more dense than oxygen
D. is lighter than oxygen

25. While playing baseball in a city at a high altitude, a player should be able to hit the ball farther because at the high altitude

A. balls are more "alive"
B. pitchers can't throw the ball as hard
C. the ball parks are smaller
D. there are fewer molecules in the air

26. A fluid will always

A. be wet
B. be colder than things around it
C. have the same shape as its container
D. be round like a drop of water

27. Which of the following was <u>not</u> considered an element by ancient peoples ?

A. Sun
B. Air
C. Earth
D. Fire

28. Inside a closed bottle, air presses

A. only against the lid
B. only against the sides
C. only against the bottom
D. in all directions

29. Oxidation is the process of oxygen

A. combining with something else
B. being produced by green plants
C. being weighed
D. being produced by animals

30. Which of the following is a "layer" of the atmosphere?

A. Troposphere
B. Stratosphere
C. Ionosphere
D. All of the above

31. At room temperature air is

A. liquid
B. solid
C. fluid
D. molecule

32. People on earth live in an ocean of air. Where in this air ocean do they live?

A. Near the top
B. Near the middle
C. Near the bottom
D. Near the equator

33. Suppose you put a drinking straw into a glass of water. Now if you put your finger over the top of that straw and lift it from the water, there will still be water inside the straw because

A. air is lighter than water
B. the straw is very narrow
C. air is pushing up on the water at the bottom of the straw
D. air above the water in the straw holds it in

34. Air is made up mostly of

A. different gases
B. dust particles
C. water particles
D. oxygen

35. If you weren't wearing a space suit and you fell out of a rocket flying in space, you would be killed by

A. too much pressure on the outside of your body
B. intense cold
C. heat of the sun
D. lack of pressure on the outside of your body

36. If you were riding a bicycle on the highway and a long truck passed close to you at a fast speed, air pressure might push you

A. up into the air
B. into the side of the truck
C. down onto the pavement
D. into the ditch

37. If you removed most of the air from a container, the molecules left in the container would

A. settle to the bottom
B. move slower
C. evaporate
D. spread out

38. It is hard to pull a suction cup off a wet, smooth surface because

A. the vacuum inside holds it tightly against the surface
B. air outside the cup pushes against it and holds the cup against the surface
C. high air pressure inside holds it against the surface
D. the moisture makes it stick

39. You are able to "see your breath" when it is cold outside because

A. it turns to snow
B. it warms the air and makes it visible
C. the oxygen condenses
D. water vapor from your mouth cools and forms droplets

40. It is easier for jets to fly at higher altitudes than at lower altitudes because

A. they run into fewer molecules in the air
B. there is more oxygen for fuel at high altitudes
C. there are no winds at high altitudes
D. they are almost weightless at high altitudes

41. Anything which flows is called a

A. gas
B. liquid
C. fluid
D. solid

42. Blowing more molecules into a balloon will

A. increase the pressure in the balloon
B. decrease the weight
C. lower the temperature
D. decrease the density

43. If our air had half as much oxygen as it now does, forest fires would be

A. less likely to start
B. harder to control
C. hotter than the ones we have now
D. more likely to occur on high mountains

44. The gas which causes objects to rust is

A. nitrogen
B. carbon dioxide
C. helium
D. oxygen

45. You would become short of breath more easily running on a mountain top than running at sea level because

A. it is colder on the mountain top
B. you would be breathing in too much nitrogen
C. there is more carbon dioxide on the mountain top
D. there is less oxygen at higher altitudes

46. Which of the following can be most easily compressed?

A. Soil
B. Water
C. Nitrogen gas
D. Tar

47. The "hissing" sound that is made when a can of vacuum-packed coffee is opened is caused by

A. air escaping
B. air rushing in
C. pressure decreasing
D. air in the can contracting

48. A helium filled balloon will rise into the air because heavier air pushes it up. The balloon will stop rising when it

A. reaches the top of the atmosphere
B. gets as large as it can get
C. becomes too cold to rise higher
D. becomes the same weight as air around it

49. If an inflated football were left in a room where the air was gradually being removed, the

A. weight of the football would increase
B. pressure inside the football would increase
C. weight and pressure inside the football would not change
D. size of the football would increase

50. Any push or pull is called

A. density
B. force
C. weight
D. mass

51. The earth pulls all things toward it. Because of this we say all things on earth have

A. molecules
B. atoms
C. weight
D. magnetism

52. At sea level, the distance between gas molecules in the air is

A. about an inch
B. more than a mile
C. nearly 80 feet
D. less than the width of an eyelash

53. If you put an airtight cap on a can in which you had just boiled some water and set it aside in a cool place, the can would

A. explode
B. be crushed
C. cool slower
D. cool faster

54. The air around the earth gets its heat from

A. the earth's surface
B. the sun
C. volcanoes
D. factory smoke and car exhausts

55. Suppose you punched a small nail hole near the bottom, the middle, and near the top along the side of a tall tin can. If you covered each hole with one of your fingers, filled the can with water, then uncovered all three holes at once, the water would go out the bottom hole

A. with most force
B. with least force
C. with the same force as through the other holes
D. none of these

56. If you poured water over half a glassful of dry dirt you would see

A. bubbles of carbon dioxide
B. bubbles of water
C. bubbles of dirt
D. bubbles of air

57. Why is the gas argon used in many light bulbs ?

A. Because it won't combine with most things
B. Because it is very light
C. Because it is cheaper than any other gas
D. Because it is colorless

58. A gas which helps protect living things from too much ultraviolet light from the sun is

A. helium
B. oxygen
C. ozone
D. nitrogen

59. If you hold the tops of two sheets of notebook paper about two inches apart, then blow air between them, they will

A. move farther apart
B. move closer to each other
C. try to fly off
D. tear apart

60. In salt water, a block of wood would float higher (more of the wood out of the water) than in fresh water. This is because salt water is

A. lighter than fresh water
B. warmer than fresh water
C. heavier than fresh water
D. colder than fresh water