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A Dissertation Submitted in Partial Fulfillment of the Requirements for the Degree of Doctor of Philosophy

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Ability Groups Employed in the Experiment
CHAPTER I

INTRODUCTION AND STATEMENT OF THE PROBLEM

Introduction

There is an increasing awareness of the importance of creativity in our society and the recognition that education should contribute to this objective. This study is based on the assumption that helping to develop the creative potential of all individuals is a function of the school and that elementary science education should encourage not only the acquisition of scientific knowledge, but also the search for new meanings, implications, and ideas. As Guilford states:

We need experiments that will also assess the possible benefit of teaching for creativity in connection with regular courses in science, mathematics, and the arts.\(^1\)

Because of the rapid changes taking place in this century, a person cannot foresee what knowledge he will need ten or twenty years from now to meet his life's problems. He can, however, develop attitudes that will help him solve these problems creatively.

Need for the Study

There are demands being made upon the teacher to teach creatively; to improve the creative thinking abilities of pupils; and to increase subject matter knowledge. Methods are being suggested that

may accomplish these objectives, but as Wilson states:

The validity of suggested methods (brainstorming, sensitivity to problems, ideational fluence, synectic techniques) has not been established in any systematic research studies.2

Taylor states theoretically,

...creative thinking can deliberately be developed to some degree in our educational programs even while students are learning subject matter....3

There is little research evidence to substantiate such theory. Sommers calls upon researchers "to determine the feasibility of improving creative thinking within academic courses."4 Therefore, the investigator developed a conviction that a need to determine the effectiveness of creative exercises on the mastery of a unit in space science, as well as upon the improvement of creative thinking abilities exists.

**Statement of the Problem**

The major purpose of this study was twofold: one, to determine whether or not teachers could improve the creative thinking abilities of the pupils in their classes by using selected creative exercises. Two, to determine what affect the attempt to improve creative thinking abilities would have upon achievement in a subject matter.

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area, in this case a space science unit. The following questions were posed for investigation:

1. Is there a significant relationship between creative thinking and intelligence for pupils who have used creative exercises, pupils who have used traditional exercises, or for pupils who have not used any exercises?

2. Is there a significant difference between pupils who have used creative exercises, pupils who have used traditional exercises, and pupils who have not used any exercises on an achievement test in space science and a creative thinking test?

3. Is any significant difference, on an achievement test in space science and a creative thinking test found within the high, average, and low ability levels?

4. Is there a significant difference between male and female pupils on an achievement test in space science and a creative thinking test in classes using creative exercises, classes using traditional exercises, and classes not using any exercises?

Procedure

The study and solution of these problems involved the following steps.

1. During the months of August through December 1964, the investigator prepared thirty lesson plans and accompanying activities for the experimental and control groups, as well as an achievement test on space and space travel.

2. On December 3, 1964, the investigator submitted this proposal to the Coordinator of Educational Research, Milwaukee Public Schools, Milwaukee, Wisconsin.
3. On January 13, 1965, the investigator received authorization to conduct research in the Milwaukee Schools.

4. On January 18, 1965, the first of four meetings between the investigator and school officials were held to discuss the research proposal and problems of sampling.

5. On January 25, 1965, the Director of Educational Research randomly selected, from the elementary schools of Milwaukee, twenty-seven sixth grade classes of which nine came from schools representing high scholastic ability, nine from schools representing average scholastic ability, and nine from schools representing low scholastic ability.

Three classes were randomly selected from each of the three ability levels to represent the experimental group that used creative exercises following each science lesson. Three classes were randomly selected from each of the three ability levels to represent the traditional group that used traditional exercises following each science lesson. The remaining nine classes, of which three represented each ability level, were randomly selected as the overall control group and participated in the testing only.

Figure 1 shows the organization of the groups following suggestions by Campbell and Stanley.⁵

As Figure 1 shows, there were nine classes in each of the treatment groups. Three of these classes represented each of the three ability levels - high, average and low in each of the treatment groups.

FIGURE 1
ABILITY GROUPS EMPLOYED IN THE EXPERIMENT

| Experimental Treatment | High Ability Level | Three Sixth Grades
|-------------------------|--------------------|-------------------|
|                         | Average Ability Level | Three Sixth Grades$^A$
|                         | Low Ability Level | Three Sixth Grades

| Traditional Treatment (Control B) | High Ability Level | Three Sixth Grades$^B$
|----------------------------------|--------------------|-------------------|
|                                  | Average Ability Level | Three Sixth Grades$^C$
|                                  | Low Ability Level | Three Sixth Grades

| Control C | High Ability Level | Three Sixth Grades
|-----------|--------------------|-------------------|
|           | Average Ability Level | Three Sixth Grades
|           | Low Ability Level | Three Sixth Grades

A includes 17, 5A students
B includes 15, 5A students
C includes 32, 5A students

7. On January 26, 1965, the investigator received permission from Dr. E. Paul Torrance, at the University of Minnesota, to use Abbreviated Form VII of the Minnesota Tests of Creative Thinking.

8. On February 8, 1965, teachers began using the prepared materials each day for approximately thirty minutes until thirty lessons were completed.

9. During the week of March 22, 1965, the twenty-seven classes were administered the investigator's space and space travel achievement test and the Minnesota Tests of Creative Thinking - Abbreviated Form VII.

10. In order to seek answers to the questions posed in the
statement of the problem, statistical measures were employed. They will be discussed in Chapter 4.

Limitations of the Study

Certain limitations were inherent in a study of this nature:

1. The study was limited to twenty-seven classrooms of youngsters in grades five and six and their teachers.

2. The study was limited by the time, length, and method of instruction employed by the teachers.

3. The study was further limited by the subject matter employed and the nature of the tests used.

Definitions of Terms

Seven terms used in this thesis need special clarification in the context of this study:

1. Mastery -- the degree of success as measured by the space and space travel achievement test. Success was determined by the number of correct answers on the test.

2. Creative thinking -- no broad definition is intended. This term refers to those abilities of fluency, flexibility, originality, and elaboration as measured by the Minnesota Tests of Creative Thinking - Abbreviated Form VII. Fluency is the "total number of relevant responses, relevancy being defined in terms of the task" in the test. Flexibility means the number of different ideas, categories, principles or approaches used in responding to the tasks in the test. 6


7Ibid., pp. 21, 27.
nality is the "uncommonness of response in a statistical sense" on a particular task in the test. Elaboration is the "extent to which the idea is spelled out" or "every pertinent detail (idea) added to the original stimulus figure itself..." in each task in the test.

3. Creative exercises -- written assignments based on suggestions from various authorities for increasing creative ability. Many of these exercises were designed to include the subject matter of the lesson.

4. Traditional exercises -- written assignments considered by the investigator to be the typical science exercises following any lesson.

5. Science unit -- a packet of thirty, thirty-minute lesson plans on space and space travel designed by the investigator and used by teachers in treatment groups A and B but not by teachers in treatment C.

6. Treatments -- three treatment groups were designated. Treatment A referred to the experimental group using the thirty science lessons, four of which were brainstorming lessons. The experimental group used creative exercises following each science lesson. Treatment B referred to the control group using the thirty science lessons without the four brainstorming lessons. The traditional group used traditional exercises following each science lesson. Treatment C referred to the group taking only the tests and affected by neither

---


9 Torrance, op. cit., p. 38.

10 Torrance, op. cit., p. 19.
the unit nor the exercises.

7. **Significant differences** -- the result of statistical measures used to determine large differences (at the .05 level of confidence) between the experimental and control groups. Significant differences were determined by the analysis of covariance and the analysis of variance.

**Summary**

In Chapter 1, the investigator attempted to indicate the role of the school and the elementary science program for developing creative thinking.

Needs for research concerning the development of creativity through subject matter, in this case science was emphasized. More specifically, four questions were posed regarding the use of creative exercises in subject matter mastery and creative thinking.

Procedures used in the study to find the answers to these questions were described.

Limitations of this study were established and the definitions of terms were clarified.
CHAPTER 2

REVIEW OF RELATED LITERATURE

Introduction

A review of the literature in creativity and elementary science indicates that a synthesis of the research in these fields is necessary if one is to understand the role that each plays in the teaching-learning process.

The writer attempts to present a comprehensive review of creativity as it relates to the teaching-learning process. This was done so that the reader could develop an accurate picture of the relationship of research in creativity to the teaching-learning process. This was accomplished by identifying research in the following areas: the definitions of creativity, characteristics of creative individuals, creativity and general education, and finally creativity in the teaching and learning of elementary science.

Definitions of Creativity

In the previous chapter creative thinking was defined and limited to the abilities of fluency, flexibility, originality, and elaboration. For the purpose of elucidation, a few definitions by leading authorities in various fields is appropriate.

Process and product. Rogers asserts that the creative process is the
...emergence in action of a novel relational product, growing out of the uniqueness of the individual on the one hand, and the materials, events, people or circumstances of his life on the other.  

Andrews conceives of creativity as a

...process in which man manipulates external symbols or objects as a means of self-actualization to produce an unusual event uncommon to himself and his environment.  

Russell states that "creativity involves production, some tangible outcome, and originality."  

Kubie believes that

...uncovering of new facts and of new relationships among both old and new data is not the whole of creativity, it is the essential process without which there can be no such thing as creativity.  

Sawrey and Telford state that

...creativity has to do with the processes of producing original ideas, novel problem solutions, and utilizable innovations. Originality is, of course, basic to becoming creative.  

Rosten defines creativity as

...a shuttle between fancy and discipline, between imagination and system, between freedom and control, between fantasy and...

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reason, between reverie and evidence, between imagination and analysis. 6

Problem-solving. Gordon in discussing his theory of synectics defines the creative process as the "mental activity in problem-solving situations where artistic or technical inventions are the result." 7

Eisner says that,

...divergent thinking is the type that most characterizes creativity. It is thinking that is speculative, that 'takes off' from information already possessed. 8

Brandwein states that,

...creative thinking is not very clearly distinguished from thinking that is termed problem-solving or logical thinking or reasoning. 9

He continues his definition indicating that

...we may appropriately regard thinking as creative when a number of discrete units become organized into a new (to the organizer) and meaningful pattern or formulation. 10

And finally, the National Education Association, in its text, Deciding What To Teach, states that

...creative thinking begins with 'openness,' a tendency or willingness to bring together a wide range of ideas, facts, and hypotheses and to consider their relationships without

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10 Ibid., p. 64.
being bound by preconceived or conventional conclusions.¹¹

Summary. These definitions lead to the conclusion that creativity and/or creative thinking involves a process and a product. The process of realistic thinking, imagination, divergent and convergent thinking, and manipulation leads to the production of something new, unusual, novel, at least to the individual. Thus, from this view, it would appear that all individuals are capable of creative thinking to a greater or lesser degree. And like learning, which involves a process and a product, it has significance in the teaching of subject matter.¹²

From a study of these definitions, a review of the characteristics of creative individuals will help develop a comprehensive picture of the creative student.

Characteristics of Creative Individuals

Several studies provide us with a rather comprehensive analysis of the characteristics of creative people. Barron describes the creative individual as

...especially observant,...seeks to point to the usually unobserved;...independent, sharp observation;...vigorous;...complex, (and)...flexible....¹³

MacKinnon's description adds the possession of a

...high level of effective intelligence, an openness to experience,...freedom from crippling restraints and


impoverying inhibitions,...esthetie sensitivity, cognitie
flexibility,...independence in thought and action,...high level
of creative energy,...unquestioning commitment to creative
endeavor, and his unceasing striving for solutions to the ever
more difficult problems that he constantly sets for himself.14

Taylor describes the creative individual as possessing some of
the following: ability to sense problems and ambiguities, questioning
ability; ability to hypothesize, to foresee consequences, to infer
causes, to evaluate, to like to think, to manipulate and play with
ideas; the need for autonomy, intense esthetic and moral commitment,
non-conforming, self-sufficient; independent, emotionally sensitive,
dominant and self-assertive, and more introverted but bold.15

Guiford's16 factor-analytic studies provide further insight into
recognizing the creative individual.

With the creative individual so aptly described, is there any
evidence to a statement made earlier that all individuals possess
creative ability to some extent?

Wilson,17 Russell,18 Andrews,19 Lowenfeld,20 Hallman,21 and

14Donald W. MacKinnon. "What Makes a Person Creative?" Saturday

15Calvin W. Taylor, "A Tentative Description of the Creative
Washington, D.C.: Association for Supervision and Curriculum Develop-

16J. P. Guilford, "Creativity: Its Measurement and Development," A
Source Book for Creative Thinking. S. J. Parnes and H. F. Harding

17Robert C. Wilson, "Creativity," Education For The Gifted. The
Fifty-seventh Yearbook of the National Society for the Study of Edu-
p. 109.

18David H. Russell, Children's Thinking. New York: Ginn and

Mayer agree that everyone possesses creative abilities to some degree and that there are implications in this concept for education. Mayer says that "the point is not that creativity is confined to the few; rather that all are in some degree capable of creative work."  

**Summary and implications.** The editors of *Education U.S.A.* provide an excellent description of the creative individual which will serve as a summary of this section. The editors describe the creative individual as one who is

...intelligent (but not necessarily markedly so,) independent, curious, skeptical, emotionally committed to his work, energetic, esthetically sensitive, introverted, nonconformist, occasionally egotistical, (and) almost always actuated by a 'sense of destiny.'

The implications for education gleaned from these descriptions highlight the importance of the inclusion of creative techniques in the teaching-learning process. The next section of this chapter will explore the role education is expected to assume in enhancing creative abilities. For it is in the classroom where "education for creativity" will pay dividends. Teachers must recognize the need for creative

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23Ibid., p. 112.

education. They must recognize creative students. Torrance says that

...in each classroom, three characteristics stand out as identifying the highly creative children; there is a tendency for them to gain a reputation for having wild or silly ideas. Their work is characterized by its productivity of ideas 'off the beaten track.' And, the highly creative are characterized by humor and playfulness.25

And, finally the teacher must know how to enhance the creative potential of each student. As William Gordon states:

...the creative process in human beings can be concretely described and...should be usable in teaching methodology to increase the creative output of both individuals and groups.26

Creativity and Education

Recent research is beginning to point the way that education can help in developing creative abilities. It may be argued that the research is causing more problems than it is solving, but the writer feels that this trend is providing added insight into the educative process, the concept of intelligence and achievement, and hopefully science education.

The importance of imagination. In discussing education as a creative process, Mayer states that:

...the mind is creative and is constantly engaged in the reconstruction of its environment....Through the study of creativity we ought to pay more attention to the way our mind works, the way we think, and the way we achieve conclusions....More knowledge of the creative process will combine factual precision with valuational boldness in education ...the study of creativity ought to convince us of the importance of imagination in education.27

26Gordon, op. cit., p. 5.
Osborn has long recognized the importance of imagination in education. His book emphasizes its universality and encourages the techniques of brainstorming, individual ideation, check-lists, and attribute listing, as aids to improving creative problem-solving ability.28

Osborn reviews the creative education movement indicating that separate courses in creative problem-solving started at the State University of Buffalo in 1949 and that creative teaching institutes were pioneered at the University in 1958.29

The significance of intelligence. The relationship between creativity and intelligence provides some evidence that intelligence alone does not account for creative behavior.

Getzels and Jackson30 found that creativity and intelligence are positively related but this relationship is not very high. They state that:

...creative students were quite superior in scholastic achievement. Despite this, the teachers showed no special preference for them as students, whereas they did show a special preference for the high I.Q. students of similar scholastic achievement.31

Taylor states that:

...the best conclusion at present is that intelligence, as measured, accounts for only a minor portion of the variation in creative performance and, by itself is by no means an adequate measure of creativity.32


31 Ibid., p. 125.

32 Taylor, op. cit., pp. 93-94.
Torrance found that creative thinking ability increases from grades one through three; but about grade four and grade seven there is a decrease in this ability. He says "we may expect decrements in creative thinking ability and in creative production at about the ages of five, nine, and twelve...."34

School grades offer little evidence according to the research, for predicting creative performance. They have shown "to have low validity in predicting creative performance."35

Taylor reports low or negative correlations of academic grades with on-the-job performance in research work.

Can creativity be taught? A methodology of creative teaching, according to Lowenfeld

...can at best help to develop an atmosphere conducive to the unfolding of creative potentials in individuals.... Such a methodology still needs the stronger ties with subject-matter and skills in the various areas of creative teaching.37

Getzels states that "no single set of principles of instruction for creative thinking and problem-solving can be drawn from present


34 Ibid., p. 103.


theory and research." He suggests, however, that

...we have tended to look at teaching from the perspective of learning and thinking....It may be advisable to...look at learning and thinking from the perspective of the practice of teaching, the hope being (for) at least one substantial treatise...on 'theories of Teaching-Learning-Thinking....'

Parnes states that

...we still know little about what 'creativity' really is. But we do know how to stimulate greater creative behavior in individuals.

He also illustrates this point by describing some educational programs designed to improve creative ability.

Parnes and Meadows report that an experimental group taking a course in creative problem-solving produced a significant increase in good-quality ideas and an increase on the personality variable—dominance—than the control group.

Hallman presents an excellent theoretical framework for his belief that creativity can be taught.

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39 Ibid., pp. 266-267.


41 Ibid., pp. 332-337.


Cartledge and Kauser\textsuperscript{44} conclude that even first grade children can benefit from training in creative thinking.

Hutchinson, in a study of creative and productive thinking in the classroom, found that

\textit{...modification of instructional procedure resulted in better achievement for the experimental group over the control group. Students were able to experience a wider range of intellectual activity while learning subject matter and at no expense of learning the subject matter.}\textsuperscript{45}

In another study, Rouse\textsuperscript{46} found significant results in a training program on the productive thinking of educable mentally retarded children.

In discussing his attempts to increase creative thinking, Torrance states that

\textit{...in all grades, we found a consistent tendency for the trained subjects to produce more responses, more flexible responses, and more clever responses than the untrained ones.}\textsuperscript{47}

In other words, the teacher must have creative thinking as a specific objective, teach for it, if he expects youngsters to demon-


strate this skill or use it in new situations. Stollberg, 48 de Hurd and Johnson, 49 Mills and Dean, 50 and Dressel 51 indicate that teaching must be directed toward an objective such as critical thinking, problem-solving, or creative thinking if these are to be attained by students.

Hoover 52 appears to be one of the first authors to treat "brainstorming" as a technique to activate the desire to learn. At least he is one of the first to utilize brainstorming and imagination in a textbook on instructional practices in the secondary school.

Teacher's role. The role of the teacher cannot be minimized. The research cited highlights the demands placed on the teacher for fostering creativity.

Eisner suggests five guidelines for developing creativity in the classroom:

First, the classroom teacher must reduce those conditions that hamper creativity; second, she must develop those abilities


that are conducive to it... Third, the students need to have experience and skill in the subject matter area itself... Fourth, a person must be able to control the syntax and techniques of the discipline within which he is working... Fifth and finally, creative behavior like most other types of behavior should be rewarded when it occurs.53

Yamamoto asserts that "the role of creative thinking in real educational settings is not a simple clear-cut one."54 He found no significant difference between high creative teachers and low creative teachers in background factors, such as sex, marital status, age, educational attainment, and teaching experience.55

Assagioli urges the teacher "to create a favourable psychological atmosphere, a positive rapport, ... encouragement and appreciation..."56

Torrance asks teachers to

...provide opportunities for creative behavior,...develop skills for creative learning,...reward creative achievements,...provide for continuity of creative development,...and establish creative relationships.57

Weir suggests that learning in and of itself is a creative act.

Learning is an act of creation in which the learner brings into


55Ibid., p. 2801.


being new measures for the ordering and enrichment of his own living. 58

Further, Weir states,

Teaching is involvement with other human beings in the uniquely human experience of choosing... (and) the processes through which man's unique creative powers are brought to bear upon the mysteries of existence. 59

Summary. To conclude this section on creativity and education, a note of caution is sounded. Mueller 60 is one of the first to raise questions concerning the ability of the public schools to foster creativity. Margolin, 61 Nordberg, 62 Wallen, 63 and DeWille 64 suggest that we need more research in order to prevent "creativity" from becoming another educational fad.

Thus, we have a fairly good picture of what creativity is; the characteristics of creative people; and the significance of creativity to the teaching-learning process. It remains our final task to relate the topic of creativity to a subject matter area and complete the entire picture. Hence the next section will review the literature in

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59 Ibid., p. 408.
elementary science education and determine the relationship, if any, that elementary science has to creativity.

Can elementary science contribute to the development of creative ability? In elementary science education, creative thinking can and should be developed. The objectives of science education provide a basis for teaching children to develop their creative abilities while learning science concepts. This attitude, which included open-mindedness, curiosity, and investigation, as well as the development of problem-solving ability corresponds favorably with the meanings and implication of the definitions of creativity and creative thinking. 65

As Taylor says, "most school programs do little to help identify and develop creativity in our science students." 66 Blough states that "science is a method of discovery - it is a creative intellectual activity..." 67

Navarra states the position clearly.

The proper study of and participation in science should have in it the same qualities of creativity and use of imagination employed by the individual child as he uses clay, tempera, finger paint - or actively participates in any of the many art forms. In a sense, I am asserting and exhorting that anything less than this does not develop the full meaning and impact of science in the life of the individual. 68

Very little research, if any, is available to verify the value of creative techniques or exercises for the teaching or learning of science.


67 Glenn O. Blough, op. cit., p. 48.

There is not sufficient proof that developing creative thinking ability can be a concomittant result of science instruction. However, some motivation and guidelines are provided by studies and research in other aspects of science education.

Watson and Vessel indicate that teaching for a specific objective usually produces the objective.

Mason implies from his study that:

The ability to think scientifically can be taught more effectively when students are given direct training in the methods of science than when they do not receive such training. Problem-solving can be an effective method for teaching both facts and skills inherent in the methods of science.

Kastrinos concludes from his study that:

1. A critical thinking approach to the teaching of high school biology can produce significant changes in the student's critical thinking ability....
2. This method of teaching can also bring about a significant change in subject matter mastery.

Navarra seems to be one of the first science educators to recognize the importance of creative imagination. In 1963, he stated:

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One need only to view the nature of scientific advancement to be convinced of the importance of the skillful use of creative imagination. Thus, it would seem, one of the prime functions of elementary science is to nurture and encourage the skillful use of creative imagination.\textsuperscript{74}

Peterson and Robinson\textsuperscript{75} reported some of the aspects and implications that research in creativity held for science education.

Taylor states:

It is possible that many types of information can be learned more economically and effectively by creative rather than authoritarian techniques. Our preliminary evidence seems to indicate that we should start earlier to introduce students into research activities, to have them learn how to collect data, to make observations on new problems, and learn on their own rather than only from teachers and textbooks.\textsuperscript{76}

Hilgard warns educators that "we must not develop critical abilities to the point that anything unproven is stupid or that anything weak is altogether wrong."\textsuperscript{77} Blough concurs, urging that "the science program should encourage creativity and originality in the activities of children.\textsuperscript{78}

Aitkin implies from his research that:

...if originality is considered desirable when children hypothesize, it should be noted that children exercise this behavior

\textsuperscript{74}Ibid., p. 231.


\textsuperscript{78}Glenn O. Blough, "Developing Science Programs in the Elementary School," Rethinking Science Education. op. cit., p. 121.
most effectively in classrooms where they, in part, select the
problems they work on.\textsuperscript{79}

Banghart and Spraker\textsuperscript{80} investigated the role of group influence
on creativity during mathematical problem-solving. They found no
significant difference between group and individual problem solvers in
terms of creativity but they did find a significant difference between
levels of intelligence.

Neal implies from his study that "children develop creative abili-
ties through the use of the methods of scientific inquiry."\textsuperscript{81}

Hess states that:

...one of the primary purposes of elementary school education is
the maximizing of mental capabilities by systematic stimulation
and exercise of mental faculties.\textsuperscript{82}

Both Hurd\textsuperscript{83} and Rubin\textsuperscript{84} believe that the curriculum can provide
for the enhancement of creative thinking abilities. As Rubin puts it,
"a curriculum designed to encourage creativeness holds value for all
students not merely the creative gifted minority."\textsuperscript{85}

\textsuperscript{79}Myron J. Aitkin, "A Study of Formulating and Suggesting Tests
for Hypotheses in Elementary School Science Learning Experiences,"

\textsuperscript{80}Frank W. Banghart and Harold S. Spraker, "Group Influence on
Creativity in Mathematics," The Journal of Experimental Education.

\textsuperscript{81}Louise A. Neal, "Techniques for Developing Methods of
Scientific Inquiry in Children in Grades One Through Six," Science

\textsuperscript{82}Robert D. Hess, "The Latent Resources of the Child's Mind,

\textsuperscript{83}Paul D. Hurd, "The New Curriculum Movement in Science," The

\textsuperscript{84}Louis J. Rubin, "Creativity and the Curriculum," Phi Delta

\textsuperscript{85}Ibid., p. 439.
The teacher, of course, will provide the climate for the development of creative ability. Teachers will need to teach science

...so that it is an 'introduction to learning how to learn' rather than...a collection of today's answers to questions which will be answered differently tomorrow.86

In a very new, and very good science book for teachers, Carin and Sund87 dedicate an entire chapter to the encouragement of creativity in science. As the authors state:

Creativity cannot be taught as a process, but by developing situations that demand imagination, originality, and problem-solving, the children are more likely to be creative.88

Kranzer states that:

...schools need teachers that are imaginative and creative rather than literal-minded; teachers who can help select material that is intrinsically rewarding to children and enlist them in the learning process.89

Thus, it appears that elementary science education can contribute to the development of creative ability, but this potential depends, in part, upon elementary teachers. It is fitting, then, to conclude this section of the chapter by quoting from one of the new books designed to help teachers teach science effectively.

Science teaching, because of the nature of science itself, is concerned with problem-solving which can do much to foster the manifestation of creative abilities....Science experiments


88Ibid., p. 134.

which are designed to utilize the imagination, originality, and curiosity of children will most likely foster the development of creative thought and will build toward the attainment of better science teaching objectives. 90

Summary of Chapter 2

The writer attempted to present a comprehensive view of the research in creativity and science education.

The chapter presented research in the following areas: the definitions of creativity and the implications these definitions have for the education process; the characteristics of creative individuals; creativity and education; and creativity and science education.

Highlights of the research indicated that creativity involves a process and a product of which there seems to be a commonality among people. The characteristics of creative individuals added further insight appropriate to the teacher-student relationship. All authorities agree that education must foster creativity but there was little agreement on how this is to be done. Elementary science education research seemed to be opening up new avenues for enhancing creativity through science instruction although a paucity of research exists.

90 Arthur Carin and Robert B. Sund, op. cit., p. 140.
CHAPTER 3

PLAN OF THE EXPERIMENT

Introduction

Advocates of creativity have stated that creative abilities can be increased through existing school programs. That is, the curriculum as it is now structured can provide the framework for developing creative ability. A review of the literature has shown, however, that little empirical evidence exists to support this assumption. The literature also indicates that the teaching of elementary school science needs to be improved if the objectives of elementary science are to be accomplished. Through this study, the investigator has sought to evaluate the use of selected creative exercises as a means of improving creative thinking abilities and the effect of this on the mastery of a space science unit in sixth grade classes. The following questions have been posed for investigation:

1. Is there a significant relationship between creative thinking and intelligence for pupils who have used creative exercises, pupils who have used traditional exercises, and for pupils who have not used any exercises?

2. Is there a significant difference between pupils who have used creative exercises, pupils who have used traditional exercises, and pupils who have not used any exercises on an achievement test in space science and a creative thinking test?
3. Is any significant difference, on an achievement test in space science and a creative thinking test, found within the high, average, and low ability levels?

4. Is there a significant difference between male and female pupils on an achievement test in space science and a creative thinking test in classes using creative exercises, classes using traditional exercises, and classes not using any exercises?

Administrative Considerations

In order to obtain a valid comparison of the effectiveness of the experimental and control methods, it was necessary to formulate specific administrative procedures to be used in the experiment.

Determination of the study group. It was decided that a city school system be selected in order to include many students from three ability levels and that grade six would comprise the population.

Approval by Milwaukee School officials led to a randomly selected sample determined in the following manner:

a. The Director of Educational Research indicated that school records of intelligence and achievement provide an index to the average general scholastic ability level of the school.

b. Schools were ranked, by the Director, according to the measured ability of its population, ranging from high general ability to low general ability.

c. The list of schools was divided into three ability levels: high, average, and low, by the Director and his staff.

d. A random selection of fifteen schools was made, by the Director, from each ability category, using a table of random numbers.
e. Using a table of random numbers, the Director selected nine schools from the list of fifteen in each category to participate in the experiment.

f. Using a table of random numbers, the Director selected from the nine schools (Figure 1, Chapter 1) in each ability category, three schools to use the experimental materials, three schools to use the traditional materials, and three schools to take the tests only.

g. A memorandum (see Appendix A) was sent to the principal of each school selected explaining the experiment and inquiring whether or not he wished his school to participate. If a principal did not wish to participate, his school was replaced by the next school on the list. This procedure was followed until a sample of twenty-seven schools was completed.

h. It should be noted that although grade six was originally selected, the Milwaukee School system operates on a semester basis, therefore, the sample included some 5A (second semester) fifth-grade students. These students were in the same classrooms with 6B (first semester) sixth-grade students. Social studies and science is taught to the entire class without reference to grade level.

Table 1 shows the population used in the experiment. The total sample included eight hundred fifty-one students, but because of absences, incomplete tests, and transfers, seven hundred ninety students, in twenty-seven classes, were used in the study.

Two hundred fifty-four pupils used the experimental materials. Two hundred seventy-six pupils used the traditional materials and two hundred sixty pupils participated in the testing program only.

Two hundred sixty-nine pupils represented the high ability level;
two hundred seventy-eight pupils represented the average ability level; and two hundred forty-three represented the low ability level.

**TABLE 1**

POPULATION BY ABILITY LEVEL AND TREATMENTS OF PUPILS USED IN THIS STUDY

<table>
<thead>
<tr>
<th>Ability Level</th>
<th>Treatments</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>A</td>
<td>B</td>
</tr>
<tr>
<td>High</td>
<td>92</td>
<td>95</td>
</tr>
<tr>
<td>Average</td>
<td>86</td>
<td>95</td>
</tr>
<tr>
<td>Low</td>
<td>76</td>
<td>86</td>
</tr>
<tr>
<td>Total</td>
<td>254</td>
<td>276</td>
</tr>
</tbody>
</table>

Teaching considerations during the experiment. It was agreed by the Director of Educational Research and this investigator that little or no supervision would occur during the experiment. The Elementary Science Supervisor visited each of the eighteen classrooms, using the experimental and traditional lesson plans and exercises, for the purposes of encouragement and to answer questions. The Science Supervisor indicated after his visitation that most teachers enjoyed having science lesson plans to teach from. No aid was provided the teacher other than the prepared lesson plans and activity sheets.

**Distribution and Collection of Materials**

After the sample had been selected, the investigator called each school secretary and asked her to inform the teacher that during the week of February 1, 1965, the materials would be delivered and that the experiment was to begin on Monday, February 8, 1965.
During the week of February 1, 1965, the investigator delivered the lesson plans and exercises to each teacher and again informed him that the material was self-explanatory, that youngsters were to do all exercises, and that the experiment was to begin on February 8, 1965. At this time, the investigator answered questions raised by the teachers.

During the sixth week of the teaching period (March 15, 1965), the investigator delivered the space science achievement tests (see Appendix D) and the Minnesota Tests of Creative Thinking (see Appendix E) to all twenty-seven schools.

During the week of March 22, 1965, these tests were administered, on different days, by the teachers and collected by this investigator.

Description of Differences in Treatment Groups and Exercises

Experimental group. The experimental group, treatment A, used the creative exercises and thirty lesson plans in space science, four of which were group brainstorming lessons (See Appendix B).

The investigator developed four brainstorming lessons for the teachers to use, in order to give the class practice in using this technique so that it could be applied to the creative exercises following each lesson.

Traditional group. The traditional group, treatment B, used the traditional exercises and thirty lesson plans in space science (See Appendix C). This group had different lessons to substitute for the four brainstorming lessons used by the experimental group.

Control group. The overall control group, treatment C, used no lesson plans or exercises but did participate in the testing program.
Creative and traditional exercises. As the investigator has already indicated, he attempted to determine whether or not teachers could use "special" exercises to improve children's creative thinking abilities. In order to do this, he carefully built a series of approximately eighty-six exercises based on suggestions from authorities indicated in Chapter 2. These creative exercises had to meet two criteria: one, they had to attempt to influence some aspect of creative thinking; and two, as much as possible, they had to deal with the subject matter, namely space science.

The investigator developed what he considered to be traditional science exercises. Activities of this nature are usually listed in science texts.

Tests to Measure Creative Thinking and Space Science Achievement

The Minnesota Tests of Creative Thinking. The Minnesota Tests of Creative Thinking—Abbreviated Form VII was selected as a measure of children's creative thinking abilities because it can be used in grades five and six and it appears to be valid.¹

"...It has not been possible to assemble comprehensive norms, validity data specific to this battery and the like. The tasks which make up this battery, however, have given good evidence of validity in earlier studies."²

In Chapter Three of his book, Guiding Creative Talent, Torrance offers several types of evidence of validity.³

²Ibid., Appendix A.
The tasks discriminate industrial arts students rated as highly creative from those rated as least creative, saleswomen who work in creative departments from those who work in routine departments. With elementary school children, it was validated in terms of observed behavior in small group nominations, and on the basis of peer and teacher nominations, and on the basis of achievement of the traditional kinds. 

Yamamoto’s evidence of the validity of tests of creative thinking against teacher nominations for total creativity scores was found significant at .001 level of confidence. 

Although there is no specific evidence of the reliability for Abbreviated Form VII, Yamamoto provides evidence for the Ask and Guess Test and the Test of Imagination which involves items used in Abbreviated Form VII as "Toy Dog Improvement" and "Circles." Test-retest reliabilities for these two sub-tests are .66 and .61, respectively. These correlations are significant at the .01 level of confidence. The total reliability for both tests is .79, significant at the .01 level of confidence. Yamamoto states that "reliabilities for each sub-scores vary but the total scores would seem to be reliable enough for most purposes." 

Administration of creative thinking test. During the week of March 22, 1965, the Minnesota Tests of Creative Thinking—Abbreviated

4Ibid., p. 64.
6Ibid., pp. 87-89.
7Ibid., pp. 88-89.
8Ibid., p. 89.
9Ibid., p. 86.
Form VII was administered to all students in the sample. Directions in the manual provided by Dr. Torrance were mimeographed (see Appendix E) and distributed to the twenty-seven teachers in the experiment.

**Test to Measure Space Science Achievement.** Since a standardized test was not available to measure knowledge of space science, the investigator constructed a test for this purpose.

Content validity of the space science achievement test was assumed by the construction of items that systematically sampled content taught. According to Travers, "The product of such an operation is a rough-and-ready judgment, and no satisfactory methods have been devised for quantifying this relationship."\(^{10}\)

The reliability of the test is .80, as computed by means of Kuder-Richardson Formula 21.\(^{11}\) The computations using the formula are found in Chapter Four.

**Administration of Space Science Achievement Test.** During the week of March 22, 1965 the Space Science Achievement Test was administered to all students in the sample. Each teacher in the experiment administered the test following the directions provided (see Appendix D).

**Test to Measure Intelligence.** The investigator had to use existing school records to obtain intelligence test scores. The Milwaukee School system administers the Lorge-Thorndike Intelligence Tests.

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The scores from the Lorge-Thorndike Intelligence Test were used to determine the relationship between creative thinking and intelligence, and creative thinking and space science achievement.

Scoring Procedures for the Minnesota Tests of Creative Thinking and the Space Science Achievement Test

The Minnesota Tests of Creative Thinking. The scoring of the test was done by the investigator and four high-school boys. The boys were trained to score two sections of the test using Torrance's scoring guide. This investigator scored the fluency and elaboration tasks of the test and the boys scored flexibility and originality. Yamamoto presents evidence of inter-scorer reliability among four scorers ranging from .97 to .99. The assumption that reliability will be equally as high is made because the investigator scores half of all the completed tasks while the usual procedure is to divide the tests among scorers and have them score the entire test. Data obtained from the administration of this test was used to compare the experimental and control groups in the four categories of creative thinking that the test measures.

The Space Science Achievement Test. The true-false items of the test were hand scored by the investigator. The multiple-choice items were machine scored by the investigator using the facilities at Marquette University. Data obtained from the administration of this test was used to compare the experimental and control groups on space science achievement.

Summary of Chapter 3

Chapter 3 has provided a detailed description of the procedures used in this experiment. A table was presented to clarify the number of pupils in the sample. Descriptions of the various social classes and
treatment groups in the experiment were explained. Randomization procedures used to select samples for statistical consideration were described. School records used and teaching considerations made during the course of the experiment were explained. Chapter 4 will present an analysis of the findings of the teaching experiment.
CHAPTER 4

STATISTICAL PROCEDURES

Analysis of the data that are presented in this chapter pertains to the comparison of attained scores on a creative thinking test and a space science achievement test as recorded by pupils in groups established on the basis of teaching treatment.

The major purpose of this study was twofold: one, to determine whether or not teachers could improve the creative thinking abilities of the pupils in their classes by using selected creative exercises. Two, to determine what affect the attempt to improve creative thinking abilities would have upon achievement in a subject matter area, in this case a space science unit.

The following questions were posed for statistical considerations:

1. Is there a significant relationship between creative thinking and intelligence for pupils who have used creative exercises, for pupils who have used traditional exercises, or for pupils who have not used any exercises?

2. Is there a significant difference between pupils who have used creative exercises, pupils who have used traditional exercises, and pupils who have not used any exercises on an achievement test in space science and a creative thinking test?

3. Is any significant difference, on an achievement test in space science and a creative thinking test, found within the high,
average, and low ability levels?

4. Is there a significant difference between male and female pupils, on an achievement test in space science and a creative thinking test, in classes using creative exercises, classes using traditional exercises, and classes not using any exercises?

In order to answer the above questions, it was necessary to classify schools according to the average general scholastic ability of pupils in the school, obtain an intelligence score for each pupil, and analyze the scores in creative thinking and space science achievement which had been attained by the classes selected for statistical consideration. The scores attained by randomly selected classes in the control and experimental groups were used to seek answers to each of the posed questions.

Definition of Terms for Tests

For clarification the various test categories defined in Chapter 1 are re-stated as follows:

Fluency—the total number of relevant responses in each task of the test.

Flexibility—the number of different ideas, categories, or principles used on each task of the test.

Originality—the uncommonness of responses on a particular task in the test.

Elaboration—the extent to which an idea is spelled out as measured by each task on the test.

Space Science Achievement—the degree of success as measured by the number of correct answers on the test.
Statistical Procedures to Measure the Relationship
Between Intelligence and Creative Thinking and
Intelligence and Space Science Achievement

In order to investigate the problem of this study, it was
necessary to determine the degree of relationship between scores ob-
tained on the Lorge-Thorndike Intelligence Test, Form B, and the
Minnesota Tests of Creative Thinking, and intelligence test scores and
scores on the Space Science Achievement Test. If there was a signifi-
cant relationship between intelligence and the four categories of the
creative thinking test and intelligence and space science achievement,
then, statistical procedures would have to be used that would control
intelligence as an influencing factor on fluency, flexibility, origi-
nality, elaboration, and space science achievement.

The investigator had to determine the degree of relationship for
each treatment group and each category on the creative thinking test
since Dr. Torrance does not recommend the addition of raw scores in
order to obtain a total creative thinking score. 1

The investigator assumed the null hypothesis, that there was no
significant relationship between intelligence and creative thinking,
and intelligence and space science achievement for each of the treatment
groups.

The investigator wished to test the significance of each of the
coefficients of correlation obtained by the computer (IBM 7040) at
Marquette University's Computer Center.

The statistical test used to test the significance from zero to

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1E. Paul Torrance, Administration and Scoring Manual for Abbrevia-
ted Form VII, Minnesota Tests of Creative Thinking. Minneapolis:
Bureau of Educational Research, College of Education, University of
Minnesota, 1963. Appendix A.
each of the coefficients of correlation was a "t" test formula for significance of correlation as stated by Ferguson.\(^2\) The formula was given as follows:

\[ t = r \sqrt{\frac{N - 2}{1 - r^2}} \]

Unless "t" equaled a value greater than 1.96, the null hypothesis that no significant correlation existed between intelligence and creative thinking and intelligence and space science achievement was accepted.

Table 2 shows the correlation between intelligence and creative thinking and intelligence and space science achievement for the experimental group.

**TABLE 2**

RELATIONSHIP BETWEEN I.Q. AND CREATIVE THINKING AND I.Q. AND SPACE SCIENCE ACHIEVEMENT FOR THE EXPERIMENTAL GROUP

<table>
<thead>
<tr>
<th>Test</th>
<th>N</th>
<th>r</th>
<th>(t) (calc.)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fluency</td>
<td>254</td>
<td>.35</td>
<td>6.09*</td>
</tr>
<tr>
<td>Flexibility</td>
<td>254</td>
<td>.30</td>
<td>5.25*</td>
</tr>
<tr>
<td>Originality</td>
<td>254</td>
<td>.33</td>
<td>5.58*</td>
</tr>
<tr>
<td>Elaboration</td>
<td>254</td>
<td>.07</td>
<td>1.10</td>
</tr>
<tr>
<td>Space Science Achievement</td>
<td>254</td>
<td>.65</td>
<td>13.48*</td>
</tr>
</tbody>
</table>

*(significant relationship)*

Table 3 shows the correlations between intelligence and creative

thinking and intelligence and space science achievement for the traditional group (Control group B).

**TABLE 3**

**RELATIONSHIP BETWEEN I.Q. AND CREATIVE THINKING AND I.Q. AND SPACE SCIENCE ACHIEVEMENT FOR THE TRADITIONAL GROUP**

<table>
<thead>
<tr>
<th>Test</th>
<th>N</th>
<th>r</th>
<th>t(calc.)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fluency</td>
<td>276</td>
<td>.31</td>
<td>5.26*</td>
</tr>
<tr>
<td>Flexibility</td>
<td>276</td>
<td>.24</td>
<td>4.52*</td>
</tr>
<tr>
<td>Originality</td>
<td>276</td>
<td>.17</td>
<td>2.80*</td>
</tr>
<tr>
<td>Elaboration</td>
<td>276</td>
<td>.24</td>
<td>4.07*</td>
</tr>
<tr>
<td>Space Science Achievement</td>
<td>276</td>
<td>.71</td>
<td>16.40*</td>
</tr>
</tbody>
</table>

*(significant relationship)*

Table 4 shows the correlations between intelligence and creative thinking and intelligence and space science achievement for the control group C.

**TABLE 4**

**RELATIONSHIP BETWEEN I.Q. AND CREATIVE THINKING AND I.Q. AND SPACE SCIENCE ACHIEVEMENT FOR THE CONTROL GROUP**

<table>
<thead>
<tr>
<th>Test</th>
<th>N</th>
<th>r</th>
<th>t(calc.)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fluency</td>
<td>260</td>
<td>.13</td>
<td>2.02*</td>
</tr>
<tr>
<td>Flexibility</td>
<td>260</td>
<td>.20</td>
<td>3.28*</td>
</tr>
<tr>
<td>Originality</td>
<td>260</td>
<td>.28</td>
<td>4.68*</td>
</tr>
<tr>
<td>Elaboration</td>
<td>260</td>
<td>.09</td>
<td>1.45</td>
</tr>
<tr>
<td>Space Science Achievement</td>
<td>260</td>
<td>.63</td>
<td>12.78*</td>
</tr>
</tbody>
</table>

*(significant relationship)*
As Tables 2, 3, and 4 show, the relationship between intelligence and space science achievement was significant for all groups. The relationship between the sub-tests of the creative thinking test was significant for all categories except elaboration. However, for the sake of consistency, the investigator considered the factor of intelligence in all statistical procedures used to answer the other questions posed in the study.

Analysis of the Reliability of the Space Science Achievement Test

To determine the reliability of the space science achievement test, Kuder-Richardson Formula 21 was used. The formula was given as follows:

\[ r = \frac{n}{n-1} \left( 1 - \frac{\bar{X} (n - \bar{X})}{ns_x^2} \right) \]

The results indicated that the test was reliable at \( r = .80 \) and thus useful for drawing inferences as reported in this study.

Analysis of the Minnesota Tests of Creative Thinking and the Space Science Achievement Test Results

Data obtained from the Minnesota Tests of Creative Thinking and the Space Science Achievement Test were used to determine treatment effect.

The mean scores for each treatment group on the Minnesota Tests of Creative Thinking, the Lorge-Thorndike Intelligence Test, and the Space Science Achievement Test are shown in Appendix F.

The mean scores for male and female pupils, in each of the treatment groups in the three ability levels, on the Minnesota Tests of 

\(^3\text{Ibid., p. 282.}\)
Creative Thinking, the Lorge-Thorndike Intelligence Test, and the Space Science Achievement Test are shown in Appendix G.

In order to compare the effectiveness of using creative exercises with traditional exercises and with no exercises, it was necessary to determine if the difference between mean scores achieved by the experimental and control groups was significant. To achieve this, the null hypothesis was assumed; that there was no significant difference between mean scores of the experimental and control groups. Thus if statistical evidence failed to reject the null hypothesis, it was assumed that any difference discovered could be attributed to chance.

The statistical test used to accept or reject the null hypothesis was the analysis of covariance as stated by Wert, Neidt, and Ahmann.⁴ If the "F" test proved significant, the investigator used a "t" test in order to determine differences between pair of means. The "t" test formula, as stated by Wert, Neidt, and Ahmann,⁵ was given as follows:

\[
t = \frac{\bar{x}_1 - \bar{x}_2}{\sqrt{s^2 \left( \frac{1}{k_1} + \frac{1}{k_2} \right)}}
\]

A level of confidence of five percent was adopted by the investigator in presenting the statistical findings. Therefore, if "F" was significant it was followed by a "t" test which had to equal at least 1.96 or the null hypothesis that no true difference probably existed between the means was accepted.


⁵Ibid., p. 135.
Comparison of Fluency Test Scores

In Table 5, the mean scores in fluency for the experimental group in each ability level is compared with the mean scores of the control groups in each ability level to determine the significance of the difference of these scores.

**TABLE 5**

**ADJUSTED MEAN SCORES IN FLUENCY FOR TREATMENT GROUPS IN EACH ABILITY LEVEL**

<table>
<thead>
<tr>
<th>Ability Level</th>
<th>Treatment Group</th>
<th>Adjusted Means</th>
<th>F-test</th>
</tr>
</thead>
<tbody>
<tr>
<td>High</td>
<td>Group C</td>
<td>45.05</td>
<td></td>
</tr>
<tr>
<td>( F_{2,267} )</td>
<td></td>
<td></td>
<td>27.08*</td>
</tr>
<tr>
<td>Average</td>
<td>Group A</td>
<td>58.43</td>
<td></td>
</tr>
<tr>
<td>( F_{2,276} )</td>
<td></td>
<td></td>
<td>45.54*</td>
</tr>
<tr>
<td>Low</td>
<td>Group A</td>
<td>44.59</td>
<td></td>
</tr>
<tr>
<td>( F_{2,241} )</td>
<td></td>
<td></td>
<td>1.91</td>
</tr>
<tr>
<td></td>
<td>Group C</td>
<td>44.99</td>
<td></td>
</tr>
</tbody>
</table>

*(significant at the .05 level of confidence)*

As Table 5 shows, the difference between the fluency mean scores attained by fifth and sixth grade pupils in the high and average ability levels is significant. There was no significant difference between the fluency mean scores for each of the treatment groups in the low ability level.
In Table 6, the fluency mean scores attained by pupils in Groups A, B, and C in the high ability level are compared to determine the significance of the difference of these scores.

TABLE 6

COMPARISON OF ADJUSTED MEAN SCORES IN CREATIVE THINKING—
FLUENCY—HIGH ABILITY LEVEL

<table>
<thead>
<tr>
<th>Grades Five and Six</th>
<th>No.</th>
<th>Adjusted Mean Scores</th>
<th>S.D.</th>
<th>S.E.D.</th>
<th>Diff.</th>
<th>t(calc.)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Group A Experimental</td>
<td>92</td>
<td>58.08</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Group B Traditional</td>
<td>95</td>
<td>45.06</td>
<td>14.82</td>
<td>2.16</td>
<td>13.02</td>
<td>6.06*</td>
</tr>
<tr>
<td>Group A Experimental</td>
<td>92</td>
<td>58.08</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Group C Control</td>
<td>82</td>
<td>45.05</td>
<td>14.82</td>
<td>2.25</td>
<td>13.02</td>
<td>5.78*</td>
</tr>
<tr>
<td>Group B Traditional</td>
<td>95</td>
<td>45.06</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Group C Control</td>
<td>82</td>
<td>45.05</td>
<td>14.82</td>
<td>2.24</td>
<td>.01</td>
<td>.004</td>
</tr>
</tbody>
</table>

*(significant at the .05 level of confidence)

As Table 6 shows, the mean score in fluency attained by fifth and sixth graders in Group A was significantly greater than the mean scores in fluency of fifth and sixth graders in Groups B and C. Therefore, the null hypothesis of no significant difference between classes using creative exercises, classes using traditional exercises, and classes not using exercises, can be rejected. There was no significant difference between fluency mean scores attained by pupils in Groups B and C. Therefore, the null hypothesis of no significant difference between
classes using traditional exercises and classes not using exercises cannot be rejected and must be accepted.

In Table 7, the fluency mean scores attained by pupils in Groups A, B, and C in the average ability level are compared to determine the significance of the difference of these scores.

**TABLE 7**

**COMPARISON OF ADJUSTED MEAN SCORES IN CREATIVE THINKING—FLUENCY—AVERAGE ABILITY LEVEL**

<table>
<thead>
<tr>
<th>Grades Five and Six</th>
<th>Adjusted Mean Scores</th>
<th>S.D.</th>
<th>S.E. D.</th>
<th>Diff.</th>
<th>t(calc.)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Group A Experimental</td>
<td>86</td>
<td>58.43</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Group B Traditional</td>
<td>95</td>
<td>50.30</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Group A Experimental</td>
<td>86</td>
<td>58.43</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Group C Control</td>
<td>97</td>
<td>39.69</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Group B Traditional</td>
<td>95</td>
<td>50.30</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Group C Control</td>
<td>97</td>
<td>39.69</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*(significant at the .05 level of confidence)*

As Table 7 shows, the mean score in fluency attained by fifth and sixth graders in Group A was significantly greater than the mean scores in fluency of fifth and sixth graders in Groups B and C. Therefore, the null hypothesis of no significant difference between classes using creative exercises, classes using traditional exercises, and classes not using exercises, can be rejected. The mean score in
fluency attained by fifth and sixth graders in Group B was significantly greater than the fluency mean score attained by fifth and sixth graders in Group C. Therefore, the null hypothesis of no significant difference between classes using traditional exercises and classes not using exercises can be rejected.

There was no significant difference in the fluency mean scores of the experimental and control groups in the low ability level. Therefore, the null hypothesis of no significant difference between classes using creative exercises, classes using traditional exercises, and classes not using exercises cannot be rejected, and must be accepted.

Comparison of Flexibility Test Scores

In Table 8, the mean scores in flexibility for the experimental group in each ability level is compared with the mean scores of the control groups in each ability level to determine the significance of the difference of these scores.

As Table 8 shows, the difference between the flexibility mean scores attained by fifth and sixth grade pupils in the high, average, and low ability levels is significant.

In Table 9, the flexibility mean scores attained by pupils in Groups A, B, and C in the high ability level are compared to determine the significance of the difference of these scores.

As Table 9 shows, the mean score in flexibility attained by fifth and sixth graders in Group A was significantly greater than the mean scores in flexibility of fifth and sixth graders in Groups B and C. The flexibility mean score attained by fifth and sixth graders in
Group C was significantly greater than the flexibility mean score attained by fifth and sixth graders in Group B. Therefore, the null hypothesis of no significant difference between classes using creative exercises, classes using traditional exercises, and classes not using exercises, can be rejected. The null hypothesis of no significant difference between classes using traditional exercises and classes not using exercises, can be rejected with the difference favoring the classes not using exercises.

**TABLE 8**

**ADJUSTED MEAN SCORES IN FLEXIBILITY FOR TREATMENT GROUPS IN EACH ABILITY LEVEL**

<table>
<thead>
<tr>
<th>Ability Level</th>
<th>Treatment Group</th>
<th>Adjusted Means</th>
<th>F-test</th>
</tr>
</thead>
<tbody>
<tr>
<td>High</td>
<td>Group A</td>
<td>33.35</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Group B</td>
<td>24.31</td>
<td>30.01*</td>
</tr>
<tr>
<td></td>
<td>Group C</td>
<td>29.91</td>
<td></td>
</tr>
<tr>
<td>(F&lt;sub&gt;2,267&lt;/sub&gt;)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>High</td>
<td>Group A</td>
<td>30.30</td>
<td></td>
</tr>
<tr>
<td>Average</td>
<td>Group B</td>
<td>28.70</td>
<td>27.46*</td>
</tr>
<tr>
<td></td>
<td>Group C</td>
<td>28.15</td>
<td></td>
</tr>
<tr>
<td>(F&lt;sub&gt;2,276&lt;/sub&gt;)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Low</td>
<td>Group A</td>
<td>23.60</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Group B</td>
<td>25.09</td>
<td>18.77*</td>
</tr>
<tr>
<td></td>
<td>Group C</td>
<td>25.76</td>
<td></td>
</tr>
<tr>
<td>(F&lt;sub&gt;2,241&lt;/sub&gt;)</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*(significant at the .05 level of confidence)*
TABLE 9
COMPARISON OF ADJUSTED MEAN SCORES IN CREATIVE THINKING-
FLEXIBILITY-HIGH ABILITY LEVEL

<table>
<thead>
<tr>
<th>Grades Five and Six</th>
<th>No.</th>
<th>Adjusted Mean Scores</th>
<th>S.D.</th>
<th>S.E. D.</th>
<th>Diff.</th>
<th>t(calc.)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Group A Experimental</td>
<td>92</td>
<td>33.35</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Group B Traditional</td>
<td>95</td>
<td>7.42</td>
<td>1.08</td>
<td>9.04</td>
<td>8.35*</td>
<td></td>
</tr>
<tr>
<td>Group A Experimental</td>
<td>92</td>
<td>33.35</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Group C Control</td>
<td>82</td>
<td>7.42</td>
<td>1.13</td>
<td>3.44</td>
<td>3.05*</td>
<td></td>
</tr>
<tr>
<td>Group B Traditional</td>
<td>92</td>
<td>24.31</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Group C Control</td>
<td>82</td>
<td>7.42</td>
<td>1.12</td>
<td>5.60</td>
<td>5.00*</td>
<td></td>
</tr>
</tbody>
</table>

*(significant at the .05 level of confidence)*

In Table 10, the flexibility mean scores attained by pupils in Groups A, B, and C in the average ability level are compared to determine the significance of the difference of these scores.

As Table 10 shows, the mean score in flexibility attained by fifth and sixth graders in Group A was not significantly greater than the mean score in flexibility of fifth and sixth graders in Group B. Therefore, the null hypothesis of no significant difference between classes using creative exercises and classes using traditional exercises cannot be rejected and must be accepted. The mean score in flexibility attained by fifth and sixth graders in Group A was significantly greater than
TABLE 10

COMPARISON OF ADJUSTED MEAN SCORES IN CREATIVE THINKING-
FLEXIBILITY-AVERAGE ABILITY LEVEL

<table>
<thead>
<tr>
<th>Grades Five and Six</th>
<th>No.</th>
<th>Adjusted Mean Scores</th>
<th>S.D.</th>
<th>S.E. D.</th>
<th>Diff.</th>
<th>t(calc.)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Group A Experimental</td>
<td>86</td>
<td>30.30</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Group B Traditional</td>
<td>95</td>
<td>28.70</td>
<td>6.41</td>
<td>.94</td>
<td>1.60</td>
<td>1.70</td>
</tr>
<tr>
<td>Group A Experimental</td>
<td>96</td>
<td>30.30</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Group C Control</td>
<td>97</td>
<td>28.15</td>
<td>6.41</td>
<td>.94</td>
<td>2.15</td>
<td>2.30*</td>
</tr>
<tr>
<td>Group B Traditional</td>
<td>95</td>
<td>28.70</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Group C Control</td>
<td>97</td>
<td>28.15</td>
<td>6.41</td>
<td>.92</td>
<td>.55</td>
<td>.59</td>
</tr>
</tbody>
</table>

*(significant at the .05 level of confidence)*

The flexibility mean score attained by fifth and sixth graders in Group C. Therefore, the null hypothesis of no significant difference between classes using creative exercises and classes not using exercises, can be rejected. The mean score in flexibility attained by fifth and sixth graders in Group B was not significantly greater than the mean score in flexibility of fifth and sixth graders in Group C. Therefore, the null hypothesis of no significant difference between classes using traditional exercises and classes not using exercises cannot be rejected and must be accepted.

In Table 11, the flexibility mean scores attained by pupils in Groups A, B, and C in the low ability level are compared to determine
the significance of the difference of these scores.

TABLE II

COMPARISON OF ADJUSTED MEAN SCORES IN CREATIVE THINKING-
FLEXIBILITY-LOW ABILITY LEVEL

<table>
<thead>
<tr>
<th>Grades Five and Six</th>
<th>No.</th>
<th>Adjusted Mean Scores</th>
<th>S.D.</th>
<th>S.E.</th>
<th>Diff.</th>
<th>t(calc.)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Group A Experimental</td>
<td>76</td>
<td>23.60</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Group B Traditional</td>
<td>76</td>
<td>25.09</td>
<td>5.06</td>
<td>.30</td>
<td>1.51</td>
<td>1.87</td>
</tr>
<tr>
<td>Group A Experimental</td>
<td>76</td>
<td>23.60</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Group C Control</td>
<td>81</td>
<td>25.76</td>
<td>5.06</td>
<td>.30</td>
<td>2.16</td>
<td>2.70*</td>
</tr>
<tr>
<td>Group B Traditional</td>
<td>86</td>
<td>25.09</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Group C Control</td>
<td>81</td>
<td>25.76</td>
<td>5.06</td>
<td>.78</td>
<td>.87</td>
<td>.87</td>
</tr>
</tbody>
</table>

*(significant at the .05 level of confidence)

As Table II shows, the mean score in flexibility attained by fifth and sixth graders in Group B was not significantly greater than the mean scores in flexibility of fifth and sixth graders in Group A. Therefore, the null hypothesis of no significant difference between classes using creative exercises and classes using traditional exercises cannot be rejected and must be accepted.

The mean score in flexibility attained by fifth and sixth graders in Group C was significantly greater than the flexibility mean score attained by fifth and sixth graders in Group A. Therefore, the null
hypothesis of no significant difference between classes using creative exercises and classes not using exercises, can be rejected with the difference favoring the control group. The mean score in flexibility attained by fifth and sixth graders in Group C was not significantly greater than the mean score in flexibility of fifth and sixth graders in Group B. Therefore, the null hypothesis of no significant difference between classes using traditional exercises and classes not using exercises cannot be rejected and must be accepted.

Comparison of Originality Test Scores

In Table 12, the mean scores in originality for the experimental groups in each ability level is compared with the mean scores of the control groups in each ability level to determine the significance of the difference of these scores.

<table>
<thead>
<tr>
<th>Ability Level</th>
<th>Treatment Group</th>
<th>Adjusted Means</th>
<th>F-test</th>
</tr>
</thead>
<tbody>
<tr>
<td>High</td>
<td>Group A</td>
<td>49.75</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Group B</td>
<td>22.81</td>
<td>51.02*</td>
</tr>
<tr>
<td>((F_{2,267}))</td>
<td>Group C</td>
<td>39.30</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Group A</td>
<td>49.31</td>
<td></td>
</tr>
<tr>
<td>Average</td>
<td>Group B</td>
<td>34.94</td>
<td>62.00*</td>
</tr>
<tr>
<td>((F_{2,276}))</td>
<td>Group C</td>
<td>26.90</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Group A</td>
<td>29.92</td>
<td></td>
</tr>
<tr>
<td>Low</td>
<td>Group B</td>
<td>28.76</td>
<td>1.80</td>
</tr>
<tr>
<td>((F_{2,241}))</td>
<td>Group C</td>
<td>25.15</td>
<td></td>
</tr>
</tbody>
</table>

*(significant at the .05 level of confidence)*
As Table 12 shows, the difference between the originality mean scores attained by fifth and sixth grade pupils in the high and average ability levels is significant. There is no significant difference between the originality mean scores for each of the treatment groups in the low ability level.

In Table 13, the originality mean scores attained by pupils in Groups A, B, and C of the high ability level are compared to determine the significance of the difference of these scores.

**TABLE 13**

**COMPARISON OF ADJUSTED MEAN SCORES IN CREATIVE THINKING-ORIGINALITY-HIGH ABILITY LEVEL**

<table>
<thead>
<tr>
<th>Grades Five and Six</th>
<th>No.</th>
<th>Adjusted Mean Scores</th>
<th>S.D.</th>
<th>S.E.D.</th>
<th>Diff.</th>
<th>t(calc.)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Group A Experimental</td>
<td>92</td>
<td>49.72</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Group B Traditional</td>
<td>95</td>
<td>17.23</td>
<td>2.52</td>
<td>26.91</td>
<td>10.71*</td>
<td></td>
</tr>
<tr>
<td>Group A Experimental</td>
<td>92</td>
<td>49.72</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Group C Control</td>
<td>82</td>
<td>17.23</td>
<td>2.62</td>
<td>10.42</td>
<td>3.99*</td>
<td></td>
</tr>
<tr>
<td>Group B Traditional</td>
<td>95</td>
<td>22.81</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Group C Control</td>
<td>82</td>
<td>17.23</td>
<td>2.60</td>
<td>16.51</td>
<td>6.34*</td>
<td></td>
</tr>
</tbody>
</table>

*(significant at the .05 level of confidence)*

As Table 13 shows, the mean score in originality attained by fifth and sixth graders in Group A was significantly greater than the mean scores in originality of fifth and sixth graders in Groups B and C.
The originality mean score attained by fifth and sixth graders in Group C was significantly greater than the originality mean score attained by fifth and sixth graders in Group B. Therefore, the null hypothesis of no significant difference between classes using creative exercises, classes using traditional exercises, and classes not using exercises, can be rejected. The null hypothesis of no significant difference between classes using traditional exercises and classes not using exercises, can be rejected with the difference favoring the classes not using exercises.

In Table 14, the originality mean scores attained by pupils in Groups A, B, and C in the average ability level are compared to determine the significance of the difference of these scores.

**TABLE 14**

**COMPARISON OF ADJUSTED MEAN SCORES IN CREATIVE THINKING—ORIGINALITY—AVERAGE ABILITY LEVEL**

<table>
<thead>
<tr>
<th>Grades Five and Six</th>
<th>Adjusted Mean Scores</th>
<th>S.D.</th>
<th>S.E.</th>
<th>Diff.</th>
<th>t(calc.)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Group A Experimental</td>
<td>86</td>
<td>49.31</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Group B Traditional</td>
<td>95</td>
<td>34.34</td>
<td>1.20</td>
<td>14.97</td>
<td>7.49*</td>
</tr>
<tr>
<td>Group A Experimental</td>
<td>86</td>
<td>49.31</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Group C Control</td>
<td>97</td>
<td>26.90</td>
<td>1.99</td>
<td>22.41</td>
<td>11.27*</td>
</tr>
<tr>
<td>Group B Traditional</td>
<td>95</td>
<td>34.34</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Group C Control</td>
<td>97</td>
<td>26.90</td>
<td>1.97</td>
<td>7.44</td>
<td>3.79*</td>
</tr>
</tbody>
</table>

*(significant at the .05 level of confidence)*
As Table 14 shows, the mean score in originality attained by fifth and sixth graders in Group A was significantly greater than the mean scores in originality of fifth and sixth graders in Groups B and C. Therefore, the null hypothesis of no significant difference between classes using creative exercises, classes using traditional exercises, and classes not using exercises, can be rejected. The mean score in originality attained by fifth and sixth graders in Group B was significantly greater than the originality mean score attained by fifth and sixth graders in Group C. Therefore, the null hypothesis of no significant difference between classes using traditional exercises and classes not using exercises, can be rejected. There was no significant difference in the originality mean scores of the experimental and control groups in the low ability level. Therefore, the null hypothesis of no significant difference between classes using creative exercises, classes using traditional exercises, and classes not using exercises cannot be rejected and must be accepted.

Comparison of Elaboration Test Scores

In Table 15, the mean scores in elaboration for the experimental group in each ability level is compared with the mean scores of the control groups in each ability level to determine the significance of the difference of these scores.

As Table 15 shows, the difference between elaboration mean scores attained by fifth and sixth grade pupils in the high, average, and low ability levels is significant.

In Table 16, the elaboration mean scores attained by pupils in Groups A, B, and C of the high ability level are compared to determine the significance of the difference of these scores.
### TABLE 15

**ADJUSTED MEAN SCORES IN ELABORATION FOR TREATMENT GROUPS IN EACH ABILITY LEVEL**

<table>
<thead>
<tr>
<th>Ability Level</th>
<th>Treatment Groups</th>
<th>Adjusted Means</th>
<th>F-test</th>
</tr>
</thead>
<tbody>
<tr>
<td>High</td>
<td>Group A</td>
<td>13.16</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Group B</td>
<td>7.42</td>
<td>5.16*</td>
</tr>
<tr>
<td></td>
<td>Group C</td>
<td>10.12</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Group A</td>
<td>13.10</td>
<td></td>
</tr>
<tr>
<td>Average</td>
<td>Group B</td>
<td>11.48</td>
<td>13.39*</td>
</tr>
<tr>
<td></td>
<td>Group C</td>
<td>5.81</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Group A</td>
<td>13.11</td>
<td></td>
</tr>
<tr>
<td>Low</td>
<td>Group B</td>
<td>8.81</td>
<td>13.35*</td>
</tr>
<tr>
<td></td>
<td>Group C</td>
<td>7.83</td>
<td></td>
</tr>
</tbody>
</table>

*(significant at the .05 level of confidence)*

### TABLE 16

**COMPARISON OF ADJUSTED MEAN SCORES IN CREATIVE THINKING-ELABORATION-HIGH ABILITY LEVEL**

<table>
<thead>
<tr>
<th>Grades Five and Six</th>
<th>No.</th>
<th>Adjusted Mean Scores</th>
<th>S.D.</th>
<th>S.E.D</th>
<th>Diff</th>
<th>t(calc.)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Group A Experimental</td>
<td>92</td>
<td>13.16</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Group B Traditional</td>
<td>95</td>
<td>7.42</td>
<td>5.04</td>
<td>.74</td>
<td>5.74</td>
<td>7.80*</td>
</tr>
<tr>
<td>Group A Experimental</td>
<td>92</td>
<td>13.16</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Group C Control</td>
<td>82</td>
<td>10.12</td>
<td>5.04</td>
<td>.77</td>
<td>3.04</td>
<td>3.97*</td>
</tr>
<tr>
<td>Group B Traditional</td>
<td>95</td>
<td>7.42</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Group C Control</td>
<td>82</td>
<td>10.12</td>
<td>5.04</td>
<td>.76</td>
<td>2.70</td>
<td>3.54*</td>
</tr>
</tbody>
</table>

*(significant at the .05 level of confidence)*
As Table 16 shows, the mean scores in elaboration attained by fifth and sixth graders in Group A was significantly greater than the mean scores in elaboration of fifth and sixth graders in Groups B and C. The elaboration mean score attained by fifth and sixth graders in Group C was significantly greater than the elaboration mean score attained by fifth and sixth graders in Group B. Therefore, the null hypothesis of no significant difference between classes using creative exercises, and classes not using exercises, can be rejected. The null hypothesis of no significant difference between classes using traditional exercises and classes not using exercises, can be rejected with the difference favoring the classes not using exercises.

In Table 17, the elaboration mean scores attained by pupils in Groups A, B, and C in the average ability level are compared to determine the significance of the difference of these scores.

**TABLE 17**

**COMPARISON OF ADJUSTED MEAN SCORES IN CREATIVE THINKING-ELABORATION-AVERAGE ABILITY LEVEL**

<table>
<thead>
<tr>
<th>Grades Five and Six</th>
<th>No.</th>
<th>Adjusted Mean Scores</th>
<th>S.D.</th>
<th>S.E.D.</th>
<th>Diff.</th>
<th>t(calc.)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Group A Experimental</td>
<td>86</td>
<td>13.10</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Group B Traditional</td>
<td>95</td>
<td>11.48</td>
<td>5.21</td>
<td>.76</td>
<td>1.62</td>
<td>2.12*</td>
</tr>
<tr>
<td>Group A Experimental</td>
<td>86</td>
<td>13.10</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Group C Control</td>
<td>97</td>
<td>5.81</td>
<td>5.21</td>
<td>.76</td>
<td>7.29</td>
<td>9.57*</td>
</tr>
<tr>
<td>Group B Traditional</td>
<td>95</td>
<td>11.48</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Group C Control</td>
<td>97</td>
<td>5.81</td>
<td>5.21</td>
<td>.75</td>
<td>5.67</td>
<td>7.53*</td>
</tr>
</tbody>
</table>

*(significant at the .05 level of confidence)*
As Table 17 shows, the mean score in elaboration attained by fifth and sixth graders in Group A was significantly greater than the mean score in elaboration of fifth and sixth graders in Group B. Therefore, the null hypothesis of no significant difference between classes using creative exercises and classes using traditional exercises can be rejected. The mean score in elaboration attained by fifth and sixth graders in Group B was significantly greater than the elaboration mean score attained by fifth and sixth graders in Group C. Therefore, the null hypothesis of no significant difference between classes using creative exercises and classes not using exercises, can be rejected. The mean score in elaboration attained by fifth and sixth graders in Group B was significantly greater than the mean score in elaboration of fifth and sixth graders in Group C. Therefore, the null hypothesis of no significant difference between classes using traditional exercises and classes not using exercises, can be rejected.

In Table 18, the elaboration mean scores attained by pupils in Groups A, B, and C in the low ability level are compared to determine the significance of the difference of these scores.

As Table 18 shows, the mean score in elaboration attained by fifth and sixth graders in Group A was significantly greater than the mean scores in elaboration of fifth and sixth graders in Groups B and C. Therefore, the null hypothesis of no significant difference between classes using creative exercises, classes using traditional exercises, and classes not using exercises, can be rejected. The mean score in elaboration attained by fifth and sixth graders in Group B was not significantly greater than the mean score in elaboration of fifth and sixth graders in Group C. Therefore, the null hypothesis of no
significant difference between classes using traditional exercises and classes not using exercises cannot be rejected and must be accepted.

**TABLE 18**

COMPARISON OF ADJUSTED MEAN SCORES IN CREATIVE THINKING-ELABORATION-LOW ABILITY LEVEL

<table>
<thead>
<tr>
<th>Grades Five and Six</th>
<th>No.</th>
<th>Adjusted Mean Scores</th>
<th>S.E.</th>
<th>S.E.D.</th>
<th>Diff.</th>
<th>t(calc.)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Group A Experimental</td>
<td>76</td>
<td>13.11</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Group B Traditional</td>
<td>86</td>
<td>6.69</td>
<td>1.56</td>
<td>4.30</td>
<td>2.76*</td>
<td></td>
</tr>
<tr>
<td>Group A Experimental</td>
<td>76</td>
<td>13.11</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Group C Control</td>
<td>81</td>
<td>6.69</td>
<td>1.06</td>
<td>5.28</td>
<td>4.97*</td>
<td></td>
</tr>
<tr>
<td>Group B Traditional</td>
<td>86</td>
<td>6.69</td>
<td>1.04</td>
<td>.98</td>
<td>.95</td>
<td></td>
</tr>
<tr>
<td>Group C Control</td>
<td>81</td>
<td>6.69</td>
<td>1.04</td>
<td>.98</td>
<td>.95</td>
<td></td>
</tr>
</tbody>
</table>

*(significant at the .05 level of confidence)*

Comparison of Space Science Achievement Test Scores

In Table 19, the mean scores in space science achievement for the experimental group in each ability level is compared with the mean scores of the control groups in each ability level to determine the significance of the difference of these scores.

As Table 19 shows, the difference between the space science achievement mean scores attained by fifth and sixth grade pupils in the high, average, and low ability levels is significant.
TABLE 19

ADJUSTMENT MEAN SCORES IN SPACE SCIENCE ACHIEVEMENT
FOR TREATMENT GROUPS IN EACH ABILITY LEVEL

<table>
<thead>
<tr>
<th>Ability Level</th>
<th>Treatment Group</th>
<th>Adjusted Means</th>
<th>F-test</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Group A</td>
<td>75.17</td>
<td></td>
</tr>
<tr>
<td>High</td>
<td>Group B</td>
<td>78.01</td>
<td>66.12*</td>
</tr>
<tr>
<td>(F2,267)</td>
<td>Group C</td>
<td>58.16</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Group A</td>
<td>69.14</td>
<td></td>
</tr>
<tr>
<td>Average</td>
<td>Group B</td>
<td>67.51</td>
<td>32.07*</td>
</tr>
<tr>
<td>(F2,276)</td>
<td>Group C</td>
<td>55.07</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Group A</td>
<td>61.44</td>
<td></td>
</tr>
<tr>
<td>Low</td>
<td>Group B</td>
<td>60.06</td>
<td>57.34*</td>
</tr>
<tr>
<td>(F2,241)</td>
<td>Group C</td>
<td>45.73</td>
<td></td>
</tr>
</tbody>
</table>

*(significant at the .05 level of confidence)*

In Table 20, the mean scores in space science achievement attained by pupils in Groups A, B, and C in the high ability level are compared to determine the significance of the difference of these scores.

As Table 20 shows, the mean score in space science achievement attained by fifth and sixth graders in Group A was not significantly greater than the mean score in space science achievement of fifth and sixth graders in Group B. Therefore, the null hypothesis of no significant difference between classes using creative exercises and classes using traditional exercises cannot be rejected and must be accepted.

The mean score in space science achievement attained by fifth and sixth graders in Group A was significantly greater than the mean score in space science achievement attained by fifth and sixth graders in Group
C. Therefore, the null hypothesis of no significant difference between classes using creative exercises and classes not using exercises can be rejected. The mean score in space science achievement attained by fifth and sixth graders in Group B was significantly greater than the space science achievement mean score attained by fifth and sixth graders in Group C. Therefore, the null hypothesis of no significant difference between classes using traditional exercises and classes not using exercises can be rejected.

**TABLE 20**

<table>
<thead>
<tr>
<th>Grades Five and Six</th>
<th>No.</th>
<th>Adjusted Mean Scores</th>
<th>S.D.</th>
<th>S.E.D.</th>
<th>Diff.</th>
<th>t(calc.)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Group A Experimental</td>
<td>92</td>
<td>75.17</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Group B Traditional</td>
<td>95</td>
<td>78.01</td>
<td>11.00</td>
<td>1.61</td>
<td>2.84</td>
<td>1.77</td>
</tr>
<tr>
<td>Group A Experimental</td>
<td>92</td>
<td>75.17</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Group C Control</td>
<td>82</td>
<td>58.16</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Group B Traditional</td>
<td>95</td>
<td>78.01</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Group C Control</td>
<td>82</td>
<td>58.16</td>
<td>11.00</td>
<td>1.66</td>
<td>19.85</td>
<td>11.95*</td>
</tr>
</tbody>
</table>
| *(significant at the .05 level of confidence)*

In Table 21, the mean scores in space science achievement attained by pupils in Groups A, B, and C in the average ability level are compared to determine the significance of the difference of these scores.
<table>
<thead>
<tr>
<th>Grades Five and Six</th>
<th>No.</th>
<th>Adjusted Mean Scores</th>
<th>S.D.</th>
<th>S.E.D.</th>
<th>Diff.</th>
<th>t(calc.)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Group A Experimental</td>
<td>86</td>
<td>69.14</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Group B Traditional</td>
<td>95</td>
<td>12.38</td>
<td>1.81</td>
<td>1.63</td>
<td>.90</td>
<td></td>
</tr>
<tr>
<td>Group A Experimental</td>
<td>86</td>
<td>69.14</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Group C Control</td>
<td>97</td>
<td>12.38</td>
<td>1.81</td>
<td>14.07</td>
<td>7.79*</td>
<td></td>
</tr>
<tr>
<td>Group B Traditional</td>
<td>95</td>
<td>67.51</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Group C Control</td>
<td>97</td>
<td>12.38</td>
<td>1.79</td>
<td>12.44</td>
<td>6.97*</td>
<td></td>
</tr>
</tbody>
</table>

*(significant at the .05 level of confidence)*

As Table 21 shows, the mean score in space science achievement attained by fifth and sixth graders in Group A was not significantly greater than the mean score in space science achievement of fifth and sixth graders in Group B. Therefore, the null hypothesis of no significant difference between classes using creative exercises and classes using traditional exercises cannot be rejected and must be accepted. The mean score in space science achievement attained by fifth and sixth graders in Group A and Group B was significantly greater than the space science achievement mean score attained by fifth and sixth graders in Group C. Therefore, the null hypothesis of no significant difference between classes using creative exercises or traditional
exercises and classes not using exercises, can be rejected.

In Table 22, the mean scores in space science achievement attained by pupils in Groups A, B, and C in the low ability level are compared to determine the significance of the difference of these scores.

**TABLE 22**

**COMPARISON OF ADJUSTED MEAN SCORES IN SPACE SCIENCE ACHIEVEMENT-LOW ABILITY LEVEL**

<table>
<thead>
<tr>
<th>Grades Five and Six</th>
<th>No.</th>
<th>Adjusted Mean Scores</th>
<th>S.D.</th>
<th>S.E.D.</th>
<th>Diff.</th>
<th>t(calc.)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Group A Experimental</td>
<td>76</td>
<td>61.44</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Group B Traditional</td>
<td>86</td>
<td>60.06</td>
<td>10.29</td>
<td>1.63</td>
<td>1.38</td>
<td>.85</td>
</tr>
<tr>
<td>Group A Experimental</td>
<td>76</td>
<td>61.44</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Group C Control</td>
<td>81</td>
<td>45.73</td>
<td>10.29</td>
<td>1.64</td>
<td>15.71</td>
<td>9.60*</td>
</tr>
<tr>
<td>Group B Traditional</td>
<td>86</td>
<td>60.06</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Group C Control</td>
<td>81</td>
<td>45.73</td>
<td>10.29</td>
<td>1.60</td>
<td>14.33</td>
<td>8.99*</td>
</tr>
</tbody>
</table>

*(significant at the .05 level of confidence)*

As Table 22 shows, the mean score in space science achievement attained by fifth and sixth graders in Group A was not significantly greater than the mean score in space science achievement of fifth and sixth graders in Group B. Therefore, the null hypothesis of no significant difference between classes using creative exercises and classes using traditional exercises cannot be rejected and must be
accepted. The mean score in space science achievement attained by fifth and sixth graders in Group A and Group B was significantly greater than the space science achievement mean score attained by fifth and sixth graders in Group C. Therefore, the null hypothesis of no significant difference between classes using creative exercises or traditional exercises and classes not using exercises, can be rejected.

Statistical Procedures to Measure Results Between Male and Female Pupils

In order to determine if a significant difference existed between males and females in each of the treatment groups on the creative thinking test and the space science achievement test, it was necessary to adjust the mean scores in each of these groups. The previous regression coefficients calculated for the analysis of covariance were used to adjust these scores in order to control for intelligence.

The null hypothesis was assumed, that there was no significant male-female difference in each of the treatment groups on the creative test and the space science achievement test. Thus, if statistical evidence failed to reject the null hypothesis, it was assumed that any difference discovered could be attributed to chance. The statistical test used to accept or reject the null hypothesis was the analysis of variance as stated by Wert, Neidt, and Ahmann.5

A level of confidence of five percent was adopted by the investigator in presenting the statistical findings. Since the degree of freedom for F(1, 8) was the same throughout all analyses, it can be stated that unless "F" equaled at least 5.32, the null hypothesis that

5Ibid., pp. 189-190.
no true difference probably existed between the adjusted mean scores of male and female pupils was accepted. Class differences are not pertinent to this study.

Comparison of Adjusted Mean Scores of the Experimental Group

In Table 23, the fluency mean scores of males and females are compared to determine the significance of the difference of these scores.

TABLE 23
ADJUSTED MEAN SCORES IN CREATIVE THINKING-FLUENCY-
MALES AND FEMALES IN THE EXPERIMENTAL GROUP

<table>
<thead>
<tr>
<th>Class</th>
<th>Male</th>
<th>Female</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>62.41</td>
<td>68.63</td>
</tr>
<tr>
<td>2</td>
<td>54.35</td>
<td>53.69</td>
</tr>
<tr>
<td>3</td>
<td>55.43</td>
<td>49.78</td>
</tr>
<tr>
<td>4</td>
<td>55.40</td>
<td>69.46</td>
</tr>
<tr>
<td>5</td>
<td>52.50</td>
<td>58.99</td>
</tr>
<tr>
<td>6</td>
<td>53.06</td>
<td>63.84</td>
</tr>
<tr>
<td>7</td>
<td>46.65</td>
<td>53.23</td>
</tr>
<tr>
<td>8</td>
<td>35.29</td>
<td>46.08</td>
</tr>
<tr>
<td>9</td>
<td>43.55</td>
<td>48.58</td>
</tr>
<tr>
<td>Totals</td>
<td>458.64</td>
<td>512.28</td>
</tr>
</tbody>
</table>

Fluency Mean

Number

<table>
<thead>
<tr>
<th>Source of Variation</th>
<th>Degrees of Freedom</th>
<th>Sum of Squares</th>
<th>Mean Square</th>
<th>F-test</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sex</td>
<td>1</td>
<td>159.81</td>
<td>159.81</td>
<td>3.75*</td>
</tr>
<tr>
<td>Class</td>
<td>8</td>
<td>970.41</td>
<td>121.30</td>
<td>6.64*</td>
</tr>
<tr>
<td>Residual</td>
<td>8</td>
<td>146.11</td>
<td>18.26</td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>17</td>
<td>1276.33</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*(significant at the .05 level of confidence)
As Table 23 shows, the mean score in fluency attained by fifth and sixth grade females in Group A was significantly greater than the mean score in fluency of fifth and sixth grade males in Group A. Therefore, the null hypothesis of no significant difference between males and females in the experimental group in fluency can be rejected.

In Table 24, the flexibility mean score of males in Group A is compared with the fluency mean score of females in Group A to determine the significance of the difference of these scores.

As Table 24 shows, the mean score in flexibility attained by fifth and sixth grade females in Group A was not significantly greater than the mean score in flexibility of fifth and sixth grade males in Group A. Therefore, the null hypothesis of no significant difference between males and females in the experimental group in flexibility cannot be rejected and must be accepted.

In Table 25, the originality mean score of males in Group A is compared with the originality mean score of females in Group A to determine the significance of the difference of these scores.

As Table 25 shows, the mean score in originality attained by fifth and sixth grade females in Group A was significantly greater than the mean score in originality of fifth and sixth grade males in Group A. Therefore, the null hypothesis of no significant difference between males and females in the experimental group in originality cannot be rejected and must be accepted.

In Table 26, the elaboration mean score of males in Group A is compared with the elaboration mean score of females in Group A to determine the significance of the difference of these scores.

As Table 26 shows, the mean score in elaboration attained by fifth
and sixth grade females in Group A was not significantly greater than the mean score in elaboration for fifth and sixth grade males in Group A. Therefore, the null hypothesis of no significant difference between males and females in the experimental group in elaboration cannot be rejected and must be accepted.

### Table 24

**Adjusted Mean Scores in Creative Thinking-Flexibility-Males and Females in the Experimental Group**

<table>
<thead>
<tr>
<th>Class</th>
<th>Male</th>
<th>Female</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>35.17</td>
<td>35.94</td>
</tr>
<tr>
<td>2</td>
<td>31.81</td>
<td>31.11</td>
</tr>
<tr>
<td>3</td>
<td>33.19</td>
<td>26.23</td>
</tr>
<tr>
<td>4</td>
<td>28.67</td>
<td>31.77</td>
</tr>
<tr>
<td>5</td>
<td>29.83</td>
<td>32.40</td>
</tr>
<tr>
<td>6</td>
<td>27.27</td>
<td>30.70</td>
</tr>
<tr>
<td>7</td>
<td>27.18</td>
<td>32.33</td>
</tr>
<tr>
<td>8</td>
<td>18.59</td>
<td>22.34</td>
</tr>
<tr>
<td>9</td>
<td>25.88</td>
<td>27.04</td>
</tr>
<tr>
<td>Totals</td>
<td>257.64</td>
<td>270.36</td>
</tr>
<tr>
<td>Flexibility Mean</td>
<td>28.63</td>
<td>30.04</td>
</tr>
<tr>
<td>Number</td>
<td>139</td>
<td>115</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Source of Variation</th>
<th>Degrees of Freedom</th>
<th>Sum of Squares</th>
<th>Mean Square</th>
<th>F-test</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sex</td>
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<td>14.74</td>
<td>14.74</td>
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</tr>
<tr>
<td>Class</td>
<td>8</td>
<td>260.52</td>
<td>32.57</td>
<td>5.56*</td>
</tr>
<tr>
<td>Residual</td>
<td>8</td>
<td>46.85</td>
<td>5.86</td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>17</td>
<td>322.11</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*(significant at the .05 level of confidence)*
TABLE 25
ADJUSTED MEAN SCORES IN CREATIVE THINKING-ORIGINALITY-
MALES AND FEMALES IN THE EXPERIMENTAL GROUP

<table>
<thead>
<tr>
<th>Class</th>
<th>Male</th>
<th>Female</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>50.85</td>
<td>51.60</td>
</tr>
<tr>
<td>2</td>
<td>54.42</td>
<td>46.10</td>
</tr>
<tr>
<td>3</td>
<td>45.36</td>
<td>32.06</td>
</tr>
<tr>
<td>4</td>
<td>45.65</td>
<td>44.55</td>
</tr>
<tr>
<td>5</td>
<td>48.42</td>
<td>54.18</td>
</tr>
<tr>
<td>6</td>
<td>41.16</td>
<td>53.24</td>
</tr>
<tr>
<td>7</td>
<td>46.66</td>
<td>46.09</td>
</tr>
<tr>
<td>8</td>
<td>16.78</td>
<td>23.21</td>
</tr>
<tr>
<td>9</td>
<td>26.46</td>
<td>32.02</td>
</tr>
<tr>
<td>Totals</td>
<td>385.76</td>
<td>386.12</td>
</tr>
<tr>
<td>Originality Mean</td>
<td>42.86</td>
<td>42.90</td>
</tr>
<tr>
<td>Number</td>
<td>139</td>
<td>115</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Source of Variation</th>
<th>Degrees of Freedom</th>
<th>Sum of Squares</th>
<th>Mean Square</th>
<th>F-test</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sex</td>
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<td>.01</td>
<td>.01</td>
<td>.002</td>
</tr>
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<td>Class</td>
<td>8</td>
<td>1644.91</td>
<td>205.61</td>
<td>6.99*</td>
</tr>
<tr>
<td>Residual</td>
<td>8</td>
<td>235.22</td>
<td>29.41</td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>17</td>
<td>1880.21</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*(significant at the .05 level of confidence)

In Table 27, the space science achievement mean score of males in Group A is compared with the space science achievement mean score of females in Group A to determine the significance of the difference of these scores.

As Table 27 shows, the mean score in space science achievement attained by fifth and sixth grade males in Group A was significantly greater than the mean score in space science achievement of fifth and
TABLE 26
ADJUSTED MEAN SCORES IN CREATIVE THINKING-ELABORATION-
MALES AND FEMALES IN THE EXPERIMENTAL GROUP

<table>
<thead>
<tr>
<th>Class</th>
<th>Male</th>
<th>Female</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>11.04</td>
<td>6.92</td>
</tr>
<tr>
<td>2</td>
<td>11.36</td>
<td>8.00</td>
</tr>
<tr>
<td>3</td>
<td>4.09</td>
<td>3.34</td>
</tr>
<tr>
<td>4</td>
<td>12.30</td>
<td>11.36</td>
</tr>
<tr>
<td>5</td>
<td>12.05</td>
<td>11.20</td>
</tr>
<tr>
<td>6</td>
<td>9.21</td>
<td>9.50</td>
</tr>
<tr>
<td>7</td>
<td>14.83</td>
<td>18.59</td>
</tr>
<tr>
<td>8</td>
<td>9.89</td>
<td>15.23</td>
</tr>
<tr>
<td>9</td>
<td>2.73</td>
<td>13.52</td>
</tr>
<tr>
<td>Totals</td>
<td>94.50</td>
<td>97.66</td>
</tr>
</tbody>
</table>

Elaboration Mean
10.50
10.85

Number
139
115

Source of Variation | Degrees of Freedom | Sum of Squares | Mean Square | F-test |
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Sex</td>
<td>1</td>
<td>.78</td>
<td>.78</td>
<td>.17</td>
</tr>
<tr>
<td>Class</td>
<td>8</td>
<td>193.11</td>
<td>24.14</td>
<td>5.30</td>
</tr>
<tr>
<td>Residual</td>
<td>8</td>
<td>36.42</td>
<td>4.55</td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>17</td>
<td>230.31</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

sixth grade females in Group A. Therefore, the null hypothesis of no significant difference between males and females in the experimental group in space science achievement can be rejected.

In Table 26, the fluency mean score of males in Group A is compared with the fluency mean scores of females in Group to determine the significance of the difference of these scores.
### TABLE 27
ADJUSTED MEAN SCORES IN SPACE SCIENCE ACHIEVEMENT
FOR MALES AND FEMALES IN THE EXPERIMENTAL GROUP

<table>
<thead>
<tr>
<th>Class</th>
<th>Male</th>
<th>Female</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>74.20</td>
<td>61.38</td>
</tr>
<tr>
<td>2</td>
<td>76.67</td>
<td>71.30</td>
</tr>
<tr>
<td>3</td>
<td>71.69</td>
<td>65.59</td>
</tr>
<tr>
<td>4</td>
<td>66.44</td>
<td>60.66</td>
</tr>
<tr>
<td>5</td>
<td>73.01</td>
<td>73.04</td>
</tr>
<tr>
<td>6</td>
<td>63.40</td>
<td>64.65</td>
</tr>
<tr>
<td>7</td>
<td>65.85</td>
<td>60.61</td>
</tr>
<tr>
<td>8</td>
<td>76.53</td>
<td>74.67</td>
</tr>
<tr>
<td>9</td>
<td>74.55</td>
<td>70.18</td>
</tr>
<tr>
<td>Totals</td>
<td>642.34</td>
<td>602.08</td>
</tr>
</tbody>
</table>

Space Science Achievement Mean
Male: 71.37
Female: 66.90

Number
Male: 139
Female: 115

<table>
<thead>
<tr>
<th>Source of Variation</th>
<th>Degrees of Freedom</th>
<th>Sum of Squares</th>
<th>Mean Square</th>
<th>F-test</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sex</td>
<td>1</td>
<td>89.97</td>
<td>89.97</td>
<td>10.65*</td>
</tr>
<tr>
<td>Class</td>
<td>8</td>
<td>370.11</td>
<td>46.26</td>
<td>5.47*</td>
</tr>
<tr>
<td>Residual</td>
<td>8</td>
<td>67.61</td>
<td>8.45</td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>17</td>
<td>527.69</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*(significant at the .05 level of confidence)

As Table 28 shows, the mean score in fluency attained by fifth and sixth grade females in Group B was not significantly greater than the mean score in fluency of fifth and sixth grade males in Group B. Therefore, the null hypothesis of no significant difference between males and females in the traditional group in fluency cannot be rejected and must be accepted.
TABLE 28
ADJUSTED MEAN SCORES IN CREATIVE THINKING-FLUENCY-
MALES AND FEMALES IN CONTROL GROUP B

<table>
<thead>
<tr>
<th>Class</th>
<th>Male</th>
<th>Female</th>
</tr>
</thead>
<tbody>
<tr>
<td>10</td>
<td>43.13</td>
<td>43.48</td>
</tr>
<tr>
<td>11</td>
<td>46.28</td>
<td>34.59</td>
</tr>
<tr>
<td>12</td>
<td>44.99</td>
<td>46.16</td>
</tr>
<tr>
<td>13</td>
<td>50.74</td>
<td>59.96</td>
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<tr>
<td>14</td>
<td>33.99</td>
<td>40.89</td>
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<tr>
<td>15</td>
<td>45.61</td>
<td>52.34</td>
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<tr>
<td>16</td>
<td>45.52</td>
<td>44.25</td>
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<td>17</td>
<td>39.30</td>
<td>40.87</td>
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<tr>
<td>18</td>
<td>45.96</td>
<td>60.20</td>
</tr>
<tr>
<td>Totals</td>
<td>395.52</td>
<td>422.74</td>
</tr>
<tr>
<td>Fluency Mean</td>
<td>43.95</td>
<td>46.96</td>
</tr>
<tr>
<td>Number</td>
<td>141</td>
<td>135</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Source of Variation</th>
<th>Degrees of Freedom</th>
<th>Sum of Squares</th>
<th>Mean Square</th>
<th>F-test</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sex</td>
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<td>41.17</td>
<td>41.17</td>
<td>1.48</td>
</tr>
<tr>
<td>Class</td>
<td>8</td>
<td>596.64</td>
<td>74.58</td>
<td>2.69</td>
</tr>
<tr>
<td>Residual</td>
<td>8</td>
<td>222.00</td>
<td>27.75</td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>17</td>
<td>859.81</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

In Table 29, the flexibility mean score of males in Group B is compared with the flexibility mean score of females in Group B to determine the significance of the difference of these scores.

As Table 29 shows, the mean score in flexibility attained by fifth and sixth grade females in Group B was not significantly greater than the mean score in flexibility of fifth and sixth grade males in Group B. Therefore, the null hypothesis of no significant difference
between males and females in the traditional group in flexibility cannot be rejected and must be accepted.

**TABLE 29**

**ADJUSTED MEAN SCORES IN CREATIVE THINKING-FLEXIBILITY-MALES AND FEMALES IN CONTROL GROUP B**

<table>
<thead>
<tr>
<th>Class</th>
<th>Male</th>
<th>Female</th>
</tr>
</thead>
<tbody>
<tr>
<td>10</td>
<td>24.64</td>
<td>25.13</td>
</tr>
<tr>
<td>11</td>
<td>22.38</td>
<td>20.28</td>
</tr>
<tr>
<td>12</td>
<td>25.40</td>
<td>24.75</td>
</tr>
<tr>
<td>13</td>
<td>28.90</td>
<td>31.73</td>
</tr>
<tr>
<td>14</td>
<td>22.98</td>
<td>24.32</td>
</tr>
<tr>
<td>15</td>
<td>29.30</td>
<td>31.36</td>
</tr>
<tr>
<td>16</td>
<td>23.19</td>
<td>23.72</td>
</tr>
<tr>
<td>17</td>
<td>25.41</td>
<td>27.61</td>
</tr>
<tr>
<td>18</td>
<td>27.38</td>
<td>35.50</td>
</tr>
<tr>
<td>Totals</td>
<td>229.58</td>
<td>244.40</td>
</tr>
<tr>
<td>Flexibility Mean</td>
<td>25.51</td>
<td>27.16</td>
</tr>
<tr>
<td>Number</td>
<td>141</td>
<td>135</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Source of Variation</th>
<th>Degrees of Freedom</th>
<th>Sum of Squares</th>
<th>Mean Square</th>
<th>F-test</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sex</td>
<td>1</td>
<td>12.20</td>
<td>12.20</td>
<td>2.96</td>
</tr>
<tr>
<td>Class</td>
<td>8</td>
<td>204.24</td>
<td>25.53</td>
<td>6.20*</td>
</tr>
<tr>
<td>Residual</td>
<td>8</td>
<td>32.93</td>
<td>4.12</td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>17</td>
<td>249.37</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*(significant at the .05 level of confidence)*

In Table 30, the originality mean score of males in Group B is compared with the originality mean score of females in Group B to determine the significance of the difference of these scores.
TABLE 30

ADJUSTED MEAN SCORES IN CREATIVE THINKING-ORIGINALITY-
MALES AND FEMALES IN CONTROL GROUP B

<table>
<thead>
<tr>
<th>Class</th>
<th>Male</th>
<th>Female</th>
</tr>
</thead>
<tbody>
<tr>
<td>10</td>
<td>20.48</td>
<td>21.45</td>
</tr>
<tr>
<td>11</td>
<td>23.82</td>
<td>16.44</td>
</tr>
<tr>
<td>12</td>
<td>24.94</td>
<td>21.01</td>
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<tr>
<td>13</td>
<td>28.21</td>
<td>31.55</td>
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<tr>
<td>14</td>
<td>30.48</td>
<td>27.65</td>
</tr>
<tr>
<td>15</td>
<td>39.30</td>
<td>38.93</td>
</tr>
<tr>
<td>16</td>
<td>18.84</td>
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<td>17</td>
<td>29.75</td>
<td>27.36</td>
</tr>
<tr>
<td>18</td>
<td>40.36</td>
<td>57.39</td>
</tr>
</tbody>
</table>

Totals   256.18  261.07
Originality Mean 28.46  29.01
Number  141  135

<table>
<thead>
<tr>
<th>Source of Variation</th>
<th>Degrees of Freedom</th>
<th>Sum of Squares</th>
<th>Mean Square</th>
<th>F-test</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sex</td>
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<td>1.33</td>
<td>1.33</td>
<td>.06</td>
</tr>
<tr>
<td>Class</td>
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<td>1551.83</td>
<td>193.98</td>
<td>8.09*</td>
</tr>
<tr>
<td>Residual</td>
<td>8</td>
<td>121.80</td>
<td>23.98</td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>17</td>
<td>1744.96</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*(significant at the .05 level of confidence)

As Table 30 shows, the mean score in originality attained by fifth and sixth grade females in Group B was not significantly greater than the mean score in originality of fifth and sixth grade males in Group B. Therefore, the null hypothesis of no significant difference between males and females in the traditional group in originality cannot be rejected and must be accepted.
In Table 31, the elaboration mean score of males in Group B was compared with the elaboration mean score of females in Group B to determine the significance of the difference of these scores.

**TABLE 31**

ADJUSTED MEAN SCORES IN CREATIVE THINKING-ELABORATION MALES AND FEMALES IN CONTROL GROUP B

<table>
<thead>
<tr>
<th>Class</th>
<th>Male</th>
<th>Female</th>
</tr>
</thead>
<tbody>
<tr>
<td>10</td>
<td>3.16</td>
<td>5.29</td>
</tr>
<tr>
<td>11</td>
<td>3.89</td>
<td>4.45</td>
</tr>
<tr>
<td>12</td>
<td>2.31</td>
<td>2.65</td>
</tr>
<tr>
<td>13</td>
<td>6.59</td>
<td>5.68</td>
</tr>
<tr>
<td>14</td>
<td>9.09</td>
<td>5.98</td>
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<tr>
<td>15</td>
<td>12.86</td>
<td>9.56</td>
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<tr>
<td>16</td>
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<td>17</td>
<td>8.17</td>
<td>8.35</td>
</tr>
<tr>
<td>18</td>
<td>10.41</td>
<td>15.23</td>
</tr>
</tbody>
</table>

Totals 63.61 60.26
Elaboration Mean 7.07 6.70
Number 141 135

<table>
<thead>
<tr>
<th>Source of Variation</th>
<th>Degrees of Freedom</th>
<th>Sum of Squares</th>
<th>Mean Square</th>
<th>F-test</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sex</td>
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<td>.62</td>
<td>.62</td>
<td>.13</td>
</tr>
<tr>
<td>Class</td>
<td>8</td>
<td>212.24</td>
<td>26.53</td>
<td>5.38*</td>
</tr>
<tr>
<td>Residual</td>
<td>8</td>
<td>39.44</td>
<td>4.93</td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>17</td>
<td>252.03</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*(significant at the .05 level of confidence)*

As Table 31 shows, the mean score in elaboration attained by fifth and sixth grade males in Group B was not significantly greater
than the mean score in elaboration of fifth and sixth grade females in Group B. Therefore, the null hypothesis of no significant difference between males and females in the traditional group in elaboration cannot be rejected and must be accepted.

In Table 32, the space science achievement mean score of males in Group B is compared with the space science achievement mean score of females in Group B to determine the significance of the difference of these scores.

**TABLE 32**

ADJUSTED MEAN SCORES IN SPACE SCIENCE ACHIEVEMENT FOR MALES AND FEMALES IN CONTROL GROUP B

<table>
<thead>
<tr>
<th>Class</th>
<th>Male</th>
<th>Female</th>
</tr>
</thead>
<tbody>
<tr>
<td>10</td>
<td>73.78</td>
<td>70.54</td>
</tr>
<tr>
<td>11</td>
<td>80.53</td>
<td>80.70</td>
</tr>
<tr>
<td>12</td>
<td>69.84</td>
<td>69.63</td>
</tr>
<tr>
<td>13</td>
<td>67.83</td>
<td>64.86</td>
</tr>
<tr>
<td>14</td>
<td>77.47</td>
<td>65.93</td>
</tr>
<tr>
<td>15</td>
<td>64.70</td>
<td>51.55</td>
</tr>
<tr>
<td>16</td>
<td>71.94</td>
<td>62.97</td>
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<tr>
<td>17</td>
<td>69.87</td>
<td>74.33</td>
</tr>
<tr>
<td>18</td>
<td>68.23</td>
<td>62.77</td>
</tr>
<tr>
<td>Totals</td>
<td>644.19</td>
<td>603.28</td>
</tr>
</tbody>
</table>

Space Science Achievement Mean

<table>
<thead>
<tr>
<th>Number</th>
<th>Male</th>
<th>Female</th>
</tr>
</thead>
<tbody>
<tr>
<td>141</td>
<td>71.58</td>
<td>67.03</td>
</tr>
<tr>
<td>135</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Source of Variation**

<table>
<thead>
<tr>
<th>Source of Variation</th>
<th>Degrees of Freedom</th>
<th>Sum of Squares</th>
<th>Mean Square</th>
<th>F-test</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sex</td>
<td>1</td>
<td>93.09</td>
<td>93.09</td>
<td>5.53*</td>
</tr>
<tr>
<td>Class</td>
<td>8</td>
<td>603.04</td>
<td>75.38</td>
<td>4.47</td>
</tr>
<tr>
<td>Residual</td>
<td>8</td>
<td>134.72</td>
<td>16.85</td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>17</td>
<td>839.92</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*(significant at the .05 level of confidence)*
As Table 32 shows, the mean score in space science achievement attained by fifth and sixth grade males in Group B was significantly greater than the mean score in space science achievement of fifth and sixth grade females in Group B. Therefore, the null hypothesis of no significant difference between males and females in the traditional group in space science achievement can be rejected.

In Table 33, the fluency mean score of males in Group C is compared with the fluency mean score of females in Group C to determine the significance of the difference of these scores.

<table>
<thead>
<tr>
<th>Class</th>
<th>Male</th>
<th>Female</th>
</tr>
</thead>
<tbody>
<tr>
<td>19</td>
<td>45.07</td>
<td>52.69</td>
</tr>
<tr>
<td>20</td>
<td>44.40</td>
<td>36.56</td>
</tr>
<tr>
<td>21</td>
<td>39.40</td>
<td>42.23</td>
</tr>
<tr>
<td>22</td>
<td>35.02</td>
<td>41.63</td>
</tr>
<tr>
<td>23</td>
<td>34.77</td>
<td>35.98</td>
</tr>
<tr>
<td>24</td>
<td>41.92</td>
<td>43.95</td>
</tr>
<tr>
<td>25</td>
<td>33.26</td>
<td>40.42</td>
</tr>
<tr>
<td>26</td>
<td>49.20</td>
<td>48.03</td>
</tr>
<tr>
<td>27</td>
<td>43.01</td>
<td>42.23</td>
</tr>
<tr>
<td>Totals</td>
<td>366.05</td>
<td>333.72</td>
</tr>
<tr>
<td>Fluency Mean</td>
<td>40.67</td>
<td>42.64</td>
</tr>
<tr>
<td>Number</td>
<td>148</td>
<td>112</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Source of Variation</th>
<th>Degrees of Freedom</th>
<th>Sum of Squares</th>
<th>Mean Square</th>
<th>F-test</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sex</td>
<td>1</td>
<td>17.33</td>
<td>17.33</td>
<td>1.42</td>
</tr>
<tr>
<td>Class</td>
<td>8</td>
<td>357.79</td>
<td>44.72</td>
<td>3.66</td>
</tr>
<tr>
<td>Residual</td>
<td>8</td>
<td>27.68</td>
<td>12.21</td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>17</td>
<td>472.80</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
As Table 33 shows, the mean score in fluency attained by fifth and sixth grade females in Group C was not significantly greater than the mean score in fluency of fifth and sixth grade males in Group C. Therefore, the null hypothesis of no significant difference between males and females in the control group in fluency cannot be rejected and must be accepted.

In Table 34, the flexibility mean score of males in Group C is compared with the flexibility mean score of females in Group C to determine the significance of the difference of these scores.

**TABLE 34**

**ADJUSTED MEAN SCORES IN CREATIVE THINKING-FLEXIBILITY-MALES AND FEMALES IN CONTROL GROUP C**

<table>
<thead>
<tr>
<th>Class</th>
<th>Male</th>
<th>Female</th>
</tr>
</thead>
<tbody>
<tr>
<td>19</td>
<td>29.30</td>
<td>32.20</td>
</tr>
<tr>
<td>20</td>
<td>30.13</td>
<td>25.28</td>
</tr>
<tr>
<td>21</td>
<td>26.20</td>
<td>26.74</td>
</tr>
<tr>
<td>22</td>
<td>24.28</td>
<td>28.25</td>
</tr>
<tr>
<td>23</td>
<td>22.58</td>
<td>21.72</td>
</tr>
<tr>
<td>24</td>
<td>25.85</td>
<td>25.39</td>
</tr>
<tr>
<td>25</td>
<td>24.94</td>
<td>26.75</td>
</tr>
<tr>
<td>26</td>
<td>28.16</td>
<td>26.32</td>
</tr>
<tr>
<td>27</td>
<td>18.42</td>
<td>21.28</td>
</tr>
<tr>
<td>Totals</td>
<td>229.87</td>
<td>234.03</td>
</tr>
<tr>
<td>Flexibility Mean</td>
<td>25.54</td>
<td>26.00</td>
</tr>
<tr>
<td>Number</td>
<td>143</td>
<td>112</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Source of Variation</th>
<th>Degrees of Freedom</th>
<th>Sum of Squares</th>
<th>Mean Square</th>
<th>F-test</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sex</td>
<td>1</td>
<td>1.04</td>
<td>1.04</td>
<td>.27</td>
</tr>
<tr>
<td>Class</td>
<td>8</td>
<td>160.22</td>
<td>20.03</td>
<td>5.15</td>
</tr>
<tr>
<td>Residual</td>
<td>6</td>
<td>31.11</td>
<td>3.89</td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>17</td>
<td>192.37</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
As Table 34 shows, the mean score in flexibility attained by fifth and sixth grade females in Group C was not significantly greater than the mean score in flexibility of fifth and sixth grade males in Group C. Therefore, the null hypothesis of no significant difference between males and females in the control group in flexibility cannot be rejected and must be accepted.

In Table 35, the originality mean score of males in Group C is compared with the originality mean score of females in Group C to determine the significance of the difference of these scores.

**TABLE 35**

**ADJUSTED MEAN SCORES IN CREATIVE THINKING-ORIGINALITY-MALES AND FEMALES IN CONTROL GROUP C**

<table>
<thead>
<tr>
<th>Class</th>
<th>Male</th>
<th>Female</th>
</tr>
</thead>
<tbody>
<tr>
<td>19</td>
<td>46.22</td>
<td>54.38</td>
</tr>
<tr>
<td>20</td>
<td>36.83</td>
<td>25.61</td>
</tr>
<tr>
<td>21</td>
<td>28.59</td>
<td>30.13</td>
</tr>
<tr>
<td>22</td>
<td>26.09</td>
<td>29.88</td>
</tr>
<tr>
<td>23</td>
<td>16.69</td>
<td>15.55</td>
</tr>
<tr>
<td>24</td>
<td>30.97</td>
<td>32.68</td>
</tr>
<tr>
<td>25</td>
<td>22.65</td>
<td>24.14</td>
</tr>
<tr>
<td>26</td>
<td>31.85</td>
<td>26.87</td>
</tr>
<tr>
<td>27</td>
<td>15.03</td>
<td>16.28</td>
</tr>
<tr>
<td>Totals</td>
<td>254.92</td>
<td>256.22</td>
</tr>
<tr>
<td>Originality Mean</td>
<td>28.32</td>
<td>28.47</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Source of Variation</th>
<th>Degrees of Freedom</th>
<th>Sum of Squares</th>
<th>Mean Square</th>
<th>F-test</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sex</td>
<td>1</td>
<td>.09</td>
<td>.09</td>
<td>.01</td>
</tr>
<tr>
<td>Class</td>
<td>8</td>
<td>1661.38</td>
<td>207.67</td>
<td>13.62*</td>
</tr>
<tr>
<td>Residual</td>
<td>8</td>
<td>122.01</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>17</td>
<td>1783.48</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*(significant at the .05 level of confidence)*
As Table 35 shows, the mean score in originality attained by fifth and sixth grade females in Group C was not significantly greater than the mean score in originality of fifth and sixth grade males in Group C. Therefore, the null hypothesis of no significant difference between males and females in the control group in originality cannot be rejected and must be accepted.

In Table 36, the elaboration mean score of males in Group C is compared with the elaboration mean score of females in Group C to determine the significance of the difference of these scores.

**TABLE 36**

<table>
<thead>
<tr>
<th>Class</th>
<th>Male</th>
<th>Female</th>
</tr>
</thead>
<tbody>
<tr>
<td>19</td>
<td>7.22</td>
<td>3.54</td>
</tr>
<tr>
<td>20</td>
<td>4.88</td>
<td>.17</td>
</tr>
<tr>
<td>21</td>
<td>8.61</td>
<td>3.68</td>
</tr>
<tr>
<td>22</td>
<td>.74</td>
<td>1.99</td>
</tr>
<tr>
<td>23</td>
<td>4.41</td>
<td>7.12</td>
</tr>
<tr>
<td>24</td>
<td>3.80</td>
<td>3.99</td>
</tr>
<tr>
<td>25</td>
<td>8.13</td>
<td>8.98</td>
</tr>
<tr>
<td>26</td>
<td>10.98</td>
<td>7.81</td>
</tr>
<tr>
<td>27</td>
<td>4.32</td>
<td>4.34</td>
</tr>
<tr>
<td>Totals</td>
<td>51.61</td>
<td>41.62</td>
</tr>
<tr>
<td>Elaboration Mean</td>
<td>5.73</td>
<td>4.62</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Source of Variation</th>
<th>Degrees of Freedom</th>
<th>Sum of Squares</th>
<th>Mean Square</th>
<th>F-test</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sex</td>
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<td>5.55</td>
<td>5.55</td>
<td>1.19</td>
</tr>
<tr>
<td>Class</td>
<td>8</td>
<td>121.31</td>
<td>15.16</td>
<td>3.26</td>
</tr>
<tr>
<td>Residual</td>
<td>6</td>
<td>37.22</td>
<td>4.65</td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>17</td>
<td>164.08</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
As Table 36 shows, the mean score in elaboration attained by fifth and sixth grade males in Group C was not significantly greater than the mean scores in elaboration of fifth and sixth grade females in Group C. Therefore, the null hypothesis of no significant difference between males and females in the control group in elaboration cannot be rejected and must be accepted.

In Table 37, the space science achievement mean score of males in Group C is compared with the space science achievement mean score of females in Group C to determine the significance of the difference of these scores.

**TABLE 37**

**ADJUSTED MEAN SCORES IN SPACE SCIENCE ACHIEVEMENT FOR MALES AND FEMALES IN CONTROL GROUP C**

<table>
<thead>
<tr>
<th>Class</th>
<th>Male</th>
<th>Female</th>
</tr>
</thead>
<tbody>
<tr>
<td>19</td>
<td>50.40</td>
<td>43.70</td>
</tr>
<tr>
<td>20</td>
<td>64.67</td>
<td>52.37</td>
</tr>
<tr>
<td>21</td>
<td>60.63</td>
<td>49.78</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>22</td>
<td>51.17</td>
<td>49.37</td>
</tr>
<tr>
<td>23</td>
<td>54.97</td>
<td>46.43</td>
</tr>
<tr>
<td>24</td>
<td>61.85</td>
<td>49.59</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>25</td>
<td>38.57</td>
<td>36.89</td>
</tr>
<tr>
<td>26</td>
<td>40.27</td>
<td>38.18</td>
</tr>
<tr>
<td>27</td>
<td>46.32</td>
<td>41.90</td>
</tr>
<tr>
<td>Totals</td>
<td>468.85</td>
<td>408.21</td>
</tr>
</tbody>
</table>

**Space Science Achievement Mean**

<table>
<thead>
<tr>
<th>Male</th>
<th>Female</th>
</tr>
</thead>
<tbody>
<tr>
<td>52.09</td>
<td>45.36</td>
</tr>
</tbody>
</table>

**Number**

<table>
<thead>
<tr>
<th>Male</th>
<th>Female</th>
</tr>
</thead>
<tbody>
<tr>
<td>148</td>
<td>112</td>
</tr>
</tbody>
</table>

**Source of Variation**

<table>
<thead>
<tr>
<th>Source of Variation</th>
<th>Degrees of Freedom</th>
<th>Sum of Squares</th>
<th>Mean Square</th>
<th>F-test</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sex</td>
<td>1</td>
<td>204.28</td>
<td>204.28</td>
<td>17.49*</td>
</tr>
<tr>
<td>Class</td>
<td>8</td>
<td>856.63</td>
<td>107.08</td>
<td>9.17*</td>
</tr>
<tr>
<td>Residual</td>
<td>8</td>
<td>92.44</td>
<td>11.68</td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>17</td>
<td>1154.35</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*(significant at the .05 level of confidence)*
As Table 37 shows, the mean score in space science achievement attained by fifth and sixth grade males in Group C was significantly greater than the mean score in space science achievement of fifth and sixth grade females in Group C. Therefore, the null hypothesis of no significant difference between males and females in the control group in space science achievement can be rejected.

Summary of Chapter 4

Chapter four has provided a detailed analysis of the data. The analysis indicated that the experimental group was significantly superior to the traditional and control groups but this difference varied with ability level and the sub-categories of the creative thinking test. The experimental and traditional groups were significantly superior to the control group in space science achievement. The males were significantly superior to the females in space science achievement in all ability levels. The females were significantly superior to the males in fluency in the experimental group.

Conclusions drawn from the data presented in this chapter will be discussed in Chapter 5.
CHAPTER 5

SUMMARY AND CONCLUSIONS

Introduction

Educators have long been concerned with the problems of teaching for creative thinking in order to meet the diverse needs of children. This concern has led to some experimentation with teaching methods designed to improve the creative abilities of children while teaching subject matter. Many of the experiments have been conducted within special elementary school programs.

Little empirical evidence exists, however, concerning suggested creative teaching techniques and the effects these have upon the creative and academic abilities of pupils within the typical elementary school program.

Restatement of the Problem

The major purpose of this study was twofold: one, to determine whether or not teachers could improve the creative thinking abilities of pupils in their classes by using selected creative exercises. Two, to determine what affect the attempt to improve creative thinking abilities would have upon achievement in a subject matter area, in this case a space science unit.

The following questions were posed for statistical considerations:
1. Is there a significant relationship between creative thinking
and intelligence for pupils who have used creative exercises, for pupils who have used traditional exercises, or for pupils who have not used any exercises?

2. Is there a significant difference between pupils who have used creative exercises, pupils who have used traditional exercises, and pupils who have not used any exercises on an achievement test in space science and a creative thinking test?

3. Is any significant difference, on an achievement test in space science and a creative thinking test, found within the high, average, and low ability levels?

4. Is there a significant difference between male and female pupils, on an achievement test in space science and a creative thinking test, in classes using creative exercises, classes using traditional exercises, and classes not using any exercises?

Population of the Study

The study group used in this investigation was randomly selected from the elementary schools of Milwaukee, Wisconsin. Milwaukee, the tenth largest city in the United States, has a heterogeneous school population with children from all economic levels, varying abilities, diverse interests, and different familial settings.

From this population, all elementary schools were divided into three ability levels: high, average, and low by the Director of Educational Research. Using a table of random numbers, the Director selected nine schools from each ability level. Three schools were randomly selected to use the experimental materials, three to use the traditional materials, and three to take the tests only.

It should be noted that although grade six was originally
selected, the Milwaukee School system has a semester plan, therefore, the sample included some 5A (second semester) fifth-grade students. These students were in the same classrooms with 6B (first semester) sixth grade students. Social studies and science is taught to the entire class without reference to grade level.

Conclusions

After careful examination of the data obtained in the study, conclusions to the questions which were posed in the statement of the problem were reached:

1. Is there a significant relationship between creative thinking and intelligence for pupils who have used creative exercises, pupils who have used traditional exercises, or for pupils who have not used any exercises?

   The test of significance for each of the coefficients of correlation for the treatment groups was obtained. Statistical analysis proved that there was a significant relationship at the .05 level between intelligence and creative thinking and intelligence and space science achievement for the treatment groups.

2. Is there a significant difference (.05 level) between pupils who have used creative exercises, pupils who have used traditional exercises, and pupils who have not used any exercises on an achievement test in a creative thinking and a space science test?

   A. There was a significant difference between pupils who have used creative exercises, pupils who have used traditional exercises, and pupils who have not used any exercises in creative thinking. This difference, however, varied within the three ability levels and the four sub-categories of the creative thinking test and will be reported
under question three.

B. There was no significant difference in space science achievement between pupils who used creative exercises and pupils who used traditional exercises. The investigator concluded that the use of four brainstorming lessons and creative exercises did not interfere with academic achievement.

C. There was a significant difference in space science achievement between pupils in the creative and traditional groups who used the thirty space science lessons and the control group who did not use the lessons. The investigator concluded that the use of space science lessons provided optimum opportunities to learn space science concepts than no lessons at all.

3. Is any significant difference (.05 level), on an achievement test in space science and a creative thinking test, found within the high, average, and low ability levels?

High ability level. A. The experimental group was significantly superior to the traditional and control groups in fluency, flexibility, originality, elaboration. The investigator concluded that the use of creative exercises and four brainstorming lessons may have provided optimum opportunities to demonstrate creative thinking than traditional exercises or no exercises.

B. The control group was significantly superior to the traditional group in flexibility, originality, and elaboration. The investigator concluded that for pupils in the high ability level traditional exercises and space science lessons may have interfered with flexibility, originality, and elaboration in thinking. It may be that
pupils in this ability level represent a segment of society where conforming to authority, responding to teacher demands, thinking in terms of one right answer to each question inhibits to some degree the ability to think in terms of the number of ideas, principles, or approaches used in responding to the tasks on the test.

**Average ability level.** A. The experimental group was significantly superior to the traditional and control groups in fluency, originality, and elaboration. The investigator concluded that the use of creative exercises and four brainstorming lessons may have provided optimum opportunities to demonstrate fluency, originality, and elaboration in thinking than traditional exercises or no exercises.

B. The traditional group was significantly superior to the control group in fluency, originality, and elaboration. The investigator concluded that the use of traditional exercises and space science lessons may have provided optimum opportunities to demonstrate these qualities in thinking than no exercises or lessons.

C. The experimental group was significantly superior to the control group in flexibility. The investigator concluded that the use of creative exercises and four brainstorming lessons may have provided optimum opportunities to demonstrate flexibility in thinking than no exercises or lessons.

**Low ability level.** A. The experimental group was significantly superior to the traditional and control groups in elaboration only. The investigator concluded that the use of creative exercises and four brainstorming lessons may have provided optimum opportunities to demonstrate elaboration in thinking than traditional exercises or no exercises.
B. The control group was significantly superior to the experimental group in flexibility in thinking. The investigator concluded that for low ability groups, the use of creative exercises and four brainstorming lessons had no apparent effect upon flexibility in thinking.

Space science achievement. An analysis of the space science achievement test scores showed that in all ability levels, the experimental and traditional groups were significantly superior to the control group. The investigator concluded that space science lessons and exercises provided optimum opportunities to learn space science concepts than no lessons.

4. Is there a significant difference between male and female pupils on an achievement test in space science and a creative thinking test in classes using creative exercises, classes using traditional exercises, and classes not using exercises?

A. In space science achievement, the males were significantly superior to the females in each ability level. Thus, the investigator concluded that the subject matter itself may have been an influencing factor. Male pupils' interest in space science may have contributed to the difference in mean scores.

B. On the creative thinking tests, an analysis of male-female differences in each of the treatment groups showed that the only significant difference was in fluency of thinking with the difference favoring the females in the experimental group. Thus, the investigator concluded that the use of creative exercises and four brainstorming lessons may have provided optimum opportunities for female pupils in the experimental group to exhibit fluency in thinking.
Major Conclusions

Two major purposes of the study were indicated as follows: one, to determine whether or not teachers could improve the creative thinking abilities of the pupils in their classes by using selected creative exercises. Two, to determine what affect the attempt to improve creative thinking abilities would have upon achievement in a subject matter area.

After careful examination of the data obtained in the study, the investigator concluded that teachers can improve certain creative thinking abilities using selected creative exercises but improvement varied within each ability level. The investigator also concluded that creative thinking abilities can be improved without interfering with academic achievement.

Suggestions for Further Research

The investigator of the present study recommends further research in the following areas:

1. This study dealt with the use of creative exercises, four brainstorming lessons, and a unit in space science on the creative thinking and space science achievement of fifth and sixth grade pupils. It would be desirable to experiment with a variation of this plan in grades two, three, and four or seven and eight.

2. It would be advisable to compare the effects of creative exercises and brainstorming lessons in other subject areas, to see if similar findings are obtained.

3. It would be interesting to see if growth in creative thinking is maintained over an extended period of time. Therefore, it is
recommended that a similar study be made for a period of two or more years.

4. It would be interesting to evaluate the use of specific creative teaching techniques such as brainstorming, individual ideation and the like as a means of increasing creative thinking abilities.

5. This study used science lesson plans to assist teachers in teaching space science. A similar study could be made using lesson plans in some other science area to determine science achievement in that area. This would be particularly helpful to elementary teachers needing assistance in teaching science.
BIBLIOGRAPHY


Margolin, Edythe. "Do We Really Prize Creativity?" The Elementary School Journal, 64:117-121; December 1963.


Taylor, Calvin W. "Creativity and the Classroom." Science and Children. 1:7-8; May 1964.


January 29, 1965

MEMORANDUM - Research

To: The Principal

From: Miss Paukner, Mr. Swenson, Mr. Rowe

The purpose of this memorandum is to point out some additional details concerning this study and to indicate approval of some scheduling changes which might be necessary in order to carry out the work in your school at this time.

The lesson plans and activities which have been prepared should prove very helpful to the teacher and will provide a fine learning experience for the pupils. Since the Elementary Science Committee is currently developing a grade 6 resource unit on space, we feel that the research being conducted on this study will be of particular value to this committee in finding suitable student learning experiences to demonstrate certain space concepts.

Professor DeRoche of the School of Education, Marquette University, joined the staff this year from the University of Connecticut. It is fortunate that he is available to us in this community as a resource person in the field of science education.

The classes chosen are not all composed of 6B pupils only. The class may be only grade 6B or a combination of 6B and 5A. There will be only one class participating in each school chosen.

Because of the research aspect of this activity, it is necessary that pupils in the study should not have studied the science unit on space last semester. If your pupils have, would you please inform...
Mr. Swenson or Mr. Rowe by telephone so that another school can be selected? It is also necessary because of the school calendar that work on the unit begin on Monday, February 8. If another unit such as simple chemistry should be scheduled for this six-week period beginning February 8, the other unit can be re-scheduled to be taught during the time allocated to the space unit next fall. During the six-week period, there should be thirty class sessions of thirty minutes each. The period would end March 19 and follow-up testing to be done on March 22 and 23.

The participation of your school is voluntary and if changes are required that would disrupt your schedule or are too inconvenient would you please indicate it on the attached form? Could you also call Mr. Rowe as soon as you have made your decision in order that final arrangement can be expedited this week.

Miss L. Paukner, Executive Director
Elementary Curriculum

Mr. R. Swenson, Supervisor
Elementary Curriculum

Mr. G. D. Rowe, Coordinator of
Educational Research

Enclosures:
Abstract of the Study          Pupil Activities (Control groups only)
Lesson Plans                   Space Quiz
Principal's Recommendation    Sheet for Approval of the Study
Unit on
SPACE and SPACE TRAVEL
Grade 6

Dear Teacher,

Your cooperation in using this unit on space and space travel is most appreciated.

Before starting these thirty lessons, read them over carefully and begin gathering materials. The lessons are designed to consume about thirty minutes of actual instruction. Please provide as close to thirty minutes of instruction as possible except in cases otherwise indicated.

This unit and its techniques are designed so that science teaching and learning can be exciting and meaningful. If you have any questions on procedure, use your own good judgment for solutions.

You will note that in the middle of the unit films, filmstrips, and recordings are called for. Prepare for this now and get your order in.

There is a quiz to be given in the middle of the unit which will assist you in assessing learning.

At the end of the unit, probably during the week following the last lesson, you will receive an achievement test and creative thinking test which you will administer to your class on two separate days.

The following statements should be adhered to as closely as possible.

1. Read one or two of the students' textbooks on this topic before starting unit.
2. All activities must be completed by each youngster. Some
activities follow the lesson, others are on a separate section.

3. The activities may be started at school and completed at home.

4. Pupils are to make a "space notebook" and all the activities are to be saved in this notebook.

5. The notebooks will be collected by the teacher and not returned to the students.

6. The notebooks should be graded by the teacher.

7. All notebooks will become part of the material collected by the principal.

8. Teachers should not have pupils change any material in the notebook except in the case of wrong answers. Grammatical errors, etc. should not be changed. Some exercises cannot be corrected because there are no correct answers for these.

9. All activities, once again, must be completed and whenever possible the teacher should discuss answers with the class.

10. Gather all the material needed for the science experiments used in the lessons and prepare an area in the classroom for science texts and other references.

11. Complete the teacher information sheet.

Your contribution to the research in science education is greatly appreciated. No attempt will be made to assess your science teaching ability, rather we are interested in the results of the activities on boys and girls in grade six.

Your colleagues and the profession are proud of you for participating in this research.

Enjoy the lessons. Thank You!
TO THE TEACHER: Please read carefully before beginning the lessons.

What is it?

Webster defines "brainstorm" as applied to creative collaboration as follows: "To practice a conference technique by which a group attempts all the ideas spontaneously contributed by its members." Brainstorming refers to a specific principle that can be practical and useful by individuals or groups—the principle of suspended judgment. That is, we should not try to think judicially and imaginatively at the same time. Evidence indicates that when we are trying to develop solutions or ideas, quantity breeds quality. Brainstorming sessions help students provide a quantity of ideas, the quality of which is determined after the session.

Can students use it?

Any technique that helps students to think—to develop and use ideas—is of lasting value. Many times students are stymied by problems in and out of school because they have not been taught how to attack the problem. The one thread that is common among all of us is the fact that we have problems—problems that require ideas, decisions, solutions. All humans have this experience regardless of race, color, creed, or education. Our students should be taught the techniques of creative problem-solving. Brainstorming is one of these techniques. Ideally, idea-finding should involve three procedures: individual ideation, group brainstorming, individual ideation. Students should not be led to believe that group brainstorming is a panacea to idea finding.

Osborn's rules for brainstorming sessions should be discussed by you and the class. These rules are as follows:

1. Criticism is ruled out.
   Students should be told that they are not to judge until the evaluation session. The teacher should be constantly on the alert for critical or judicial remarks.

2. Free-wheeling is welcomed.
   The teacher should explain to the class that the wilder the idea, the better. The teacher should explain that many times impractical suggestions cause other members to think about ideas that may not have occurred to them.

3. Quantity is wanted.
   The greater the number of ideas, the better the chance for useful ideas.

4. Combination and improvement are sought.
   In addition to contributing their own ideas, the students should be encouraged to develop the suggestions by others into better ideas or to combine two or more.
LESSON 1

Space and Space Travel: Introduction

A. **Purpose:** To initiate an interest in space science and the problems man may encounter in his space travels.

B. **Procedure:**
   1. Explain the word "brainstorming" to the students. (To storm the brain with ideas, etc.)
   2. Have them put their "brainstorming sheets" on their desks and discuss the meaning of this sheet.
   3. Tell them that you want them to think "with their brakes off" in answering the following questions.
   4. Have two students record the answers on the blackboard as fast as they can. The question: Tell me all you know about space and space travel. (The class will tell you some facts, misconceptions, key words, etc.)
   5. Leave these on the board and go on to the next question. Remind them that what we want is ideas, not criticism.
   6. Have two students record on paper or board the ideas the class gives to the following question: In what ways can we make new friends?
   7. After students have recorded their ideas, ask the class to select the best three. Ask: Would these ideas work? Say: See how you can think for yourself.
   8. Have class copy the ideas on space and space travel from the board. Tell them that as we study about space science we will refer to these ideas to see if our facts were correct.

C. **Activities:** Have students do the exercises listed under lesson 1 in their activity booklets.

LESSON 2

What is space?

A. **Purpose:** To develop an understanding of what space is and what it contains.

B. **Procedure:**
   1. Have the class "brainstorm" the following problem recording their ideas on the board: In what ways could we explain what space is to first graders? (Space is the relative unknown beyond the atmosphere. It is endless and has no air.)
2. Have students select the best five ideas.

3. Ask: Does brainstorming help you think up more ideas than you thought you could? (Hopefully they'll say yes.)

4. Say: Isn't it better to use brainstorming than to say: "I don't know."

5. Tell them that when they use the brainstorming technique by themselves it is called "individual ideation," that is, individual ideas.

6. Ask: What does space contain? (Our universe--sun, planets, meteors, stars, meteorites, etc., and other universes.)

7. Discuss the statement: Space is endless and has no air.

8. Discuss: If there is life in our universe--animal and plant life--might there be life in other universes? (Some scientists think that plant life exists on planets in our galaxy, but human life may exist in other universes.)

C. Activities: Have students do the exercises listed under lesson 2 in their activity booklets.

LESSON 3

Rockets for space

A. Purpose: To demonstrate why rockets are the only engines that can be used for space flight.

B. Materials: 3 different-sized glasses, 3 birthday candles.

C. Procedure:

1. Write on the blackboard: Why are rockets the only engines that can be used for space flight?

2. Stand three candles (regular or birthday candles) on a table or desk. Light each candle.

3. Have three students carefully place each glass over each candle at the same time, as shown.

4. Ask the class: What makes the candles burn? Lead the class to the understanding that oxygen (gas) is necessary for combustion (burning.)
5. Repeat the experiment. Select three different students to place the glasses over the candles.

6. Ask: When the glasses cover each candle, which candle goes out first? (Candle covered by smaller glass.)

7. Ask: Why does candle covered by smaller glass go out first? (It contains the least oxygen or air.)

8. Ask: What conclusions can you make from this experiment? Air (oxygen) or oxygen (air) is necessary for combustion (burning).

9. Explain that this burning causes energy to move an object.

10. Ask: What machines need air or oxygen to run? (Cars, motor driven lawn mowers, airplanes, etc.)

11. Tell them that in our next lesson we will discuss this experiment in relation to traveling in outer space.

Activities: Have students do the exercises listed under lesson 3 in their activity booklets.

LESSON 4

Rockets for space (continued)

A. Purpose: To demonstrate why rockets are the only engines that can be used for space flight.

B. Procedure:

1. Ask the students to recall yesterday’s experiment with the candles and glasses. What conclusions can we state from this experiment: Air (oxygen) is necessary for burning (combustion).

2. Ask:
   a. Is there air in outer space? (No)
   b. Can planes fly beyond the earth’s atmosphere (No)
   c. Why? (Ordinary engines need air for combustion or burning in order to develop energy for motion.)
   d. Can rockets fly in outer space? (Yes)
   e. How do you know?
   f. Why can rockets fly in outer space? (In order to help students answer this question, put the following diagrams on the board.)
g. Explain that an airplane carried fuel but air is needed for the fuel to burn (combustion) and supply energy. Rockets have their fuel supply and oxygen built into a section called the combustion.

C. Review with the class the following concepts:
1. Air (oxygen) is necessary for combustion (burning).

2. Ordinary airplane engines (propeller or jet) need air from the earth's atmosphere in order to fly.

3. Rockets are the only vehicles that can fly beyond the earth's atmosphere.

4. Rockets carry their own fuel supply and oxygen in order to fly in outer space.

D. Activities: Have students do the exercises listed under lesson 4 in their activity booklets.

LESSON 5

How do rocket engines work?

A. Purpose: To develop an understanding of how rocket engines work.

B. Materials: Balloons.

C. Procedure:
1. Put the following diagrams on the board.

   ![Diagram of pressure equal on all sides]
   ![Diagram of pressure on this end]

2. Say: Look at the diagram of the balloon on the board. Which one would move? (Open one). Why? (Pupils will probably say that escaping air causes it to move. This is incorrect.)

3. Tell them that the air consists of tiny molecules travelling at great speed inside the balloon: bouncing off the wall of the balloon causing pressure on the wall of the balloon.

4. Ask: What happens to the pressure when the nozzle of the balloon is opened? (It becomes unbalanced as in fig. b. The molecules near the open nozzle escape and the molecules at the front of the balloon push it.)
5. Have a student blow up a balloon and let it go. Ask what caused it to move.

6. Put this diagram on the board.

7. Ask: Will the rocket in Figure A move? (No.) Why? (Pressure of molecules - expanding gases - is equal on all sides.)

8. Ask: Will the rocket in Figure B move? (Yes.) Why? (The pressure of the gases is unbalanced and the force of the molecules up front is greater than the molecules that are escaping, thus, the molecules up front cause the rocket to move. It is not the escaping molecules that cause the motion because they exert no pressure whatsoever.)

9. Review so that the students understand that the actual push is created because more molecules bang against the forward wall of the chamber than against the back wall where most molecules are escaping.

D. Activities: Have students do the exercises listed under lesson 5 in their activity booklets.

LESSON 6

Why are spaceships given all of their forward push in the first few minutes of flight?

A. Purpose: To develop an understanding of the force of gravity.

B. Procedure:

1. Ask the class: What is gravity? (Gravity is that force which pulls any mass (matter) towards the earth. The concept was developed by Sir Isaac Newton--Newton's Law of Universal Gravitation.)

2. Ask: Who can demonstrate the concept of gravity? (Dropping an object, getting weighed on a scale (weight is the pull of gravity), etc.)

3. Ask: Why does a rocket carry so much fuel and is so big? (It has to develop a great deal of thrust (push) to lessen the force of gravity as it goes up away from the earth.)

4. Explain to the class that a rocket's speed increases because it becomes lighter as its fuel is "used up." The push is the same on the rocket even though its speed increases.
5. Explain to the class: As a rocket goes up the force of gravity weakens. Gravity weakens with altitude (height); so, the faster the rocket climbs, the faster gravity's pull on the rocket weakens.

6. For the remaining time, have the students copy in their space notebooks the three principles underlined.

C. Activities: Have students do the exercises listed under lesson 6 in their activity booklets.

LESSON 7

More About Rockets

A. Purpose: To develop an understanding of how rockets work.

B. Procedure:
1. Review the three principles in lesson six.

2. Ask:
   a. Have you ever heard that rockets have stages? (Yes)
   b. What is meant by the stage of a rocket? (A booster with its own fuel supply.)
   c. How many stages do rockets usually have? (Three)

3. Ask:
   a. Why do rockets have what scientists call stages? (To provide a thrust to carry the payload into space.)
   b. What do we mean by the word payload? (Payload is the person or thing that scientists are trying to put in orbit around the earth.)

4. Ask: What do we mean by thrust? (Power of a rocket)

5. Ask:
   a. What happens to each stage after it has "used up" its fuel supply? (The stages are dropped or jettisoned.)
   b. Why are the stages jettisoned? (To save weight and increase speed.)

6. Review the following words or concepts:
   a. The three principles in lesson six.
   b. Rocket stages.
   c. Payload.
   d. Thrust.
   e. Jettisoned.
   f. Purpose of stages.
   g. Have students record these concepts, principles, and words in their space notebooks.

C. Activities: Have students do the exercises listed under lesson 7 in their activity booklets.
What is a satellite?

A. **Purpose:** To develop an understanding of satellites.

B. **Procedure:**
   1. Ask the class for their definitions of a satellite. Record some of these on the board.

   2. Lead the class into accepting the following definition: an object or a body moving around a larger one such as the moon revolving around the earth.

   3. Ask the class for other examples:
      a. the earth revolving around the sun.
      b. a man-made satellite revolving around the earth.
      c. the moon revolving around the earth.

   4. Ask: Have you ever heard the word satellite used to describe countries? (Yes) What does the word mean in this context? (Newspapers sometimes refer to countries who rely on Russia as Russian satellite countries.)

   5. Ask: Who can name the earth's first satellite? (Moon)

   6. Ask: Who can name some man-made satellites? (Tiros, Ranger, Lunik 3, Sputnik, Mariner, etc.)

   7. Ask: Can the earth be called a satellite? (Yes, of the sun.)

   8. Review the definition of the word satellite. Have each student record it in his notebook.

C. **Activities:** Have students do the exercises listed under lesson 8 in their activity booklets.

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**LESSON 9**

How does a satellite keep from falling back to earth?

A. **Principle:** If we can raise the satellite far enough above the earth, and it moves fast enough, we can achieve a balance between two opposite forces—gravity (inward pull) and centrifugal force (outward push).

B. **Purpose:** To develop an understanding of how satellites stay in orbit.

C. **Materials:** bowl, marble.

D. **Procedure:**
   1. Have a student, in front of the class, hold the bowl with the
marble in it for all to see.

2. While he holds the bowl, ask the class: What is happening to the marble? (Gravity (inward pull) is keeping it at rest at the bottom of the bowl.)

3. Ask: How can we "launch" the marble? (Swirling or turning the bowl.)

4. Ask: What is happening to the marble? (It goes into "orbit" along the sides of the bowl.)

5. Have another student do the experiment and repeat procedures one to four to reinforce these concepts.

6. Ask another student to do the same thing except to make it go faster. Ask the class: What happens if the speed of the marble is increased? (Marble will go faster than needed to balance gravity and it will be hurled out of the bowl.)

7. Ask: What happens if the speed of the marble (satellite or payload) is reduced or slowed down? (The marble won't go fast enough to balance gravity and it will fall to the bottom of the bowl.)

8. Ask: Can someone summarize for us what concepts or principles this demonstration illustrates? Lead the class to the following concepts and have them record them in their "space notebooks" as well as the experiment that illustrates them.

   a. If we can raise a satellite far enough above the earth, and make it most fast enough, we can achieve a balance between two opposite forces—gravity (inward pull) and centrifugal force (outward push).

   b. Speed helps to counteract gravity. This speed is called centrifugal force—the tendency of objects moving in circular paths to move away from the center of rotation.

E. Activities: Have students do the exercises listed under lesson 9 in the activity booklets.

LESSON 10

What are the satellites of the sun?

A. Purpose: To develop an understanding of our universe—the sun and planets.

B. Procedure:
   1. Ask: Who can name the earth's first satellite? (Moon)

   2. Ask: Could the earth ever be a satellite? (Yes, of the sun)

   3. Ask: Does the sun have satellites? (Yes, the planets)
4. Ask: Who can name the sun's satellites or planets? (There are nine: Mercury, Venus, Mars, Earth, Jupiter, Saturn, Uranus, Neptune, Pluto.)

5. Have the students copy the following chart from the board:

Sun  Mercury  Venus  Earth  Mars  Jupiter  Saturn  Uranus  Neptune  Pluto

6. Have the class find the answers that match each planet with the correct description:

1. Pluto      ____  A. has shortest year and longest day.
2. Saturn     ____  B. has one moon.
4. Jupiter    ____  D. has so-called canals and ice-caps.
5. Uranus     ____  E. largest of all planets.
6. Mars       ____  F. has bands or rings around it.
7. Earth      ____  G. dimmest planet visible with a telescope.
8. Venus      ____  H. has two moons.
9. Mercury    ____  I. takes about 248 years to go around the sun.

7. Tell the class that the spelling of the names of the planets will be included in the weekly spelling test. At the end of fifteen or twenty minutes, correct the assignment with the class.

C. Activities: Have students do the exercises listed under lesson 10 in their activity booklets.

LESSON 11

Why does a satellite stay in orbit? (A Review)

A. Principles:
   1. Speed is one way to counteract gravity. Speed does this by setting up another force called centrifugal force.

   2. For a satellite to stay in orbit, gravity and centrifugal force must almost balance each other.

B. Purpose: To develop an understanding of the principles listed above.
C. **Materials:** String with a weight on one end. (The weight can be a simple nut or bolt tied securely to the string.)

D. **Procedure:**

1. Ask: What is a satellite? (An object or body circling a larger object or body.)

2. Ask: Name some satellites. (Earth, Moon, Sputnik, Mariner, Tiros, etc.)

3. Say: Let's find out how a satellite (man-made) keeps from falling back to earth.

4. Ask: Why is it so hard to leave the earth? (Pull of gravity.)

5. Ask: What does man do to counteract or go against gravitational pull? (He builds powerful engines that build up energy to make an object move with great speed.)

6. Ask: What is one way, then, to counteract gravity? (Speed)

7. **DEMONSTRATION:** Have a student hold up the string with a weight on it.

   a. Ask: Why is the weight at the bottom of the string? (Pull of gravity on the weight and string.)

   b. Ask: What will happen if the student lets it go? (Falls to floor)

   c. Ask: What can we do to the weight so that gravity doesn't keep it in this position? (Let the student think about this for awhile; if he can't "come up" with an answer, ask:

      1. What did we say was one way to counteract gravity? (speed)

      2. How can we give the weight some speed? (Twirl it.)

   d. Have the student twirl the weight. Be sure it is attached firmly to the string.

   e. Ask: Should student let it go? (No! Why? (It will fly out of control across the room.)

   f. Ask: When the weight is twirling around is it counteracting gravity? (Yes) What causes this? (The speed of twirling it around.)

   g. Ask: What happens if the speed is decreased? (Weight starts to pull down, gravity increases).

   h. Ask: What happens if speed is increased? (Weight forms a circular path, "straight out" gravity decreases.)

   i. Ask: What is one way to counteract gravity? (Speed)

   j. Say: There is something more than just speed that counteracts gravity. Speed sets up another force called centrifugal force (put on board.)

   k. Put on board: Centrifugal force tends to draw all things that are speeding in circular path away from the center of the earth.

1. Say: From this discussion I want you to think about how we could solve the problem of keeping a satellite in orbit without having it fall back to earth. If you solve this problem, you will also know why the earth orbits around the sun and stays in its orbit; why the moon orbits around the earth and stays in its orbit and so on. To help you with this, I suggest you get a sewing spool, a piece of string, and two weights tied to each end like this. (Show the one you have or put this diagram on the board.)

E. Activities: Have students do the exercises listed under lesson 11 in their activity booklets.

LESSON 12

Why a satellite stays in orbit? (Continued)

A. Principles: same as lesson 11.

B. Purpose: same as lesson 11.

C. Materials: Spool, string, two weights, (use metal washer or bolts or any other weights you have.) Arrange the material so that it is assembled as in this diagram:

![Diagram of a spool and two weights connected by string.]

D. Procedure:

1. Ask: Has anyone figured out how we can explain how a satellite stays in orbit by using this spool, string, and weight? (If yes, let some students explain, then continue.)

2. Ask: How did John Glenn counteract gravity? (Speed)

3. DEMONSTRATION: Say: Suppose the top weight is John Glenn's space capsule; the spool is the earth; the bottom weight is gravity and my hand and wrist the rockets or energy to produce speed.

4. Ask:
   a. How could I get John Glenn (top weight) in orbit? (Twirl the weight while holding the spool.)
   b. What were the two forces, that we talked about yesterday, that must be almost equal to each other for a satellite to stay in orbit? (Gravity and centrifugal force.)
   c. Ask: As I twirl the top weight, our satellite goes
faster. What happens to bottom weight? (It comes up to the spool, thus representing a decrease in gravity.)

d. Ask: What happens if I slow down the speed of the satellite (top weight)? (Gravity is increased, centrifugal force is decreased; bottom weight pulls top weight down toward the spool (Earth).

5. Repeat demonstration letting one or two students do the twirling and explaining.

6. Have the students copy the principles in lesson 11 in their space notebooks.

LESSON 13

A. Purpose: To discuss the material they have been doing under the "activity" section of each lesson as well as evaluating their space notebooks.

B. Procedure:

1. Have students discuss and compare the results of their "activities" in any way you desire.

2. For example, in lesson 11 activities, have students who "reach the moon" tall of some of their ideas. Have some who didn't "get off the ground" do the same. Do the same for some of the "activities" from other lessons.

3. Also be sure that all papers are up to date, completed, and in their space notebooks.

4. Correct all papers not yet corrected and discuss answers with the class.

C. Activities: Have students do the exercise listed under lesson 13 in their activity booklets.

LESSON 14

Why are the orbits of satellites elliptical?

A. Principles:

1. Satellites orbit the earth in elliptical paths.

2. The point of the path farthest out is called the apogee.

3. The point of the path closest is called the perigee.

B. Materials: Blackboard, chalk, ball, egg.

C. Procedure:

1. Ask: Explain the difference in shape between this egg and the ball.
2. Lead them to the concept that there is a difference between a circle and an oval.

3. Introduce the word ellipse in place of the word oval.

4. Draw on the board the following diagram.

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Satellite  ───────────────────────────────────────────────────────────── Apogee
Path of a satellite
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5. Explain that there is always a slight imbalance between a satellite's speed and the pull of gravity. Therefore, satellites never orbit the earth in perfect circles but in slightly flattened circles called ELLIPSES.

6. Ask the class if this would be true of the sun's satellites (planets). (Yes, it is.)

7. Explain that as the satellite circles the earth in an elliptical path it is closer at certain times and farther out at other times. The point of the path farthest out is called the apogee; the point closest in, the perigee. Show this on the diagram on the board.

8. Ask: Does the sun's satellite travel a path having an apogee and perigee? (Yes.)

9. Ask: Who can name the sun's satellites? (Mercury, Venus, Earth, Mars, Jupiter, Saturn, Uranus, Neptune, Pluto.)

D. Activities: Have students do the exercises listed under lesson 14 in their activity booklets.

LESSON 15

A. Purpose: To review some of the major concepts by means of an educational film or filmstrip.

B. Procedure:

1. Obtain one or two films or filmstrips from the following list. These films, filmstrips, or recordings are available from: Museum Audiovisual Center, 815 N. 7th St., Milwaukee, Wisconsin

2. Preview the film, filmstrip, or recording.

3. Show to class. Discuss main points.
FILMS

4493  Earth in Motion - 10 min.
4495  Earth's Rotation and Revolution - 9 min.
4492  Sun's Family - 11 min.
4478  A Trip to the Moon - 16 min.
4110  Earth Satellites: Explorers of Outer Space - 17 min.
6289  Exploring Space - 26 min.
4150  First Man Into Space - 15 min.
4473  Man and the Moon - 20 min.
6201  Man in Space - 35 min.
4107  Rockets, Guided Missiles, and Satellites - 17 min.
4113  Rockets: How they Work - 16 min.
4112  Rockets: Principles and Safety - 11 min.
4109  Engines and How They Work - 11 min.
5492  What is Space? - 10 min.

FILMSTRIPS

V = Silent Filmstrip

R = Recording

V 13526  Flight Around the Moon
V 13522  Flight Into Space
V13521  Flight to Mars
V 13524  Man and the Moon
V 13523  Man in Flight
V 13527  Man in Space
V 50523  Our Neighbors in Space
V 50569  Information from Satellites
R 50511  By Rocket to the Moon  78 RPM
R 50520  A Trip to the Planets  78 RPM
V 50511  The Sun and Its Planets
V 6115  What is Space?
V 61150  Rockets to Space
V 61151  Getting Ready for a Space Trip
V 61152  What are Satellites?
V 61153  What are Space Stations?
V 61154  A Space Trip to the Moon

LESSON 16

A. Review of Lessons 1-15

A. Purpose: To review the major concepts in previous lessons.

B. Procedure:

1. Spend ten minutes reviewing the major concepts in previous lessons in any way you desire.
SPACE QUIZ  
for  
LESSON 16

Name ____________________________

Directions: Circle the best answer.

1. What is space?
   a. unknown beyond atmosphere  
   b. dark area beyond earth     
   c. endless atmosphere         
   d. airless place

2. The candle-water glass experiment helps to explain the following concept:
   a. glass put out fire  
   b. oxygen is necessary for burning  
   c. air is needed for oxygen  
   d. burning needs space

3. Rockets do not need oxygen from the air because they:
   a. don't fly in the atmosphere  
   b. don't have propellors  
   c. carry satellites  
   d. carry their own fuel supply

4. A principle of rocket power can be explained by one of the following:
   a. balloon  
   b. candles  
   c. glasses  
   d. rockets

5. A scale is an example to prove one of the following forces:
   a. thrust  
   b. gravity  
   c. centrifugal force  
   d. centripetal force

True or False
Circle T or F after each statement.

6. The actual push of a rocket is created because more molecules bang against the forward wall than the back wall.  T  F

7. The combustion chamber is found at the top of the rocket near the payload.  T  F
8. A rocket moves forward because the molecules exert greater pressure on the front of the combustion chamber.  T  F

9. A rocket's speed increases because the push on the rocket keeps getting greater.  T  F

10. The faster a rocket climbs, the faster gravity's pull on the rocket weakens.  T  F

Matching: Put the number of the word in Column I with the correct answer in Column II.

<table>
<thead>
<tr>
<th>Column I</th>
<th>Column II</th>
</tr>
</thead>
<tbody>
<tr>
<td>gravity</td>
<td>a booster with its own fuel supply</td>
</tr>
<tr>
<td>satellite</td>
<td>to save weight and increase speed</td>
</tr>
<tr>
<td>centrifugal force</td>
<td>outward force counteracting gravity</td>
</tr>
<tr>
<td>speed</td>
<td>weakens with altitude</td>
</tr>
<tr>
<td>jettison</td>
<td>earth revolving around the sun</td>
</tr>
<tr>
<td>stage</td>
<td>largest of all planets</td>
</tr>
<tr>
<td>Jupiter</td>
<td>sets up a force called &quot;centrifugal force&quot;</td>
</tr>
<tr>
<td>Earth</td>
<td>has one moon</td>
</tr>
<tr>
<td>perigee</td>
<td>when moon is farthest from the earth</td>
</tr>
<tr>
<td>apogee</td>
<td>when satellite is nearest the earth</td>
</tr>
</tbody>
</table>

2. Administer the quiz. Twenty minutes. Have students exchange papers and correct each answer as you give them the correct answer.

LESSON 17

Problems of Space Travel: Introduction

A. Purpose: To develop an understanding of the problems of space travel.

B. Procedure:

1. Ask: What do you think would be some of the problems that man will have in going to outer space?

2. Say: Let us compare your list of problems with scientists' ideas and see if we agree with them.

   a. Have some students read their texts and problems; others can check the encyclopedia; others, various science books.

   b. Have all students record, on a sheet of paper, the problems of space travel that they found important. (TEACHER: You
will discover that scientists usually list the following as main problems of space travel: acceleration, weightlessness, meteors, cosmic rays, temperature, fuel and speed, navigation, landing, time and distance, and boredom and isolation.)

3. Have three or four students read their lists to the class. Put your list on the board and have students compare their lists to it.

4. Have class put both lists in their space notebooks.

5. Say: The lessons that follow will provide further information about the problems of space travel.

C. Activities: Have students do the exercises listed under 17 in their activity booklets.

LESSON 18

Problems of Space Travel: Acceleration

A. Purpose: To develop an understanding of acceleration, inertia, and g-force.

B. Materials: Paper cup, brick or stone or heavy object, an open box, a strong string; a marble or small ball and glass or paper cup.

C. Procedure:

1. Ask the class, What happens when a driver of a car steps on the gas pedal or accelerator? (speed is increased, we sometimes feel our bodies push against the seat.)

2. Ask: Does anyone know a word that describes this action? (Acceleration -- Put on board.)

3. Tell the class that acceleration is a word that means "increase in speed." You feel acceleration as a car gains speed. But acceleration by itself is no problem, but it goes with another force called INERTIA (put on board.)

4. DEMONSTRATION*

   a. Tell the class that you will demonstrate the meaning of inertia.

   b. Tie the string to one end of the box. Place paper cup upside down, against the other end of the box. Place the brick or stone in front of the cup but not touching. Now accelerate the box by pulling the string swiftly.

---

c. Ask the class what happened to the cup. (It was crushed.)

5. Tell the class: **Inertia** is defined as follows: An object at rest will stay at rest (cup, brick) and an object in motion will stay in motion, unless some force acts on the object. (acceleration)

6. Demonstration for inertia: Place a ball or marble in the glass or cup. Push the glass along a table top or desk in the direction of the open end. Stop the glass suddenly. Ask the class, why does the ball or marble keep on moving? (A moving body will keep moving unless something stops it.)

7. Tell the class: In this experiment, the "box" was the rocket ship, the "brick" is that part of the passenger's bones, muscles, and the "cup" is the softer material of the body such as the lungs, heart, digestive system, etc. When the thrust of the rocket begins, the acceleration is very great, and thus we get a crushing action. This crushing action is called g-force (put on board.)

8. Explain g-force. G-force is the attraction between man and earth. On earth this attraction is equal to a man's weight. Scientists say that your weight is equal to one g. As the experiment showed, an astronaut's weight increases when the thrust of the rocket pulls against his body. In a 10-g blast off (the take-off of a rocket) the weight of his body is increased ten times. Explain that g-force is reduced as ACCELERATION and INERTIA decreases but then the astronaut is in orbit and has to cope with another problem—weightlessness. This we will discuss in our next lesson.

9. Summary: Review the meaning of the concepts acceleration, inertia, and g-force for the class.

D. Activities: Have students do the exercises listed under lesson 18 in their activity booklets.

**LESSON 19**

**Problems of Space Travel: Weightlessness**

A. **Purpose:** To develop an understanding of weightlessness as a major problem of space travel.

B. **Materials:** Try to find pictures and articles on weightlessness.

C. **Procedure:**
   1. Ask: What do you think scientists mean when they talk about weightlessness?
2. Ask: Who can tell me what happens to gravity the farther away from the earth one travels? (The force of gravity is less as you move away from the earth.)

3. Ask: Is there a relationship between gravity and weight? (Yes, our weight is the pull of gravity on our bodies measured by a scale in pounds.)

4. Ask: If gravity decreases as we go into space, what happens to our weight? (It also decreases.)

5. Ask: Why is weightlessness a problem in space travel? (Men aboard a spacecraft would find themselves weightless. For example, at 60,000 miles in space, man would weigh about half a pound.)

6. Ask: Who can tell us what they think it would be like to be weightless or to live in an area with no gravity? (Topsy-turvy place, no up, no down, zero-gravity, etc.)

7. Say: Investigations by scientists and doctors about weightlessness and other problems that man will have in his space travels has led to a new field of study called aerospace medicine. Aerospace is a word that describes all the regions in the atmosphere and outer space. Aeronautics is the science of developing aircraft and spacecraft. Astronautics is the science of space flight.

D. Activities: Have students do the exercises listed under lesson 19 in their activity booklets.

LESSON 20

Problems of Space Travel: Oxygen and Temperature

A. Purpose: To develop an understanding of why oxygen and temperature are problems in space travel.

B. Materials: Two tin cans (juice), some black paint, two thermometers.

C. Procedure:
1. Before starting the lesson, paint one juice can black with black tempera paint or regular enamel paint, leave the other can its silvery color. When the paint has dried, fill each can with cold water.

2. Start the lesson by asking two students to put the thermometers in the cold water, wait a minute or two and record the temperature on the board. Now, have the students set the cans on a radiator, hot plate, or in the sun near a window. Tell the students to check the temperature in about 20 minutes, or intervals of one half hour.

3. Ask the class to recall that in an earlier lesson we learned that a rocket engine carries its own oxygen for burning the fuel.
4. Ask: What do we need to breathe here on earth? (Air-- actually oxygen forms the air.)

5. Ask: What will astronauts or space travelers use to breathe when in space? (Oxygen) Where will they get it? (Carry it with them in tanks like deep-sea divers do.)

6. Say: Scientists are working on an experiment in which the astronauts can carry tanks of algae (al-gae) in their spaceships. These algae growing in sunlight, give off oxygen into the air. They can also be used for food. Explain that scientists are trying other experiments to solve this problem.

7. Ask: What problem do you think we are trying to illustrate with our experiment with the cans and thermometers?

8. Ask: What happens the closer you get to the sun? (It gets hotter.) Does space itself have temperature? (No.) Why? (No atmosphere to reflect the light and heat from the sun.)

9. Ask: Would the side of a spaceship facing the sun be hotter or colder than the side of the ship away from the sun? (Hotter--objects in space absorb energy from the sun.)

10. Ask the two students to record the temperature of the water in the cans. (If enough time has elapsed, you will find that the water in the black can is warmer than in the silver can, but don't tell the class, let them attempt to discover it.)

11. Ask: What can has the warmer water? (Black) Why is this so? (The black can absorbed more heat.)

12. Ask: Suppose that one of the cans was a spaceship, what color might you paint it? Lead the class to the idea that although this is not the final answer, scientists might paint one side of the space ship white or silver and the other black. Then they could roll the ship around to keep temperature constant.

13. Ask: What side should be painted black? (The side away from the sun since a black surface retains heat.)

14. Ask: What side should be painted silver or white? (The side facing the sun, since silver or white would reflect many of the sun's rays and help cool off the ship.)

15. Ask: Does the color of our clothing suggest that we have used this idea. (Yes, Arabs wear in midsummer - 100° - white clothing to reflect the heat. We usually wear lighter, white clothes in the summer. White clothes are worn in hot climates because white is a good reflector and poor absorber of heat.)

16. Summarize the principles of this lesson for the class and have them record these and the experiment in their space notebooks.
a. One of the problems of space travel, is obtaining oxygen necessary for breathing and living in outer space.

b. Another problem of space travel is temperature.

c. Scientists are continually experimenting to develop new ways to solve these problems.

d. A black surface retains (absorbs or keeps) heat while a silver or white surface reflects heat.

D. Activities: Have students do the exercises under lesson 20 in their activity booklets.

LESSON 21

Problems of Space Travel: Meteors and Landing or Re-Entry

A. Purpose: To develop an understanding of how meteors and landing a spaceship can be problems in space travel.

B. Procedure:

1. The next few lessons will be basically discussion, reading, and research. You will deal with more than one problem in this lesson because scientists are still investigating the areas mentioned.

2. Ask: Have you ever looked up at the sky at night and seen a streak of light? (Yes.) What is it? (A shooting star.)

3. Say: That's its common name but what do scientists call it? (Meteor)

4. Ask: What is a meteor called if it lands on earth? (Meteorite)

5. Ask: What happens to meteors (Objects in space made of iron and rock) as they come through the earth's atmosphere? (They are destroyed because of friction and heat as they enter the earth's atmosphere.)

6. Ask: How might meteors be a problem of space flight? (Meteors might collide with spaceships.)

7. Tell the class that although this is a problem, scientists feel that the mathematical chances are good that a collision could be avoided.

8. Ask: If a meteor burns up coming through the earth's atmosphere, what might happen to a spaceship? (It could also burn up.)

9. Ask: Does anyone know how scientists are trying to solve this problem? (They have developed heat resistant shields for the space capsule.) Did Glenn's space capsule burn up? (No.)

10. Ask: How did John Glenn make his capsule come back to earth? (Retro-rockets lowered the speed of the capsule thereby allowing gravity to exert a greater force.)
11. Lead the class to the following conclusions:

a. Retro-rockets on the side of a spaceship can help allow it up and thus reduce speed so that heat and friction will be less than they are on a meteor.
b. The space capsule or ship comes through, enters the atmosphere in ever-tightening circles—"sort of side-ways"—instead of straight down from outer space to the earth. The word used to describe this problem is re-entry.
c. The spaceship used parachutes to bring it to earth slowly.

12. Summarize this lesson for the class:

a. A collision with meteors and landing are two other problems of space travel.
b. A meteor is an object in space made of iron and rock. If they fall to earth, they are called meteorites or "messengers from space."
c. A meteor and a spaceship have the same problem when coming through the earth's atmosphere—their speed and the earth's atmosphere causes heat and friction and thus they can burn up.
d. A spaceship, however, uses retro-rockets to slow it down and thus in coming through the earth's atmosphere at an angle it reduces heat and friction and doesn't burn up. It is also helped by the heat resistant material from which the space capsule is made.

LESSON 22

Problems of Space Travel: Radiation

A. Purpose: To develop an understanding of the problems of radiation in space travel.

B. Procedure:

1. In this lesson give the class the following information and then have them do the activities.

2. Tell the class:

a. The earth is constantly being bombarded by radiation from outer space but the earth's atmosphere shields us from most of the harmful rays. One type of radiation that causes us to get sunburned is called ultraviolet rays. These rays, however, can be stopped easily by opaque (nontransparent - can't see through) materials.
b. Ask: What opaque material would you use to prevent sunburn?
c. Cosmic rays are dangerous to astronauts because they are not protected by the earth's atmosphere. Cosmic rays are strong atomic rays that scientists are studying because they may be a hindrance to space travel.
d. In 1958, one of our Explorer satellites (messengers to space) sent back information about an unknown zone of radiation above the earth that scientists named Van Allen radiation belt after the scientist who discovered it. Artificial satellites are helping scientists gather more information about radiation in outer space.

D. Activities: Have students do the exercises listed under lesson 22 in their activity booklets.

LESSON 23

Problems of Space Travel: Fuel, Speed, and Navigation

A. Purpose: To develop an understanding of fuel, speed, and navigation as problems in space travel.

B. Procedure:
   1. Ask: Do you recall that when we were discussing rockets we said that rockets today usually have three stages? (Yes.) Why do you think scientists use three stage rockets? (To attain greater height and speed.)

   2. Tell the class:
      a. The method of using three stages is called the step principle.
      b. In the step principle, one rocket is fired from the nose of another rocket that already has attained considerable height and speed. Put this diagram on the board. Burnout is the point where rocket engines shut down and is jettisoned.

      ![Diagram of three-stage rocket](image)

      second stage firing
      second stage burnout
      first stage burnout
      Earth
      Satellite in orbit
      third stage firing
      third stage burnout

c. Retro-rockets on the sides, front and back of the spaceship will help the ship change direction.

d. Gyroscopes will keep the spaceship on course.

C. Activities: Have students do the exercises listed under lesson 23 in their activity booklets.
LESSON 24

Problems of Space Travel: Boredom and Isolation

A. **Purpose:** To develop an understanding of why boredom and isolation are problems of space travel.

B. **Procedure:**
   1. Ask: Have you ever been bored? (Yes) Why: (Nothing interesting to do.)
   2. Ask: Have you ever been completely alone walking up a dark street or in the house alone? (Yes.) How did you feel? (Scared)
   3. Ask: How would you like to be three hundred miles in space, all by yourself, with only a radio?
   4. Ask: Do you think boredom and isolation (being away from everything and everyone) is a problem of space travel? (Yes) Why?
   5. Ask: What do you think scientists can develop for spacemen so they won't get bored or feel isolated?
   6. Tell the class:
      a. Scientists have found that isolation produces profound fatigue. What does this mean? (Astronauts would feel tired all the time and sleep.) How would this bother the astronauts? (Wouldn't be able to do their jobs, might lose their minds, etc.) Scientists are working on ways to overcome this by testing drugs and other procedures.
      b. Scientists think that they can overcome the boredom factor for awhile by providing a full schedule of work, self-study courses, and recreation such as listening to records, playing small pinball machines, etc.

C. **Activities:** Have students do the exercises listed under lesson 24 in their activity booklets.

LESSON 25

Equipment for Space Travel: Spacesuits

A. **Purpose:** To develop an understanding of the clothing man will wear in space.

B. **Procedure:**
   1. In this lesson, the class should gather information—pictures, descriptions, and magazine articles—on space clothing worn by astronauts.
   2. You can begin the lesson by asking the class: Why does an astronaut need a special suit to wear in space? (To protect him from
radiation, heat, etc.)

3. Ask: You have heard that the astronauts wear "pressurized" suits. What does this mean? (The suits control the amount of air pressure on the astronaut's body as well as providing him with cool air and oxygen.)

4. Ask: What would happen to an astronaut if he lost his spacesuit while in orbit outside a space capsule? (He would explode. The pressure inside his body would be greater than the pressure on the outside of his body.)

5. As your class gathers information about spacesuits the following may be of interest to you.

a. Efforts are being made to make the bulky spacesuit more comfortable.

b. The spacesuits are a one piece suit made of two separate garments.

c. The three layer inner garment is made of wool, aluminumized dacron and cotton.

d. The outer garment is made of white dacron sailcloth sometimes coated with aluminum to help reflect the heat.

e. The helmet is made of fiberglass with a plexiglass face plate.

f. The spacesuit will provide oxygen, adequate temperature and also rocket power to push the astronaut through space once he leaves the capsule.

6. Have the students make a bulletin board on space equipment—suits, capsules, space stations.

C. Activities: Have students do the exercises listed under lesson 25 in their activity booklets.

LESSON 26

Equipment for Space Travel: Space Stations.

A. Purpose: To develop an understanding of the use of space stations in space travel.

B. Procedure:

1. Explain the word "brainstorming," again to the students.

2. Have them put their "brainstorming" sheets on their desks.

3. Tell them you want them to think "with the brakes off" in answering the following questions.

4. Have two students record the answers on the blackboard as fast as they can.
5. Ask: In what ways is a space station like a ship afloat in the ocean?

6. Separate the class in four groups. Each group is to "come up" with as many ideas as they can for the following question. Tell them that the group with the greatest number of ideas becomes junior spacemen.

Question: What things would man need on a space station?

7. Now, have each group review their ideas and circle the best ten to record in their space notebooks.

8. For the remainder of the period, have the students read about space stations and/or start their activity sheet.

C. Activities: Have students do the exercises listed under lesson 26 in their activity booklets.

LESSON 27

Equipment for Space Travel: Living in Space

A. Purpose: To develop an understanding of how man is expected to cope with the problems of living in space.

B. Procedures:

1. Ask: What are the things man will need for living in space? (Answers will vary. Basically the following are under investigation by scientists: heat, power, water, air conditioning, cooking, food, sewage disposal.)

2. Ask: How might man get heat when in outer space? (You have discussed this in the lesson on temperature. Heat will probably come from the sun. It may be controlled by the color of the ship's surface.)

3. Ask: How might man get power to operate the various instruments on the space ship? (Electrical energy will be generated through solar batteries from the sun.)

4. Ask: Why is air conditioning necessary? (It will be necessary to circulate the air because it will not move as it does here on earth because of weightlessness.)

5. Ask: If the air isn't circulated or changed what will happen to the people in the spaceship? (They will suffocate. The body inhales oxygen and exhales carbon dioxide. If new oxygen isn't present in the air, the astronauts will suffocate.)

6. Ask: How might man cook in outer space? (Scientists believe that a household pressure cooker will be adequate.)

7. Say: For sewage disposal it may be possible to use chemical
methods to decompose or break down the sewage and then possibly make it available for plant life.

C. **Activities:** Have students do the exercises under lesson 27 in their activity booklet.

**LESSON 28**

**Equipment for Space Travel: Living in Space**

A. **Purpose:** To develop an understanding of how man is expected to cope with the problems of living in space.

B. **Procedures:**

1. Ask: Where will man get water to drink when he is in space? (Scientists believe that the air conditioning system may be able to withdraw water from the air and recondition it for drinking.)

2. Ask: Where will man get food to eat when in space? (After the class has had a chance to discuss this problem, tell them the following facts: (Discuss each)

   a. An **algae called chlorella** may provide an answer to what man will eat in space.
   b. **Algae** is a single-celled green plant that when dehydrated is 50% protein and has valuable minerals and vitamins.
   c. Scientists believe that it will take about 150 pounds of fuel to put one pound of food into space.
   d. Because of weightlessness, food must be compressed or it will float away.
   e. Scientists are working on methods of putting foods and liquids in "tooth-paste like" tubes so that when the tube is squeezed it will go into the astronaut's mouth.

C. **Activities:** Have students do the exercises listed under lesson 28 in their activity booklets.

**LESSON 29**

**The Affect of Artificial Satellites on Our Lives**

A. **Purpose:** To develop an understanding of how artificial satellites affect our lives.

B. **Procedure:**

1. Ask the class: What is an artificial satellite? (A man-made moon or a payload in orbit around the earth.)

2. Ask: What are the names of artificial satellites orbiting the earth today? (Explorer, Tiros, Lunik, Sputnik.)

3. Ask: What do these satellites do for us on earth? (Let the class give their suggestions, then tell them that these satellites help to improve radio-televison communication, predicting weather, record
radiation around the earth, survey cosmic rays, help us chart storm patterns, record meteoric dust, gather information for man before he goes into space, transport animals to outer space so man can study problems of radiation—weightlessness; used by the Navy for navigation purposes, etc.)

4. Ask: Who is ahead in the "space race," Russia or U.S.? (Point out that Russia may have had more spectaculars, but the United States has more satellites in orbit and has more information about outer space. Manned space flight is only one aspect of the United States' program, while in Russia it seems to be the area of concentration.)

5. Discuss with the class briefly: Should the U.S. share its scientific findings about outer space with Russian scientists?

C. Activities: Have students do the exercises listed under lesson 29 in their activity booklets.

LESSON 30

Review of the Unit

A. Purpose: To show how lack of effort hampers creative thinking and to review this unit.

B. Procedure:

1. Say: I'm going to prove to you that you sometimes sell yourself short rather than use your imagination. Some of you would rather say "I don't know" instead of thinking and being imaginative. I'll prove it with this game.

2. Ask: How many like to watch or feed birds? How many could recognize and name ten varieties or kinds of birds? (You'll probably hear groans. Many will say they cannot.)

3. Say: On a sheet of paper list all the kinds of birds you can think of. Don't worry about spelling. Spell them the way they sound. (Wait 3 to 5 minutes.)

4. Ask: How many had ten or more kinds of birds listed?

5. Say: I'm going to list on the board some kinds that you may not have on your list. Copy all the birds from the board onto your list if you don't have them already. Put the following on the board: canary, duck, parakeet, chicken, turkey, owl, crow, eagle, robin, pigeon, blue-jay, woodpecker, ostrich, swan.

6. Say: You see, all of you know these birds and could have named them if you did some thinking. You probably know more about some things than you think you know, but it's easier to say, "I don't know."

7. Say: Now let's see some real thinking for the next question.
8. Ask: Why is a fish in a fishbowl like a man in outer space in a space capsule? (In both cases, man has attempted to duplicate the natural environment that the animal (man or fish) is used to.)

9. Ask: A clam sticks its neck out of the shell, brings it in when near danger and closes his shell. How does this example compare to man living in space? (Man goes out from his shell, the space station to explore, etc., return to shell when in danger or other reasons.)

10. Tell the class that there will be tests within the next week. They can use material in their space notebooks for studying.
Dear Student,

Enjoy these lessons on space and space travel. The activities the teacher will give you for each lesson are designed to help you think. THINKING CAN BE FUN. You have to learn to use your IMAGINATION. Do all the activities. If you fall behind during a lesson, "catch up" by doing the activity over the weekend. SAVE all your papers. Put them in your SPACE NOTEBOOK. They will be collected at the end of your study of space and space travel.

The teacher has for you some "brainstorming" cards that you can use to help you think of more ideas to answer some of the problems in the activities. Use these cards anytime you want to. BRAINSTORMING means to storm the brain with ideas. This card will help you to do just that. REMEMBER: THINK BIG ------ THINK WITH THE BRAKES OFF ------ USE YOUR IMAGINATION ------ DO ALL THE ACTIVITIES ------ SAVE THE ACTIVITIES.
LESSON 1 ACTIVITIES

1. Make a folder with a unique design on it and call it your SPACE NOTEBOOK.

2. THINKING FOR FUN. Use your imagination and think of ideas for the following problems. All ideas count. The more ideas the better.
   On one side of a sheet of lined paper list ideas for this problem:
   1. In what ways could you use a common brick? On the other side of the paper list ideas for this problem:
   2. In what ways could you use a paper cup?

LESSON 2 ACTIVITIES

1. Record the five best suggestions on a sheet of paper and put in your space notebook.

2. Fill in the following chart:

<table>
<thead>
<tr>
<th>Definition by</th>
<th>CLASS</th>
<th>TEACHER</th>
<th>TEXTBOOK</th>
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<tbody>
<tr>
<td>SPACE</td>
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</table>

   WHAT SPACE CONTAINS

3. Going On a Space Trip
   Read some advertisements in newspapers and magazines or listen to ads on radio or television, and then pretend you are the owner of a company that arranges space trips.

   On the back of this paper, write some ads that you can use to tell the public about service. Draw pictures if you want to. Remember! be imaginative - the more ideas, the better. If you need more space, use another sheet of paper but slip it to this one. Don't forget to put your name on it.

LESSON 3 ACTIVITIES

1. Use your imagination in solving the following problem: You are a teacher in grade two. In what ways can you explain to the children why rockets are used for space flight? Remember what you did in class today and add other ideas. Write out your ideas carefully on the back of this paper.

2. What would it be like if we didn't have oxygen for burning? List your answers at the bottom of the paper.
3. Read that part of one of the books in class that deal with rockets. Now, pretend you are a space scientist; answer the following questions on another sheet of paper—clip it to this sheet. Be sure to put your name and lesson on the other paper.

   a. Draw your own plans or pictures of what a rocket looks like!
   b. What names would you give five new rockets?
   c. Why did you give the rockets these names?
   d. How does your rocket work?

4. Thinking to Improve Things? Suppose you were a business man selling steam irons and your company asked you to think up some ideas that would improve the steam iron. You might think up some ideas like these: stretchable cord; lighter in weight; a vacuum that would pick up the lint as you ironed; a non-stickable bottom; a non-heat handle; a water storage tank; a red light to tell you when the water supply is low and so on. See how you can think up ideas to improve things. Now use your imagination to think up ideas to improve a -- television set, rocket, and ice skates. Put this on a separate sheet of paper. Don't forget your name and clip the paper to this sheet.

**LESSON 4 ACTIVITIES**

1. Unusual questions. Use your imagination to think of as many questions as you can about rockets. Remember: No answers, just questions. See how many you can list. The winner (the pupil with the most questions) gets a free trip to the moon. Number each question. Try to think up questions which other people usually do not think about and list these on the back of this paper.

2. In each sentence below you are to think of words that would sound more interesting than the underlined word. After each sentence, write two words to take the place of the underlined word. Each of the two words should mean about the same as the underlined word but sound more interesting.

   1. There is no noise in space. Ex. sound rocket
   2. Space is endless and has no air.
   3. Oxygen is necessary for combustion.
   4. The actual push of a rocket is created because molecules bang against the forward wall of the chamber.
   5. When an object falls it is because of gravity.
   7. The planets move across the sky in orbits around the sun.
   8. Speed helps counteract gravity.
9. Rockets **carry** their own fuel supply. 

10. Retro-rockets **lower** the speed of a spaceship. 

3. In Column I, list ten ways of keeping the friends you now have. In Column II, list ten ways of losing these friends. Which column was easier to do? Why?

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<thead>
<tr>
<th>Column I</th>
<th>Column II</th>
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On another sheet of paper, make the columns as above and list your ideas. Remember **THINK WITH YOUR BRAKES OFF!**

**LESSON 5 ACTIVITIES**

1. **Just Pretend**

   Pretend you are a college professor and must explain to fourth graders how rocket engines work. All you can use to explain how they work is a balloon, a blackboard, and a piece of chalk. Now tell us what you would do.

2. List as many ideas as you can for using empty cereal boxes. Do this on the back of this paper.

3. Read a section of a book to complete the following sentences:
   a. Rockets are: 
   b. Rocket engines work: 
   c. Rockets are used because: 
   d. The actual push of a rocket is caused by:
LESSON 6 ACTIVITIES

1. THINKING FOR FUN

List all the animals that might not be found in a zoo on the back of this paper.

2. Fill in the following blanks connecting the first word and the last word with words that are associated with the one before it.

Example: red

- sunset
- weather
- cold
- lemonade.

a. gravity
b. altitude
c. teacher
d. speed
e. airplane

work.
distance.
book.
vegetables.
lungs.

3. From the following numbers, list the synonyms (words that mean the same as the numbers), uses, and things associated with it.

4
3
2
1

Example:

- four
- three
- two
- one
- quartet
- trio
- duet
- single

After you have finished, ask the teacher for the answers.

LESSON 7 ACTIVITIES

1. On the back of this paper make four columns as shown below. In Column I are words you have used in these lessons. Copy these on the back leaving space between each word. In Column II write the meaning of each word. In Column III use each word in a sentence. In Column IV sketch or draw a picture to represent each word.

COLUMN I: thrust, gravity, jettison, payload, astronauts.
COLUMN II: write the meaning of each word.
COLUMN III: use each word in a sentence.
COLUMN IV: draw a picture to represent each word.
2. DO YOU HAVE YOUR THINKING CAPS ON?

Be imaginative with this exercise. This is a game in which you are to list as many things wrong with each of the following. Remember -- be imaginative. THINK WITH YOUR BRAKES OFF.

rocket:

telephone:

space travel:

vacations:

3. Try to list as many "space words" as you can that

a. begin with a

b. end with t

If you get more than twenty, you are in orbit around the earth.

LESSON 8 ACTIVITIES

1. Which of the five letters is the first letter of a word that is associated with both words but has a different meaning in relation to each word? Circle the letter. In the blank in the last column write the word. Ask the teacher for the answers after you have finished.

<table>
<thead>
<tr>
<th>Example</th>
<th>a</th>
<th>b</th>
<th>g</th>
<th>m</th>
<th>s</th>
<th>dog</th>
<th>brake</th>
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</thead>
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<tr>
<td>a. orange</td>
<td>a</td>
<td>p</td>
<td>q</td>
<td>c</td>
<td>s</td>
<td>fruit</td>
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<tr>
<td>b. measure</td>
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<td>body</td>
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<tr>
<td>c. season</td>
<td>f</td>
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<td>a</td>
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<td>l</td>
<td>accident</td>
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<td>d. clothes</td>
<td>s</td>
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<td>n</td>
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<td>paint</td>
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<td>e. flower</td>
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<td>g. earth</td>
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<td>v</td>
<td>l</td>
<td>electricity</td>
<td></td>
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<tr>
<td>h. smoke</td>
<td>w</td>
<td>p</td>
<td>g</td>
<td>o</td>
<td>e</td>
<td>tube</td>
<td></td>
</tr>
</tbody>
</table>
1. change  a s l p q  plug
j. candle  m o a n s  glue

2. Make as many letters as you can from the following marks:
   a. |||  Example H
   b. ||  Example T
   c. C  Example d

3. **Space Detectives:** Unscramble the following words to learn some of the major ideas about space travel. Write the complete sentence in the spaces below.
   a. atmosphere beyond the space relative is unknown the.
   b. endless and space air is no has.
   c. oxygen need no planes rockets as do.
   d. burning necessary is for oxygen.
   e. a is pulls gravity earth which toward matter any the.

**LESSON 9 ACTIVITIES**

1. Fill in the blanks for the **TELL ME GAME.** **TELL ME A WORD** that describes:
   a. the path of a satellite ____________.
   b. a force pulling toward the earth ____________.
   c. a force that helps to counteract gravity ____________.
   d. a force causing object moving in a circular path to move away from the center of the earth ____________.
   e. the useful cargo of a space shot ____________.
   f. a man-made moon or a planet ____________.

2. What would happen if the force of gravity stopped working on our planet? Paul your ideas on the back of this paper.

3. **PRETEND** that the only words you can use about today's lesson are: bowl, marble, gravity, centrifugal force, orbit, satellite, speed, balance. **USE YOUR IMAGINATION** and write out today's experiment using only these words. The question is: **HOW DOES A SATELLITE KEEP FROM FALLING BACK TO EARTH?** Hint: Use sketches. Do it on another paper--don't forget your name.
LESSON 10 ACTIVITIES

1. From the following two letters, try to list all the planets.
   U example: Venus  A example: Mars

2. IMAGINATION: ALICE or PETER IN PLANETLAND. Write a story about Alice or Peter in Planetland. In your story, you must include answers to the following questions:
   a. How do planets and stars differ?
   b. State a fact about each planet.
   c. Use these words: revolve, orbit, astronomer, rotation, astronaut, eclipse.
      Write this story on a sheet of lined paper. Put your name on it and clip it to this sheet.

3. PRETEND THAT YOU LIVE ON MARS or some other planet. Send a letter to a friend of yours here on earth, telling about your life on that planet.
   a. Write a letter in correct form on a sheet of lined paper.
      Clip it to this sheet.
   b. Look up some facts about living on another planet before writing the letter. Tell about the weather, weight, games, and so on.

4. List all the uses you can think of for OLD LIGHT BULBS. Use your imagination. Think Big. Think Wild. Put your ideas on the back of this paper. The more ideas the better. Silly ideas count.

LESSON 11 ACTIVITIES

1. CODED MESSAGES: Rearrange the words in these sentences. Rearrange the letters in c-d.
   a. balance in are force centrifugal and gravity because orbit in stays satellite a.
   b. centrifugal earth force the is from a outward force that pushes.
   c. depes si eny ayw et atencwotre ygtriav.
   d. ftlacneirug acro sword lal sights yawa merf hte tceren fo hestar.

2. STRETCHING YOUR IMAGINATION: Most people wouldn't know what to do with an old space capsule. Suppose the National Aviation and Space Administration (NASA) from Washington decided to give you John Glenn's old space capsule. On a sheet of paper titled Uses for a Space Capsule, list all the uses you can think of. Write your name on the sheet and clip it to the paper. Score yourself:
If you Get:  
5-10 uses — you're On The Ground  
11-15 uses — you're Flying Low  
16-20 uses — you're Getting Space Bound  
21-25 uses — you're Almost In Space  
26-30 uses — you're In Space  
31-35 uses — you're Moon Prone

LESSON 12 ACTIVITIES

1. From today's demonstration explain what would happen if you swung a paint can with an inch of water in it, around with your arm, so that in the swing, the paint can was upside down (almost over your head). Put your answer on the back of this sheet.

2. Can you "crack" this code for the U.S. Information Center?  

   a. 1-19  7-8-1-22-9-20-25  4-5-3-18-5-1-19-5-19  
        3-5-14-20-18-9-6-21-7-1-12  
        6-15-18-3-5  9-14-3-18-5-1-19-5-19
   b. 9-16-1-3-5  9-19  2-12-1-3-11  
        2-5-3-1-21-19-5  20-8-5-18-5-  
        20-15-8-20  18-5-6-12-5-3-20  
        12-9-7-8-20

LESSON 13 ACTIVITIES

1. Write ten or more song titles about space travel. Ex. You Are My Moonshine -- I Get Weightless Over You. Put these on another sheet of paper. Don't forget your name and clip it to this sheet.

2. Describe an idea for a television program on space travel. Write your ideas on another sheet of paper.

3. List as many uses that you can for an umbrella. Be imaginative. List your ideas on another sheet of paper.

4. Write a jingle about each of these words. Write these jingles on another sheet of paper: rockets, combustion, oxygen.

   Example: Rocket high, rockets low;  
   They make noise, wherever they go;  
   Flying in air, Flying in space;  
   Pushing man to an unknown place.

   Be sure to staple all the paper to this sheet.

LESSON 14 ACTIVITIES

1. Using only the words satellite, path, apogee, perigee, ellipse, explain in any way you want to what you learned from today's lesson.
(HINT: Use sketches) Put your answers on the back of this sheet.

2. WORD GAME: TELL ME! To play this game all you have to do is fill in the correct word.

Tell me a word that describes:

a. The path of a satellite __________.

b. The power of a rocket __________.

c. The way satellites go around the earth __________.

d. When the moon is closest to the earth __________.

e. When a satellite is farthest from the earth __________.

f. A smaller object circling around a bigger object __________.

g. The gas necessary for burning __________.

h. The pull of any object toward the earth __________.

i. The object scientists try to put in orbit __________.

j. The dropping of the stages of a rocket __________.

NO ACTIVITIES FOR LESSONS 15 and 16.

LESSON 17 ACTIVITIES

1. Pretend you are in a space capsule in orbit around the earth. On another sheet of paper, write a short newspaper article telling of two of your major problems.

2. If people lived on other planets, list all the things you could tell them about the earth. However, in this list you can only use nouns. Example: car, school, church, etc. Put these on the back of this paper.

3. WHAT DO YOU THINK? When you hear or read about the words or phrases listed below, what do you think they mean? Do this by yourself—do not get help from your teacher or anyone else.

Cold War
Space Race
Medicare
Population Explosion
Inertia
Step Principle

Count-down

4. List below all the nouns you can think of that use fuel and develop speed. If your score is 5-10 slow poke; 11-16 trotter; 17-22 galloped; 23-28 jet; 29-34 rocket; 35 lightning.

LESSON 18 ACTIVITIES

1. In the following activity you are given the beginning and the end of a story. It is your job to fill in the middle of the story which will lead logically to the conclusion. If you have any trouble with words, use a dictionary or science book to help you.

   Beginning: I would like to demonstrate an experiment which will help you understand why acceleration is a problem in space travel. To do this, I am going to use some words that may be new to you. These words are acceleration, inertia, g-force, and weightlessness. I am also going to use this box, paper, cup, brick, and strong.

   Middle:

   Conclusion: From this experiment I hope you understand that acceleration causes pressures on an astronaut's body which is referred to as g-force. The law of inertia, that is, an object in motion tends to stay in motion or an object at rest tends to stay at rest unless acted upon by other forces--was a basic principle in this demonstration.

   2. You have heard of definitions--the telling of what words mean. But have you heard of "sketchinitions"--the sketching or drawing the meaning of words? Make "sketchinitions" for the following words on drawing paper. If you need help, use a dictionary or science book. ellipse, orbit, apogee, perigee, acceleration, g-force, inertia. Clip the drawing paper to this sheet.

   3. Have you ever heard of anagrams? Anagrams is a game in which new words are made by rearranging the letters of another word. Example: from GENERATION, we can get words like nation, rate, near, gone, and so on. Try it with the following word, it's fun! The word is situation.

LESSON 19 ACTIVITIES

1. You know that weightlessness is a problem that man will have to solve if he hopes to live in outer space.

   a. List five important points or facts about weightlessness.
b. What ways could you suggest that would help spacemen solve this problem. THINK BIG. Put your ideas on the back of this paper.

2. On drawing paper, make SKETCHINITIONS for each of the following problems of space travel.

WEIGHTLESSNESS  TEMPERATURE  ACCELERATION

3. List six ways you might use a bicycle inside your home.

4. List six ideas which might make your classroom a more pleasant and efficient place to learn.

LESSON 20 ACTIVITIES

1. Write as many things as you can think of that use air. List these ideas on the back of this paper. THINK BIG.

2. We understand our world by thinking in terms of relationships. Words help us define and explain these relationships. For example, you just learned that there is a relationship between temperature and color.

   a. Do you think you could explain this relationship? On another sheet of paper try it. Don't forget to put your name on the paper, REMEMBER, you are going to explain the relationship between color and temperature.

   b. THINKING ABOUT RELATIONSHIPS. There are other relationships that will help you understand the world in which you live. For example, the word "smoke" might suggest the following relationships: smoke...fire...heat...warmth...home...family...brothers...and so on. HOW MANY RELATIONSHIPS CAN YOU THINK OF FROM THESE TEN WORDS? Put them on another sheet of paper.


3. Try to complete these four-word sentences making sure that each one makes sense and is a complete sentence. Do not use the same word more than once.

   a. G_________ m_________ a_________ r_________.
   b. G_________ m_________ a_________ r_________.
   c. G_________ m_________ a_________ r_________.
   d. G_________ m_________ a_________ r_________.

4. List ten ideas that would help you become rich.

LESSON 21 ACTIVITIES

1. List five facts about the problem of "re-entry" that you find in science books or the encyclopedia and then answer the following question. What would happen if there was no atmosphere?

2. Read the following story carefully. After you have read it, write as many titles for the story that you can think of.

   The spaceman used his retro-rockets to start his space capsule into the re-entry phase of his space flight. As he started to enter the earth's atmosphere, he noticed that the retro-rockets were not slowing up the space craft enough. At this speed, the friction and heat would cause his space capsule to become red hot and burn. He radioed earth for help but there was nothing that could be done. With each passing second, the temperature inside the space capsule became hotter and hotter. The scientists on earth kept talking to him, telling him to keep trying to fire the retro-rockets. Suddenly, the radio communication stopped. Everything was silent. The scientists on earth heard nothing over the radios.

   Titles:

3. Write four line rhymes about the following: meteors, satellite, re-entry, friction. Example: friction.

   With a rub, rub, rub,
   And a tear, tear, tear;
   Friction causes
   Heat and wear.

LESSON 22 ACTIVITIES

1. List all the things you can think of that are good, then list those things that are dangerous, then those things that are sad. Do this on the back of this paper.
2. The earth's atmosphere acts as the earth's space suit, shielding it from harmful radiation.
   
a. How are artificial satellites helping to solve problems of radiation?
   b. In what ways might scientists protect astronauts from harmful radiation?
   Put your ideas on a sheet of paper and clip to lesson 22.

3. List all the things from outer space that might make unusual birthday presents. Ex. a shooting star, a sun beam, Van Allen belt, etc.

**LESSON 23 ACTIVITIES**

1. a. What would you make solid so that it would last longer?
   b. What would you make larger so that it would be more exciting?

2. In what ways could we use the step principle here on earth? Put your ideas for these activities on another sheet of paper. Don't forget your name, activity number, and so forth.


4. Complete the following phrases by using three or more complete comparisons. Put on other sheet and clip it to this sheet. Example: a. as loud as: a jet, a rocket, spectators at a football game.
   
b. as mean as:  
c. as peaceful as:  
d. as fast as:  
e. as slippery as:  
f. as tall as:  
g. as quiet as:  
h. as pretty as:  
i. as sticky as:  
j. as sleepy as:  

**LESSON 24 ACTIVITIES**

1. List all the ideas that you can think of that describe how you feel when you are bored. Ex. Nothing to do, weary, sleepy, dull.

2. List all the things you might do if you were isolated in your bedroom because you didn't do an errand for your mother. Ex. Read, look out the window, count dots on the wallpaper, etc.

3. Pocketful of Miracles

   Let's imagine you are in a space ship and have nothing to do. You remember that in one of the big pockets of your space ship, the
scientists put in a bunch of assorted articles. Sorting through the pocket, you find these items: 2 magnets, 1 spool of thread, 1 paper cup, 2 glass cups, 2 tin cans, 1 brick, 1 piece of string, 2 birthday candles, 1 balloon, 2 bolts, 1 box of matches.

What things could you make? How would you make them? Put these two questions on a sheet of lined paper and use your imagination.

LESSON 25 ACTIVITIES

1. Outline a plan for improving space suits that astronauts wear. Do this on another sheet of paper. To do this, you have to know about the space suits now in use and then use your imagination to improve them. Use science books or encyclopedias to help you.

2. PRETEND YOU ARE A SALESMAN for a company that makes men's suits. You are asked to SELL A SPACE SUIT to a few men even though they don't need it here on earth. WHAT IDEAS CAN YOU THINK OF THAT WOULD HELP YOU SELL THE SPACE SUIT? Put your ideas on the back of this paper. Example: It is colorful. It has a helmet for cold weather, etc.

3. You know that the words SUN and SON sound alike but have different meanings. Use the following words in a space story.

   Title the story: THE ADVENTURES OF FRED SPACESHOT

   pale-pail; no-know; hear-here; weight-wait; tale-tail; son-sun; won-one; blue-blew; loan-lone; break-brake; through-threw.

4. Cut out three cartoons from the newspaper, paste them on a sheet of paper and write under each cartoon a humorous statement.

LESSON 26 ACTIVITIES

1. Pretend you have lived on a space station for about two months. Write a letter to the students in your class telling all about the station on which you live. Write the letter in correct form. Use reference books to help you.

2. Suppose you were one of the first persons to land on the planet Mars and you saw some fantastic animals. Make a sketch of one of these animals and write a story about it that you would send back to earth with the sketch.
3. Complete the following quotations or sayings with any idea that you think will make the saying serious or humorous.

a. To err is human, to forgive ____________________________

b. Say it with ____________________________

c. It's what's up front that ____________________________

d. Don't do tomorrow ____________________________

e. It is better to be safe than ____________________________

f. It never rains but it ____________________________

g. Don't give up the ____________________________

h. Do as we say, and not as ____________________________

i. ____________________________ tastes good like a ____________________________

j. You're in good hands with ____________________________

k. ____________________________ are for kids.

l. ____________________________ the harder they fall.

m. Silence is ____________________________

LESSON 27 ACTIVITIES

1. List some inventions that would be helpful to man living in outer space. List below.

2. In what ways are the astronauts like explorers such as Columbus and Magellan? Put your ideas below.
3. By adding lines to the incomplete figures on this page you can sketch some interesting object or pictures that have to do with space or space travel. Try to make it tall as complete and as interesting a story as you can by adding to and building up your first idea. Make an interesting title for each drawing and write it at the bottom of the block.
LESSON 28 ACTIVITIES

1. What would happen if pills were developed as a substitute for food? Put your answers on the back of the sheet.

2. Use reference books to help you answer the following questions:
   a. In what ways will food be prepared for spacemen? What suggestions do you have?
   b. Why might algae be a useful plant in outer space? Answer on back of this sheet.

3. What things would you make go sideways in order to improve them? Example: car - to get in and out of parking spaces. Put these on another sheet of paper.

4. What foods would you make different so that they would taste better? How would you make them different? Example: spinach - candy-spinach peppermints. Put your ideas on another sheet of paper.

LESSON 29 ACTIVITIES

1. In what ways do artificial satellites help space scientists?

2. Arrange the following words in an order so that you would describe a complete space shot from the beginning to the end.

   parachute, g-force, first stage, jettisoned, recovery, orbit, second stage jettisoned, blast-off, touchdown, count-down, third stage jettisoned, elliptical, re-entry, acceleration, weightlessness, retro-rockets, friction and heat.

3. Draw or sketch the complete space shot that you arranged in example two.
LESSON 30 ACTIVITIES

1. You are a television announcer for WSGC-TV. You are going to interview three astronauts who have just returned from a trip to Mars. List as many questions as you can think of that people would be interested in hearing answers to. Put these questions on the back.

2. The following list of things that you might find around the house can be used as aids in helping to explain certain concepts about space flight. Tell what each item is an example of and what scientific principle it illustrates. Use reference books or your space notebooks to help you.

   a. Balloon:
   b. Spool, thread, weights:
   c. Candles and glasses:
   d. Tin cans and thermometers:

3. Alphabet Game. Below is the alphabet. Before each letter there is a number which indicates the number of space words that we have used that begin with that letter. See if you can win. Example: B - blast-off, boredom.

6--A
2--B
6--C
1--D
1--E
3--F
2--G
1--H
3--I
2--J
0--K
1--L
4--M
2--N
2--O
4--P
0--Q
5--R
6--S
3--T
1--U
1--V
1--W
0--X
0--Y
0--Z
APPENDIX C
The lesson plans prepared for the traditional group were the same as the experimental group except for lessons 1, 2, 26, and 30. Thus, lesson plans for 1, 2, 26, and 30 are included in this appendix.

The traditional group used traditional exercises which differed from the creative exercises used by the experimental group. These exercises are included in this appendix.

LESSON 1

Space and Space Travel: Introduction

A. Purpose: To initiate an interest in space science and the problems man may encounter in his space travels.

B. Procedure:
   1. Discuss with class some of the current space news.
   2. Ask: How is space travel like the pioneers of Columbus' day?
   3. Ask: Why does man want to go into space? (One authority said, "Just because it's there.")
   4. Allow the students time for a free discussion on space travel. Have two students record the questions students would like answered during this study.

C. Activities: Have students do the exercises under lesson 1 in their activity booklets.

LESSON 2

What is space?

A. Purpose: To develop an understanding of what space is and what it contains.

B. Procedure:
   1. Ask: What is space? After class has discussed the possible answers to this question, lead them to the concept that space is the relative unknown beyond the atmosphere.
   2. Ask: What does space contain? What's in space? (Earth and other planets, sun, other universes, meteors, meteorites, stars, etc.)
   3. Discuss the statement: Space is endless and has no air.
4. Discuss: Is there life in space? (Some scientists think that life may exist in other universes but only plant life seems possible on planets in our universe.)

C. Activities: Have students do the exercises under lesson 25 in their activity booklets.

LESSON 26

Equipment for Space Travel: Space Stations

A. Purpose: To develop an understanding of the use of space stations in space travel.

B. Procedure:

1. Ask: What are space stations? (Space stations are artificial satellites that will orbit around the earth.)

2. Ask: What will they be used for? (Such stations, or platforms, will be used as a step-off point on a flight into outer space. They will serve as quarters where astronauts will live and work on space missions.)

3. Have the class start the "activities" section.

C. Activities: Have students do the exercises under lesson 26 of their activity booklets.

LESSON 30

Review of the Unit

A. Purpose: To review the major concept of space and space travel as developed in these lessons.

B. Procedure:

1. Say: As a review of this entire unit we are going to take a space trip of our own. Pretend that this classroom is a space capsule sitting on top of an Atlas rocket.

2. Ask: How do we get ready for our trip? (Space equipment checked out, spacesuits on, walk to rocket, ride up elevator to platform, enter space capsule, check instruments, wait for count-down.)

3. What is count-down? (Inverse numerical order used to designate time before rocket engines are started.)

4. Have a student start count-down.

5. Ask: When rocket engines start what happens? (Rocket leaves launching pad and starts to ascend.)

6. Ask: As we start to go up how do we feel? (Generally, excited, g-force begins, body is tense, very alert.)
7. Ask: What happens to the rocket as we get higher and higher? (Stages are jettisoned.)

8. Tell the class it is now twenty minutes after launch time.

9. Ask: Where are we now? (In space, orbiting around the earth.)

10. Ask: What are we experiencing for the first time since we left earth? (Weightlessness)

11. What is weightlessness?

12. Ask: How do we feel? How can we eat and drink? What would happen if we tried to drink a glass of water as we do on earth?

13. Ask: We are now in that part of the orbit where we will be closest to the earth. What scientific word can we use to describe this? (Perigee)

14. Say: We now want to start our landing procedure.

15. Ask: What do we do first? (Fire retro-rockets to slow up space capsule.)

16. Ask: What happens next? (Space capsule starts to enter atmosphere. Is slowed further by air molecules, capsule's "skin" starts to get hot because of friction.)

17. Ask: What happens when we are about twenty to thirty thousand feet in the air? (Parachute opens--we start to float toward the ocean.)

18. Ask: What happens as we hit the water? (The Navy begins the recovery process. Helicopters and planes begin their search.)

19. Ask: When they find us, what happens? (Helicopters drop divers who hitch space capsule to hooks from helicopter. We ride on this "hook-up" to get aircraft carrier where the capsule is open and we get out.)

20. Tell the class that there will be tests sometime within the next week. They can use the material in their space notebooks for studying. All space notebooks will be collected and graded.

C. Activities: Have students do the exercises under lesson 30 in their activity booklets.
LESSON 1

C. Activities:
   1. Have students "thumb" through books and magazines looking for
      material to use for the study.

   2. Have students make a folder with a unique design on it for
      their space notebooks. If time doesn't permit, have them finish the
      notebook at home for tomorrow's lesson.

LESSON 2

C. Activities:
   1. Have the class copy in their notebooks how various texts define
      the word space.

   2. Ask the students to bring in newspaper articles about space
      and put them in their notebooks.

   3. Make a bulletin board on space travel.

LESSON 3

D. Activities:
   1. Record in your space notebooks the experiment demonstrated in
      this lesson. Use the following outline:

      a. Materials used:
      b. What we did:
      c. What happened:
      d. What we proved:

   2. Tell the students to read, in one of the books available, about
      rockets and how they work. Ask them to record, in their space note-
      books, any information that they feel important.

   3. Draw a rocket and put it in your space notebook. Explain how
      it works.

LESSON 4

D. Activities:
   1. In your space notebook, diagram and explain in your own words
      how a rocket engine works.

   2. Cut out some pictures of rockets, launching pads, etc.

   3. List in your notebook any new words that you find in the maga-
      zines from which you cut out the pictures. Look up the meanings of
      these words and record in your notebook.
LESSON 5

D. **Activities:**
   1. Read about how rockets work. Summarize in three or four sentences what you have read.
   
      2. In your own words tell how the teacher explained how rocket engines work.
   
      3. How is a balloon like a rocket?

LESSON 6

C. **Activities:**
   1. What is gravity?
   
      2. Give an example to prove that gravity exists.
   
      3. What is meant by the word **thrust**?
      4. Why does a rocket's speed increase?
   
      5. As a rocket goes up, what happens to the gravitational pull on the rocket?

LESSON 7

C. **Activities:**
   1. Have each student draw a rocket showing its three stages and what happens in flight.
   
      2. Have students read more about rockets from various texts.
   
      3. Have the entire class find the meanings to the following "space" words: thrust, gravity, jettison, pay-load, rocket-stage, combustion, astronautics.

LESSON 8

C. **Activities:**
   1. Have the class investigate some of the man-made satellites that have orbited the earth.
   
      2. Have each student cut out pictures from magazines and newspapers about satellites and tell what they do for man.
   
      3. Write a short story about how it would feel being on a satellite in space by yourself.

LESSON 9

E. **Activities:**
   1. Record in your space notebooks the experiment demonstrated in
this lesson. Use the following outline:

a. Material used;
b. What we did;
c. What happened;
d. What we proved;

2. Define the following words: gravity, satellite, centrifugal force, payload, orbit.

3. Answer this question: How does a satellite keep from falling back to earth?

LESSON 10

C. Activities: The Sun and the Planets

1. Fill in the blanks:

The earth revolves around the ______. The planets revolve around the ______. The stars are not part of the ______. The brightest planet is ______. All planets receive their light from the ______, and because they all ______, they have day and night. The planets nearest the sun have the shortest ______ and the longest ______. The planets ______ the sun receive the most ______.

2. Match the following by copying the sentences below.

1. Mars A. is the largest planet.
2. Jupiter B. is the planet nearest the sun.
3. Mercury C. is the planet farthest from the sun.
4. Pluto D. is nearly the same size as the earth.
5. Neptune E. is the planet with rings.
6. Saturn F. may have oxygen in its atmosphere.
7. Uranus G. is the dimmest planet visible without a telescope.
8. Venus H. was discovered by mathematical calculation.

3. Find meaning and put in notebook: orbit, eclipse, comet, revolution, rotation, meteor, astronomer, gravitation.

4. Know how to spell these words and the name of the planets.

5. State two ways in which planets are different from stars. In what form are all the materials in the sun? Why?

LESSON 11

E. Activities:

1. Fill in the blanks in the following statements.

a. ______ is one way to counteract gravity.
b. ______ sets up another force called ______.
c. A ______ is a body or object circling a larger one.
d. The ______ is a satellite of the earth.
e. ______ makes it difficult to leave the earth and go to outer space.

2. Complete the following sentences:
   a. In today's lesson we tried to understand ______________.
   b. To understand this, we used ______________.
   c. We concluded that ______________.

LESSON 12

E. Activities:
   1. Answer the following questions:
      a. What was today's lesson about?
      b. What did the demonstration prove?
      c. What materials did we use?
      d. What were the conclusions?

2. Define: gravity, centrifugal force, orbit, satellite.

3. Use each of the words you defined in a sentence.

LESSON 13

C. Activities: Have students do the exercises listed under lesson 13 in their activity booklets.

LESSON 14

D. Activities:
   1. Fill in the following diagram with words for each number and define the words numbered 2, 4, 5, 6.

   1. earth
   2. satellite
   3. path of a satellite
   4. ellipse
   5. apogee
   6. perigee

2. What is the difference between the words eclipse and ellipse?

LESSON 15

C. Activities:
   1. There will be a quiz during the next lesson (tomorrow), so review material in your space notebooks.

LESSON 16

C. Activities:
   Have all students continue their reading on space and space travel
and bring their space notebooks up to date. This would be a good time to check on the notebooks to assure that all pupils have completed the assignments.

LESSON 17

C. Activities:
1. Read about these problems in a science book or find newspaper articles on as many of the problems as you can.

2. Know the definitions of each of the words that tells about a problem of space travel.

LESSON 18

D. Activities:
1. Record in your space notebooks the experiment we did today. Use the following as a guide:
   
   a. Material used:
   b. What we did:
   c. What happened:
   d. What we proved:

2. Define the following words: acceleration, inertia, g-force, weightlessness.

3. Read various books to find out how they explain acceleration as a problem of space travel.

LESSON 19

D. Activities:
1. What is meant by the following words: aerospace, aeronautics, astronautics.


3. What is weightlessness?

4. Why is weightlessness a problem in space travel?

LESSON 20

D. Activities:
1. Answer the following questions:
   
   a. What experiment did we do today?
   b. What did we prove?

2. Why is oxygen a problem in space travel?

3. Why is temperature a problem in space travel?
4. How will algae be used in space flights?

LESSON 21

C. Activities:
Use science books to find answers to the following questions:

1. Why is "re-entry" a problem in space travel?
2. What is a meteor?
3. What are retro-rockets?

LESSON 22

C. Activities:
Find the answers to the following questions from science books or encyclopedia:

1. What is radiation?
2. What are cosmic rays?
3. Why is radiation a problem in space travel?
4. List some interesting facts about radiation in outer space.

LESSON 23

C. Activities:
Use your science books or encyclopedias to answer the following questions:

1. How are gyroscopes used to navigate the space craft?
2. What is the step principle?
3. Define the following words and use them in a sentence: burn-out, booster, stages, jettison.

LESSON 24

C. Activities:
1. Read about boredom and isolation from various science texts and encyclopedias.
2. What does isolation mean? Boredom?
3. Why are these problems of space travel?

LESSON 25

C. Activities:
1. Why do astronauts wear special spacesuits?
2. Read about spacesuits in science books and encyclopedias.

3. What would happen to an astronaut if his spacesuit was damaged while he was in outer space?

LESSON 26

C. Activities:
1. Find the answers to the following questions from reference books:
   a. What are space stations?
   b. What will they be used for?
   c. How will they be put in space?

2. Make a drawing or sketch of a space station.

3. What will astronauts need on a space station in order to live there for about a year?

LESSON 27

C. Activities:
Use reference books to find information about the following:

Heat: How will man keep warm?

Power: How will he get energy to operate the instruments?

Air: What will man do for food and fresh air supply in the space ship?

Cooking: How might man cook his food?

LESSON 28

C. Activities:
1. Use reference books to obtain information on the following problems of living in outer space.

   Water -- Food-Eating and Weightlessness.

2. What is algae?

LESSON 29

C. Activities:
1. Cut out and read articles from the daily newspaper or magazines about the so-called "space race."

2. How might Columbus and his men be compared to astronauts?

3. What is an artificial satellite?

4. How do artificial satellites help space scientists?
C. Activities:
Use your space notebooks and reference books to answer the following questions.

1. What is space?
2. Why are rockets the only engines that can be used in outer space?
3. Make a diagram showing how a rocket engine works.
4. What is gravity?
5. What are satellites?
6. How does a satellite keep from falling back to earth?
7. What are the satellites of the sun?
8. Know the definitions of the words given you in the activities.
Achievement Test
Space and Space Travel Test

Directions for Administering:

To the teacher:

There is no time limit on this test. Please allow sufficient time for all youngsters to complete the test. Electrographic pencils must be used since the test will be machine scored.

Before starting the test, have students fill out the information requested on the answer sheet. Then go over the directions indicated on the answer sheet with the class.

Since the first fifteen items on the test are true or false statements point out clearly that a true statement is to be marked in column one, a false statement in column two. This applies to the first fifteen items. After that, the youngster has four choices. No answers should be marked in column five. Repeat these directions if necessary and answer any questions on procedure before youngsters start the test. Thank you.
Achievement Test

SPACE AND SPACE TRAVEL TEST

Directions: In the following problems, if you believe that a statement is true, fill in the space in column one (1) on the answer sheet. If you believe that the statement is false or incorrect, fill in the space in column two (2) on the answer sheet. Answer all statements or questions.

PROBLEM SITUATION

The year is 2122. You live on earth and you have just received a letter from John Adams who lives on a space station. John, who is a friend of yours, makes the following statements about his life in a space station.

1. People here are almost weightless.
2. Looking out the window of our space station, I can see the cows and horses in the pasture.
3. An airplane loaded with food supplies landed here yesterday.
4. People travel by means of small rockets.
5. From here the earth looks larger than the sun.
6. We saw the man in the moon yesterday.
7. I threw a baseball over half a mile.
8. We were visited by strange people from Jupiter.
9. Our air conditioners, stoves, and refrigerators are run by solar energy.
10. On earth, I weighed 70 pounds but up here I weigh 80 pounds.
11. John Glenn was welcomed by our president yesterday.
12. The stars are made of gases.
13. The distances in our universe are measured in light years.
14. We had an accident yesterday. One of the astronauts, while in outer space, lost his space suit and melted.
15. Our space station came very close to the planet Geras last week.
MULTIPLE CHOICE

Mark the correct answer in the answer sheet by putting an X under the correct number.

1. The earth is a
   1. meteor
   2. planet
   3. star
   4. sun

2. A scale can be used as an example of
   1. inertia
   2. stage
   3. distance
   4. gravity

3. The base or area from which most of our rockets are launched is
   1. Cape Johnson
   2. Cape Horn
   3. Cape Hope
   4. Cape Kennedy

4. Radiation particularly dangerous in space travel is
   1. cosmic rays
   2. ultraviolet rays
   3. alpha rays
   4. delta rays

5. A method using three stages of a rocket to get it into space is described as the
   1. stage principle
   2. booster principle
   3. step principle
   4. counting principle

6. The moon revolving around the earth is an example of a
   1. payload
   2. planet
   3. stage
   4. satellite

7. The earth might be described as a satellite of the
   1. universe
   2. moon
   3. sun
   4. star
8. For a satellite to stay in orbit what two forces must almost balance each other?
   1. gravity and centripetal force
   2. gravity and centrifugal force
   3. gravity and inertia
   4. gravity and satellites

9. If you take a marble, put it in a cup, push the cup and then stop it suddenly, the marble will keep going. This experiment demonstrates the principle of
   1. friction
   2. gravity
   3. speed
   4. inertia

10. The object that man is in when he is sent into space is a
    1. cage
    2. compartment
    3. boattail
    4. capsule

11. The section of a rocket or spacecraft that gives it that extra push at take-off is called a
    1. blast-off
    2. booster
    3. nose cone
    4. pad

12. The procedure for checking each system before a rocket launching using inverse numerical order is called a
    1. mock-up
    2. count-down
    3. check-up
    4. take-off

13. The force which tends to draw all things away from the center of the earth is
    1. centrifugal force
    2. centripetal force
    3. magnetism
    4. gravity

14. The tendency of an object to remain at rest or if moving to remain in motion is called
    1. inertia
    2. resistance
    3. acceleration
    4. force
15. The largest of these planets
   1. Neptune
   2. Mercury
   3. Mars
   4. Jupiter

16. Spacemen will have to solve the problem of
   1. cloud chambers
   2. cosmic rays
   3. comets
   4. short stars

17. The earth revolves around the sun once every
   1. 300 days
   2. 365 days
   3. month
   4. decade

18. Russia sends up bigger rockets and space vehicles because their rockets have greater
   1. thrust
   2. scientists
   3. chambers
   4. propellors

19. Distance in space is measured in
   1. centuries
   2. light years
   3. space years
   4. thousand years

20. A force acting upon an object causes it to move in the direction of the
   1. planets
   2. North Pole
   3. earth
   4. force

21. When you light a match you have to rub it against a rough surface; when doing this you make use of
   1. inertia
   2. momentum
   3. gravity
   4. friction
22. The rate of increase in the speed of an object is called
   1. motion
   2. acceleration
   3. power
   4. momentum

23. The word that means the space between planets or within the region of planets is
   1. interstellar
   2. galaxy
   3. interplanetary
   4. universal

24. One of the most difficult problems facing a man living in space will be
   1. food
   2. boredom
   3. heat
   4. planets

25. A spaceship painted black would
   1. absorb heat
   2. combust
   3. reflect heat
   4. humidify

26. If you wanted to explain the principle of rocketry you might use a
   1. ball
   2. gun
   3. balloon
   4. top

27. A word used to describe the problem of getting a space man back to earth is
   1. re-entry
   2. burning
   3. re-call
   4. friction

28. The point at which a satellite is closest to the earth is called
   1. perigee
   2. pedigree
   3. apogee
   4. umbra
29. The path or orbit of satellites takes the form of an
   1. ellipse
   2. eclipse
   3. circle
   4. square

30. Apogee is the point at which the satellite's position from the earth is
   1. farthest
   2. closest
   3. tracked
   4. on radar

31. Rockets are used for space travel because they can fly without
   1. gas
   2. wings
   3. motors
   4. air

32. The U.S. Government Space Agency has the initials
   1. NASA
   2. NSIA
   3. USSA
   4. AASA

33. An increase in motion of an object by force is called
   1. steering
   2. acceleration
   3. boosters
   4. ellipse

34. The force of gravity, as you go away from the earth
   1. increases
   2. decreases
   3. stays the same
   4. accelerates

35. A rocket used for military (war) purposes is called a
   1. bomb
   2. missile
   3. spy
   4. booster
36. The earth moves around the sun in an
   1. axis
   2. eclipse
   3. hour
   4. orbit

37. An instrument used to measure temperature is a
   1. thermometer
   2. barometer
   3. speedometer
   4. altimeter

38. Of the following types of food, the one that may be used by men in space is
   1. wheat
   2. molds
   3. yeast
   4. algae

39. The first American to orbit the earth was
   1. John Glenn
   2. Virgin Grissom
   3. Alan Shepard
   4. Leroy Cooper

40. The center of the solar system is
   1. earth
   2. sun
   3. Mars
   4. North Star

41. An artificial satellite might be thought of as a
   1. planet
   2. Russian country
   3. a meteor
   4. a man-made moon

42. When a car in which you are riding stops quickly you are thrown forward because of the law of
   1. inertia
   2. gravity
   3. falling bodies
   4. speed
43. To get into space man must use
   1. jets
   2. planes
   3. rockets
   4. wings

44. The push given to a rocket by its engines is called
   1. thrust
   2. blast-off
   3. g-force
   4. burn-out

45. The earth goes around the sun once every
   1. five months
   2. twelve months
   3. sixteen months
   4. month

46. A force which seems to draw all things to the earth is
   1. gravity
   2. centrifugal force
   3. inertia
   4. centripetal force

47. An instrument used to measure how high we go is called a
   1. speedometer
   2. altimeter
   3. thermometer
   4. micrometer

48. The planets go around the
   1. earth
   2. moon
   3. sun
   4. universe

49. A main problem of man's travels is his coming back to the earth through the
   1. meteorites
   2. atmosphere
   3. cosmic rays
   4. gravity

50. The path of a satellite is best described as its
   1. orbit
   2. circle
   3. ellipse
   4. eclipse
51. As we go higher in space the air pressure
   1. stays the same
   2. increases
   3. decreases
   4. gets warmer

52. Of the following, the name that best describes a space traveler is
   1. scientist
   2. astronaut
   3. engineer
   4. voyager

53. In order to reach space, a rocket needs accurate firings of its first, second, and third
   1. stages
   2. flights
   3. jets
   4. payload

Mark on the answer sheet the number describing a scientific principle illustrated by the cartoon.

54.  

55.  

56. rotation
2. centrifugal force
3. acceleration
4. thrust

57. power
2. motion
3. pressure
4. air

58. oxygen
2. temperature
3. acceleration
4. cosmic rays

59. acceleration
2. centrifugal force
3. gravity
4. weightlessness
61. Atomic rays that space scientists believe may be a problem in space travel are
   1. ultraviolet rays
   2. cosmic rays
   3. sun rays
   4. opaque rays

62. A "shooting star" is a name given to a falling
   1. meteor
   2. planet
   3. star
   4. rays

63. The science of space flight is called
   1. astronomy
   2. aeronautics
   3. aerospace
   4. astronautics

64. A man in space will weigh
   1. less
   2. more
   3. the same
   4. twenty pounds

65. If a meteorite is called a "messenger from space," what would be called a messenger to space?
   1. electrolyte
   2. radiosonde
   3. satellite
   4. shooting star

66. When a rocket is getting ready for take-off, it must be placed on a
   1. air base
   2. launching pad
   3. landing platform
   4. aircraft
67. The heat and friction that causes an astronaut's problems when coming back to earth is a result of the earth's

1. atmosphere
2. gravity
3. rotation
4. oceans

68. Space is best described as the

1. place beyond the atmosphere
2. endless universe
3. beyond the blue sky
4. relative unknown without air

69. A rocket's speed increases because the rocket

1. gets a greater push
2. becomes lighter because its fuel is used-up
3. goes into orbit
4. inertia

70. Combustion is another word for

1. oxygen
2. lightning
3. burning
4. friction

71. Air is necessary for

1. combustion
2. propulsion
3. burn-out
4. rocket

72. The stage of a rocket is called the

1. thrust
2. chamber
3. booster
4. payload

73. The steel and concrete support from which a missile or rocket is placed for take-off is a

1. air strip
2. launching pad
3. space building
4. platform
74. If a man is in outer space without a space suit, the lack of air pressure would cause him to

1. faint
2. explode
3. float
4. melt

75. A major problem of getting an object into space is the force needed to overcome

1. gravity
2. friction
3. atmospheric pressure
4. weather

76. The basic principle of rocket motion is best explained by the statement

1. what goes up must come down
2. to every action there is a reaction
3. to every pull there is a push
4. heat causes expansion

77. A space ship coming back to earth would have a problem because the atmosphere would cause it to

1. heat-up
2. freeze
3. use its fuel
4. lose weight

78. The farther an object goes from the earth, the less is its

1. force
2. orbit
3. weight
4. size

79. The point in flight when all fuel is used and the rocket motor stops is called

1. break-out
2. burn-out
3. second stage
4. stall-out

80. The force causing an object to move in a circular path away from the center of rotation is called

1. centrifugal force
2. centripetal force
3. G-force
4. force of friction
81. The force that man will experience when his spaceship takes off is called

1. X-force
2. centripetal force
3. inertia
4. G-force

82. A man living in a spaceship can be compared to a

1. fish in an aquarium
2. dog in a doghouse
3. cat in a dark room
4. monkey in the attic

83. Boredom and isolation might be a problem of space travel because the astronaut would be

1. alone
2. afraid
3. tired
4. working

84. The feeling of not knowing what is up or down or being at zero gravity might be classified as

1. gravity
2. weightlessness
3. inertia
4. aerospace

85. A place in which a group of people can live while orbiting the earth is called a

1. capsule
2. space capsule
3. space station
4. space pad

86. An astronaut wears a spacesuit for many reasons, one of which is that it controls the amount of

1. water vapor
2. rays
3. air pressure
4. gravity

87. Of the many things man must take with him in space flight, the most important probably is

1. food
2. oxygen
3. books
4. weights
88. Because there is no atmosphere to reflect light energy, space is
   1. bright
   2. airless
   3. silent
   4. black

89. The actual push of a rocket is caused by
   1. escaping molecules
   2. molecules banging against the front wall of the combustion chamber
   3. molecules escaping from the opening of the combustion chamber
   4. none of the above reasons

90. Electrical energy to operate the equipment on a space ship will come from the sun through the space ship's
   1. engines
   2. air conditioner
   3. generators
   4. solar batteries
ADMINISTRATION FOR ABBREVIATED FORM VII, MINNESOTA TESTS OF CREATIVE THINKING

General Instructions

Before administering Abbreviated Form VII, every effort should be made to provide as good testing conditions as possible. Make certain that adequate supplies are at hand, that everyone has a pencil and, if desired, crayon, and that the room temperature is as comfortable as possible. Also, try to make the psychological climate as comfortable and as stimulating as possible. Before passing out the test booklets, give the following brief orientation:

"During this next hour we are going to take a test which will help us tell about your ability to think of new ideas and new ways of solving problems. So, put on your best thinking cap and do your very best."

After this, pass out the test booklets. Next, have each pupil fill in the blanks at the top of the page very carefully and put his name in the upper right hand corner of each of the test booklets. Then, read with the pupils the instructions on the cover of the booklet.

After reading directions, if there are no questions, proceed with the first task.

Task 1. Figure Completion.

Read the instructions with me. (Read from test booklet.) Tell the class to go ahead! You have ten minutes.

Although the instructions have indicated that the task includes two pages and instructions are given at the bottom of the page to "Turn to next page," some pupils will not grasp this fact and will ask
about it or have to be reminded. Time the task very carefully.

Task 2. Circles.

Again, read the instructions with me. (Read from test booklet.)
All right go ahead! After ten minutes, call time and continue with

Task 3.


Again, read the instructions with me. (Read from test booklet.)
All right go ahead! You have ten minutes. After ten minutes, call

time.

Task 4. Unusual Uses of Tin Cans.

This is our last problem. Let's read the instructions. (Read
from test booklet.) Go ahead! You have ten minutes. After ten minutes
call time, ask pupils to close their booklets, and collect the booklets.
Be sure students have their names on each page of the test booklet.
ABBREVIATED FORM VII
MINNESOTA TESTS OF CREATIVE THINKING

Name _____________________________ Date __________________

Age _____ Sex _______ Grade or Classification ________________

School ___________________________ City _______________________

What kind of work would you like to do when you complete your education?

The four tasks in this booklet give you a chance to use your imagination to think up ideas. In two of these tasks you will be asked to put your ideas into words. In the other two, you will be asked to think of as many ideas as you can. Try to think of unusual, interesting, and exciting ideas—something no one else in your class will think of.

You will be timed on each of these four tasks, so make good use of your time. Work as fast as you can without rushing. If you run out of ideas before the time is called, wait until instructions are given before going on to the next task.

Do not pay any attention to the rest of this page, but do not turn to the next page until told to do so.

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Bureau of Educational Research

University of Minnesota

August 1962
TASK 1: FIGURE COMPLETION

By adding lines to the figures on this and the next page, you can sketch some interesting objects or pictures. Again, try to think of some picture or object that no one else will think of. Try to make it tell as complete and as interesting a story as you can by adding to and building up your first idea. Make up a title for each of your drawings and write at the bottom of each block next to the number of the figure.

Turn to next page
TASK 2: CIRCLES

In ten minutes see how many objects or pictures you can make from the circles below and on the next page. The circles should be the main part of whatever you make. With pencil or crayon add lines to the circles to complete your picture. You can place marks inside the circles, outside the circles, or both inside and outside the circles—wherever you want to in order to make your picture. Try to think of things that no one else will think of. Make as many different pictures or objects as you can and put as many ideas as you can in each one. Make them tell as complete and as interesting a story as you can. Add names or titles below the objects.
TASK 3: PRODUCT IMPROVEMENT

At the bottom of this page is a sketch of a stuffed toy dog of the kind you can buy in most dime stores for a half dollar to a dollar. It is about six inches long and weighs about three ounces. In the spaces on this page and the next one, list the cleverest, most interesting and unusual ways you can think of for changing this toy dog so that children will have more fun playing with it. Do not worry about how much the change would cost. Think only about what would make it more fun to play with as a toy.

1. 

2. 

3. 

Turn to next page
TASK 4: UNUSUAL USES (Tin Cans)

Most people throw their empty tin cans away, but they have thousands of interesting and unusual uses. In the spaces below and on the next page, list as many of these interesting and unusual uses as you can think of. Do not limit yourself to any one size of can. You may use as many cans as you like. Do not limit yourself to the uses you have seen or heard about; think about as many possible uses as you can.

1. ____________________________

2. ____________________________

3. ____________________________

4. ____________________________

5. ____________________________

6. ____________________________

7. ____________________________

8. ____________________________

9. ____________________________

10. ____________________________

11. ____________________________

12. ____________________________

13. ____________________________

14. ____________________________

15. ____________________________

16. ____________________________

17. ____________________________

18. ____________________________

19. ____________________________

20. ____________________________

21. ____________________________

22. ____________________________
APPENDIX F
### Table 1

**Mean Scores for Sample on the Minnesota Tests of Creative Thinking**

<table>
<thead>
<tr>
<th>Group</th>
<th>Fluency</th>
<th>Flexibility</th>
<th>Originality</th>
<th>Elaboration</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
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<td>29.35</td>
<td>43.41</td>
<td>11.90</td>
</tr>
<tr>
<td>B</td>
<td>45.63</td>
<td>26.03</td>
<td>28.56</td>
<td>9.75</td>
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<tr>
<td>C</td>
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<td>26.63</td>
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### Table 2

**Mean Scores for Sample on the Lorgrs-Thorndike Intelligence Test and the Space Science Achievement Test**

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<th>Space Science Achievement Test</th>
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<tr>
<td>C</td>
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APPENDIX G
### TABLE 1

**Mean Scores for Males and Females on the Minnesota Tests of Creative Thinking for the Experimental Group in Each Ability Level**

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<th>Ability Level</th>
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<th>Elaboration</th>
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<td>28.64</td>
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<td>27.24</td>
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TABLE 2
MEAN SCORES FOR MALES AND FEMALES ON THE LORGE-THORNDIKE INTELLIGENCE TEST AND THE SPACE SCIENCE ACHIEVEMENT TEST FOR THE EXPERIMENTAL GROUP IN EACH ABILITY LEVEL

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## TABLE 4

Mean scores for males and females on the Torndike Intelligence Test and the Space Science Achievement Test for the control group B in each ability level.

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<th>Space Science Achievement Test</th>
</tr>
</thead>
<tbody>
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TABLE 5
MEAN SCORES FOR MALES AND FEMALES ON THE MINNESOTA TESTS
OF CREATIVE THINKING FOR CONTROL GROUP C IN EACH
ABILITY LEVEL

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<th>Originality</th>
<th>Elaboration</th>
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<td>33.00</td>
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### TABLE 6

MEAN SCORES FOR MALES AND FEMALES ON THE LORGE-THORNDIKE INTELLIGENCE TEST AND THE SPACE SCIENCE ACHIEVEMENT TEST FOR CONTROL GROUP C IN EACH ABILITY LEVEL

<table>
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<th>Sex</th>
<th>I.Q. Test</th>
<th>Space Science Achievement Test</th>
</tr>
</thead>
<tbody>
<tr>
<td>High</td>
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<td>95.29</td>
<td>52.00</td>
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<tr>
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<td>48.00</td>
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<td></td>
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