AN ASSESSMENT OF THE DEVELOPMENT OF SELECTED AEROSPACE CONCEPTS IN THE LOWER ELEMENTARY SCHOOL

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> If he is indeed wise he does not bid you enter the house of his wisdom, but rather leads you to the threshold of your own mind.
>
> Kahlil Gibran
> The Prophet

The purpose of this study is to attempt to arrive at some possible alternatives for NASA's Space Science Education Project. Having been involved, either directly or indirectly, for the previous eight years I hope that this research will, in some way, contribute to the future direction and scope of the project. Also, it may somewhat repay for the support that I have received from the project.

The author wishes to express his particular appreciation to his committee chairman, Dr. Kenneth Wiggins, also to committee members Dr. Robert Purvis, Dr. Kenneth St. Clair, and Dr. L. Herbert Bruneau for professional, and more importantly, personal support and guidance during my course of study.

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Finally, I would like to dedicate this to one who has never stopped learning, my father.

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CHAPTER I

INTRODUCTION

Background of the Problem

Each event of great significance initiates a train of important after-effects. Usually, the influences of each of these events are felt slightly at first, then in ever increasing degree with the lapse of time even before the effects of prior events in related fields attain their peaks. An exception to this would be the event of the Soviet Union's launching of the world's first artificial satellite. The effect was immediate and its implications far reaching for education in general, and specifically for science and mathematics curricula. The significance of this accomplishment brought about a sudden awareness that man is on the fringe of another great era of history based upon a scientific and technological revolution of unprecedented proportion. "A revolution that would have an immediate effect upon all manking."[1] Allen also states that, "It must be regarded as the most significant of all those great revolutions of history which have affected the fate of man."[2]

One of the many reactions to this singular event was the creation, by Congress, of the National Aeronautics and Space Administration (NASA) as authorized in the Space Act of 1958. One of the missions of the Act provided that NASA, "make known to the widest extent practicable its activities and the results of those activities."[3] In line with that stated purpose, NASA's Educational Programs Division's activities are directed toward the educational community through the Space Science Education Project (SSEP). SSEP was under the direction of Oklahoma State University from 1969 through 1975. This project, known to many as Spacemobile, provides Space Science Educational Specialists who present authorative space programs to a wide range of audiences, including various professional groups. These Specialists, former experienced teachers, also conduct in-service programs to up-grade teacher competencies along with the development of curriculum supplements and guides of both a general and specific nature.

In the years 1969 through 1974, Space Science Education Specialists have made 45,641 Spacemobile presentations to a total school audience of 10,742,776.[4] (Table XII). Of this presentation total, 9,234 (20.23%) presentations were for elementary schools. Approximately 75% of elementary programming was for the upper-elementary grades. Upper-elementary grades defined as grade four, five, and six. Program totals for each of the years, 1969 through 1974, indicate similar proportions. (Tables V thru X). There are two reasons for these proportions. First, it is an unstated policy of the SSEP that because of constraint factors that Space Science Education Specialists concentrate elementary programming in the upper-elementary grades. Second, many of the Space Science Education Specialists do not have an elementary background needed to deal effectively on a lower-elementary level. Programming and work done on the lower-elementary is an exception rather than the rule.

This research is an attempt by the investigator to formalize informal knowledge gained as a Space Science Education Specialist for SSEP and NASA. More information is needed with respect to the degree and capability to which aerospace concepts can be developed with students in the lower-elementary school so that decisions may be made as to the direction and emphasis of the SSEP.

Statement of the Problem

NASA's Space Science project has been in operation since 1963. During this time, there have been hundreds of upper-elementary presentations given and classrooms visited. Prior to this time , there have been no attempts to formally evaluate possibilities of working with lower elementary students because of program constraints. This investigator, due to his prior experience as a Space Science Education Specialist, has information and experience on an informal basis that there are some possible ways in which to work effectively with students in the lower-elementary grades. This investigator feels that this research may provide formal data of possible alternatives upon which future programming decisions may be made with respect to the lower-elementary grades.

Statement of the Purpose of the Study

The purpose of this study, therefore, is to assess the development and expansion of selected aerospace concepts with students in the lower-elementary grades using a NASA-SSEP school presentation.

The Need for the Study

As previously stated, one provision of the Space Act of 1958 was dissemination of information concerning NASA's activities. NASA officials decided that the educational system of the country was the most effective way in which to disseminate new knowledge gained as a result of its activities. Part of this function is carried out by the SSEP. In order to make effective decisions regarding programs and schedules, the SSEP needs data concerning aerospace concepts and grade levels. The need for this data also concerns the improvement of the program regarding objectives, clientele, methods and techniques of presentations, materials used, and the quality of learning.

The Scope of the Study

This study was concerned with the development and expansion of selected aerospace concepts by means of a

NASA-SSEP school presentation to a select population. The population consisted of only second and third grade students of an elementary school in a central Oklahoma community with a population of thirty-thousand. It is assumed that the subjects in this study were representative of the population. The study was limited because the results cannot be generalized to second and third grade students in other parts of the country and the sample may not be representative of the nation's total second and third grade population. However, there may be inferences drawn which may lead to further study.

It is recognized that the personality of the Space Science Education Specialist is a factor in any type of presentation, therefore, a presentation was scripted and used for this study.

Definition of Terms

Aerospace Concept Inventory (ACI) - the instrument used before and after a SSEP school presentation to gather data on the development of selected aerospace concepts.

NASA - National Aeronautics and Space Administration.

SSEP - Space Science Education Project.

Space Science Education Specialist - a former teacher with at least three years teaching experience who has a specialized training in aerospace science and represents NASA and SSEP.

Upper-elementary - students in grades four, five, and six.

Lower-elementary - students in grades two and three.

Spacemobile - a mobile van equipped with demonstration equipment, space materials, and media equipment operated by a space science education specialist who gives presentations.

FOOTNOTES

[1]James G. Allen, "The Space Age in Perspective," (Chicago, Illinois, 1968).

[2]Ibid, p. 302.

[3]Space Act of 1958 (Washington, D.C., 1958).

[4]"Status of the Space Science Education Project" (Washington, D.C., 1975).

CHAPTER II

SELECTED REVIEW OF LITERATURE

Introduction

The literature reviewed in this chapter is that which the investigator felt was germaine to the area of concept development in general and aerospace concept development specifically, the first section is a brief historical view of the effect that the space age had upon educational systems in the United States. Included in this section are comments relating to various aerospace curriculum projects that evolved. The concluding section reviews concept development from various positions and theoretical frameworks.

Historical View of the Effects of the Space Age Upon Educational Systems

In all areas of life in the United States, changes have reflected the effect of the event of the launching of Sputnik by the Soviet Union. In education the effect on curricula goes from the primary level through college. Public concern and questions were directed to the educational institutions of this country. Federal monies were appropriated to up-grade the competencies of teachers in all areas. New curricula and materials were developed. It was in this period that many of the Alphabet programs, i.e., AAAS, ISCS, SCIS, and others, were developed.

Since the effects of the space age have permeated the educational system, the, ". . . from an educational point of view, teachers and curriculum planners know that adapting elements of the environments to the interest and understanding of the student is sound educational technique. So, ready or not, students are bringing aviation and aerospace into the curriculum."[1]

Since aerospace education can be integrated with all components of the curriculum, plans which integrate aerospace in the curriculum at all levels should be supported. Fishback[2] points out that, "Aerospace education, if viewed as a definite curricula offering can:

1. Make the educational program more realistic and futuristic for the student.
2. Affect the quality of the educational product in a positive manner.
3. Stimulate the spirit of inquiry so essential for continuous growth."

There have been activities which have resulted in curricula guides which integrate aerospace with all subjects, The Lincoln Plan[3] which was developed by the Lincoln, Nebraska school system in cooperation with NASA. It is a program of aerospace orientation for students from kindergarten through grade six. Activities are presented on levels of five years of age through eleven years of age. These activities have come from successful use in the Lincoln

Public Schools, and are correlated with other texts and instructional materials. Divisions of the handbook are based upon the maturity level of children -- not their chronological age.

The Aerospace Curriculum Resource Guide,[4] produced by the Massachusetts Department of Education in cooperation with NASA is another example. This guide was not developed as a new curricula, but only as a resource to serve all grade levels in all subject matter areas. These areas range from language arts to career guidance to teacher education.

Specific areas were helped with resource guides produced for singular areas of consideration such as Biology,[5] Chemistry,[6] Physics,[7] Mathematics,[8] and Indsutrial Arts.[9] In these guides for specific areas, the materials range in difficulty from a Junior High School level of understanding to those that will appeal and challenge the advance student.

Most of the aerospace materials developed were on levels for upper-elementary through college. The notable exceptions are the Lincoln Plan,[10] the Massachusetts Guide,[11] and the Oklahoma Guide.[12] For the most part, little attention has been given to the lower elementary levels in our schools.

Another area of aerospace activities is in-service for teachers on all levels. Miller[13] recommends continued selection of elementary teachers for aerospace workshops with emphasis toward development of aerospace concepts in method courses in undergraduate work. Romero[14] recommends "provision of aerospace in-service education for all educators and emphasis on methodology of teaching aerospace concepts." Sea[15] adds that "programs be developed for the purpose of improving the background and skills of teachers." One important recommendation of Sea's is that "when feasible, an attempt should be made to offer at least a portion of a workshop separately to teachers of kindergarten through grade three, and one for teachers grades four through six." This again points out that little is done in aerospace education with regard to the lower-elementary levels, either directly or indirectly.

Concept Development

Webster's Seventh New Collegiate Dictionary[16] defines a concept as ". . . something conceived in the mind: an abstract idea generalized from particular instances." Gould and Kobb[17] state that, "a concept is a kind of unit in terms of which one thinks: a unit smaller than a judgment, proposition, or theory, but one which necessarily enters into these." George,[18] Viaud,[19] Vinache,[20] Saveth,[21] and Keller[22] are only a few of the many writers who have offered a definition of concept, separate from development of concepts.

There seems to be differences concerning the definitions of concept, the nature of concept, and the development of concept. These differences are reflected in the literature. Martorella[23] lists four problems in dealing with this area of concept and concept development:

1. Similar terminology is used with different, specific meanings in various studies, although the general focus may be similar.
2. Different philosophical assumptions undergrid otherwise similar studies.
3. Some studies focus on the learning of concepts under conditions similar to those which exist in the classroom, while other do not.
4. Some studies classify discriminations between phases of concept learning, while other do not.

Pella[24] not only defines concept, but adds to his definition the characteristics of concept.

1. Concepts are ideas possessed by individuals or groups. They are a type of symbolism.
2. Concepts of any particular object, phenomena, or process exist in a continuum from simple to complex.
3. Concepts emerge as a result of experience with more than one object, phenomenon, or fact. They are generalizations.
4. Concepts are the result of abstract thinking that embraces the many experiences.
5. Concepts involve the relating of facts of supposed facts to each other by the individual.
6. Concepts are not always based upon a physical encounter.
7. Concepts are not inherent in nature or reality.
8. Concepts are not photographic images of reality.

9. Concepts are neither true nor false; they are, rather, adequate or inadequate.
10. Concepts have five primary relationships: relations to people, relations within conceptual systems, and relations to processes.
11. Concepts are useful in making predictions and interpretations.
12. The individual concepts formed in any area may be determined by the sequence of the sensory experiences received or available.
13. The individual concepts formed in any area may be determined by the cultural pattern at the time of formulation. As the culture changes, the meaning and value of a given concept may change.
14. The nature of a concept may be determined by the procedure that led to its formulation.
15. Concepts and conceptual schemes are rendered inadequate as a result of new knowledge and must undergo constant revision.

Platt[25] may be correct when he states, "A simple answer would be nobody knows; or rather, few are willing to advance a precise definition."

Vinache[26] has noted that, one of the greatest weaknesses is the unfortunate tendency to regard words as concepts rather than recognize that a verbal response is merely a label for the internal cognitive system. Ryle[27] has commented on the "frequency with which psychological investigators have erred in assuming that an item exists because it has a name."

Bruner, Goodnow, and Austin[28] devoted their major work to the description of the process by which we discriminate the attributes of things, people, and events, then place them into categories. These studies address themselves to concept formation and concept attainment and identify three types of concepts:

1. Conjunctive--presence of several attributes or characteristics.
2. Disjunctive--members of which share presence or absence of.
3. Relational--concepts in which there is a certain relationship between defining attributes.

Kagan, Moss and Sigel refer to them as:

1. Descriptive
2. Inferential
3. Relational

Hemplel[29] suggests a three-fold distinction among concepts; (1) classificatory concepts are those which divide domains into precise categories, (2) comparative concepts are those that are not numerically specified, and (3) quantitative concepts are those that indicate mathematical relationships.

The rationale for concept formation and concept attainment, according to Bruner and other,[30] is that "In order to cope with the environment, we engage in the process of categorizing, which means we render discriminately different things equivalent . . . respond to them in terms of their class membership rather than their uniqueness." Simply stated, we invent categories. It helps us in three ways.

"1. It reduced the complexity of our environment.

2. It gives us a means by which we identify objects in the word.

3. It reduces the necessity of constant learning."

Concept attainment, according to Bruner, and others,[31] occurs by making decisions about what attributes belong in what categories. Two types of attributes are significant for this concept attainment: (1) defining attributes and (2) critical attributes. A defining attribute is one set by law, by scientific convention, or by a statement of the degree of correlation between the defining attribute and an ultimate criterion. The criteria for the categories are formed by the individual and he decides what attributes are relevant to the categories. The development of the concept attainment model serves three purposes: (1) to teach students about the nature of concepts, (2) to teach students to be more effective in attaining concepts, and (3) to teach specific concapts.

Gagne[32] holds to the view, common among conditioning psychologists, that learning a concept is learning a common response, such as a name, for a class of objects or things. His account of the learning of concepts also appears to follow the operant conditioning strategy of arranging for a correct response to occur and then reinforcing that response. The information that a response is correct may reinforce a student and lead to its repetition.

Gagne[33] also makes a distinction between concept learning and concept attainment as proposed by Bruner and others. While he agrees that concept learning is essentially acquiring a common response to a class of objects, he goes on to refer to the combining of concepts into entities variously referred to as "ideas," "facts," "principles," or "rules." This combining of concepts he calls principle-learning. The reason for this distinction between concept and principle is that they represent two different kinds of "learned capabilities." If it is true that knowing a concept and knowing a principle are two different capabilities, then it may be that the conditions for learning them are also different.

Different conditions are applicable to the learning of concepts and the learning of principles. Two differences are of the greatest importance. First, concepts are prior to principles and, in this sense are simpler than principles. Second, this difference deals with verbal guidance as opposed to pure discovery as a learned method. Learning concepts by discovery appears to be inefficient, given the existence of language. Principles can be learned by discovery.

Woodruff[34] offers a different account of the nature and learning of concepts. He describes concepts as a combination of meaning, feeling, and symbols. Concept learning involves the internal processing of information which reaches us through our senses. This is not learning to make a specific response. It may be described as a reaction. A concept is a combination of meaning, value, and symbols. It is a "construct" made by the brain. Each person has to make his own concepts. The easiest way for developing this construct is through directly perceiving the thing itself. All learning begins with some form of personal contact with actual objects, events, or circumstances in life. Work done by Carroll,[35] Hastings,[36] Johnson,[37] and Serra[38] would lend support to this view.

Piaget's work, although not specifically in the area of concept development, does suggest attainment of certain concepts which occur developmentally. Piaget's view of "accommodation, assimilation," would have bearing on concept development.

Novak[39] points out that "An individual's acquisition of concepts follows a unique course; the specific experiences he has result in apprehension of a concept that may have essentially the same meaning to the individuals, but the experiential pathway used in arriving at this concept can vary appreciably." Work done by Atkin,[40] Butts,[41] and Ervin[42] would add to this view. A model for concept formation must accommodate varying patterns of concept attainment and yet provide for a conceptual product that is similar in different individuals.

Some of the advances in the behavioral sciences and biology have resulted in part from the application of information theory. The early work of Shannon[43] and Wiener[44] has been followed by applications to learning by Miller[45] and others.

In the cybernetic model suggested by Wiener[46] the important role of information input, processing, storage, output, and feedback were indicated. It also differentiates between affective information and cognitive information. There is, according to Olds,[47] some organic basis for this distinction. Also, for this model, problem solving ability could be taken as an index of concept attainment. Descriptions of creative students have been provided by Torrence[48] and others. In the cybernetic model, creativity is defined as the act of moving from one conceptual level to a higher conceptual level without direct instruction as to how to solve more complex problems. One of the problems inherent in this approach lies in the fact that we cannot always conclude when a student makes this conceptual move independently.

Psychologists have for many years carried out studies of concept learning, most of the more recent ones falling within the framework of kind of experimental tasks whose analysis was proposed by Hovland.[49] Stimulus objects or patterns are characterized according to a list of attributes each with a number of values. A concept is then defined by a division of this set into two parts, with the patterns in one part belonging to one group and the remainder to another complement group. Hunt,[50] Hunt and Marin, and Stone,[51] Johnson and Stratton[52] point out that "Most concept experiments require the subject (S) to learn to classify objects by practice with positive and negative instances and to label the positive instances with a nonsense syllable." Carroll[53] has questioned the relevance of such experiments to learning in school, as have others. Still other investigations made use of definitions, incomplete sentences, classification, use of synonyms, or a mixed program.

Along with the various approachss used are other obvious and important factors such as experience, intelligence, and sex. It has been found that providing redundancy helps to insure adequate unit mastery learning. The defining attributes of a concept are learned most readily when the concept is encountered in a large number of different contexts. Also, the evidence indicates that positive instances lead more effectively than negative instances to concept acquisition.

FOOTNOTES

[1]Woodson W. Fishback, "Aerospace in the Curriculum," Aerospace Education (Chicago, Illinois, 1968).

[2]Ibid, p. 33.

[3]"Introducing Children to Space: The Lincoln Plan" (Lincoln, Nebraska, 1968).

[4]"Massachusetts Aerospace Curriculum Guide" (Boston, Massachusetts, 1969).

[5]"Space Resources for Teachers: Biology" (Berkeley, California, 1969).

[6]"Space Resources for Teachers: Chemistry" (Muncie, Indiana, 1971).

[7]"Space Resources for Teachers: Physics" College Station, Texas, 1972).

[8]"Space Mathematics: A Resource for Teachers" (Chapel Hill, North Carolina, 1972).

[9]"Space Resources for the High School: Industrial Arts" (Miami, Florida, 1967).

[10]"Introducing Children to Space, The Lincoln Plan."

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[13]Jerry L. Miller, "Ann Assessment of the Effects of Aerospace Education Workshops Upon the Teaching of Aerospace Education Concepts in Selected Schools in Oklahoma" (Stillwater, Oklahoma, 1972).

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[25]Myles M. Platt, "Concepts and the Curriculum" (New York, New York, 1963).

[26]Vinache, p. 97.

[27]Gilbert Ryle, "Thinking" (New York, New York, 1953).

[28]Jerome Bruner, Jacqueline J. Godelnow and George A. Austin, A Study of Thinking (New York, New York, 1967).

[29]Carl G. Hemplel, "Fundamentals of Concept Formation in Empirical Science" (Chicago, Illinois, 1952).

[30]Bruner, et al.

[31]Ibid.

[32]Robert M. Gagne, "Concept Learning and the Curriculum" (Chicago, Illinois, 1965).

[33]Ibid.

[34]Asahel D. Woodruff, Basic Concepts of Teaching (San Francisco, California, 1961).

[35]J. B. Carroll, "Words, Meanings, and Concepts" (Boston, Massachusetts, 1964).

[36]J. T. Hastings, "Testing Junior High School Mathematics Concepts" (Chicago, Illinois, 1941).

[37]D. M. Johnson and C. A. O'Reilly, "Concept Attainment in Children: Classifying and Defining"(New York, New York, 1964).

[38]M. C. Serra, "How to Develop Concepts and Their Verbal Representation"(Boston, Massachusetts, 1953).

[39]Joseph D. Novak, "Further Study of Problem Solving Ability" (Lafayetts, Indian, 1963).

[40]Myron J. Atkin, "Teaching Concepts of Modern Astronomy to Elementary Children" New York, New York, 1961).

[41]David P. Butts, "The Degree to Which Children Conceptualize from Science Experience" Boston, Massachusetts, 1963).

[42]Susan M. Erwin, "Training and Logical Operation by Children" (Boston, Massachusetts, 1960).

[43]C. E. Shannon, "A Mathematical Theory of Communications" (New York, New York, 1948).

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[45]G. A. Miller, Plans and Structure of Behavior (New York, New York, 1960).

[46]Norbert Wiener, The Human Use of Human Beings (New York, New York, 1954).

[47]James Olds, "Pleasure Centers in the Brain" (Chicago, Illinois, 1956).

[48]Paul E. Torrence, Guiding Creative Talent (Englewood Cliffs, New Jersey, 1962).

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[51]E. B. Hunt, J. Marin and P. Stone, Experiments in Induction (New York, New York, 1966).

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[53] Carroll, Ibid.

CHAPTER III

DESIGN AND METHODOLOGY

Introduction

The purpose of this chapter is to describe the methodology and design of the study. Included are description of the population and sample, the procedures used for collecting the data, a description of the instrument used, and the methods employed for analyzing the data.

Description of the Population

The subjects were randomly selected students from the second and third grades of a Stillwater, Oklahoma elementary school. This school was selected on the basis of being the most representative of a cross-section of a community of thirty thousand patrons. This representativeness was based upon demographic information supplied by Stillwater school personnel. Data was collected from March 1, 1976, through March 31, 1976. Four second grades and four third grades with a total of one hundred eighty-four students participated in the NASA-SSEP school presentation given by this investigator.

Collection of the Data

Twelve third grade males, twelve third grade females, twelve second grade males, and twelve second grade females were randomly selected and placed in a set, which was labeled "Set A." The subjects in Set A were administered the Aerospace Concept Inventory prior to witnessing a NASA-SSEP presentation and eight to ten days later were administered the Aerospace Concept Inventory. An equal number of randomly selected second and third grade students were administered the Aerospace Concept Inventory twelve to fifteen days after witnessing the NASA-SSEP presentation. All second and third grade students were present at the NASA-SSEP presentation.

The Instrument

Designed by the investigator, the pre-program and post-program Aerospace Concept Inventory (ACI) instruments were identical. The instrument was comprised of twelve questions of differing levels of questions dealing with four selected aerospace concepts covered in the NASA-SSEP presentation. The different levels were, 1. knowledge level, 2. comprehension level, and 3. application level. Along with some of the questions were concrete items (Appendix B) and pictures to be manipulated or viewed prior to the question being asked and the answer being both taped and recorded by this investigator. The reasons for using an instrument of this design were: 1. desired data could be obtained by using a small number of items on the instrument; 2. use of differing levels of questions would give desired information as to the development or expansion of aerospace concepts; and 3. the instrument has the advantages of being compact and reasonably easy to administer. The subjects of the aerospace concept items were selected from official NASA-SSEP lists of concepts covered in the NASA-SSEP presentations. The form, content and appropriateness of the instrument items were validated by a panel of experts knowledgeable in elementary education, or space science, or experienced in instrument design. This panel included space science educators, a university psycologist, and teachers. A copy of the instrument can be found in Appendix B.

In order to determine item difficulty and item discrimination power, these formulas were used. The results are found in Appendix D.

A. Item Difficulty

$$P = \frac{R}{T} \times 100$$

B. Item Discrimination

$$D = \frac{R_u - R_L}{1/2T}$$

Analysis of the Data

A total of ninety-six second and third grade students were used on this study. Forty-eight students were administered the Aerospace Concept Inventory before and after the NASA-SSEP presentation. Another group of second and third students were administered the Aerospace Concept Inventory after the program. Each group was broken down as follows:

1. twelve third grade boys, 2. twelve third grade girls, 3. twelve second grade boys, and 4. twelve second grade girls. It was decided that in order to establish base line data for any changes that might occur between the pre and post groups, a t-test of significance would be appropriate for this analysis. Popham[1] discusses the t-test technique while pointing out the basic assumptions underlying its use. For the purpose of analyzing the data between the two groups of post program Aerospace Concept Inventory scores, the F test of significance was used.[2] Alpha was set at the .05 level for all testings. For the purpose of analyzing the data, the scores of the pre-post group were considered to be Set A and the post only group was Set B. The F test was then done comparing the following: 1. third grade boys versus third grade girls on total ACI post scores, 2. second grade boys versus second grade girls on total ACI post scores.

FOOTNOTES

[1] James Popham (New York, New York, 1967).

[2] James L. Bruning and B. L. Kintz, Computational Handbook of Statistics (Glenview, Illinois, 1966).

CHAPTER IV

ANALYSIS OF THE DATA

The purposes of this chapter are to present the data collected during the study and to summarize the results of the analysis of that data. The .05 level of confidence was used to determine significance for each hypothesis. Data were analyzed by the Oklahoma State University Computer Center, using the IBM 360 Model 65 computer. A t-test of significance was used for the first two hypotheses and an analysis of variance for factorial design was used for the remaining two hypotheses. The analysis of variance for factorial design used was based upon a program for a three-factor Mized Design: repeated measures on two factors developed by Bruning and Kintz at Ohio State University.[1] This program was used to determine mean squares.

<u>Hypothesis 1</u>: there will be no significant difference between the Aerospace Concept Inventory pre-program scores and the Aerospace Concept Inventory post program scores.

The computed t between the pre and post Aerospace Concept Inventory scores was 2.802 ($p < .01$). Therefore, the null hypothesis is rejected and it is concluded that there is a significant difference between the pre and post program scores, which had a mean of 45.917, as opposed to the pre-program group mean of 36.375. (See Table I).

TABLE I

T-TEST DATA BETWEEN THE AEROSPACE CONCEPT INVENTORY PRE-PROGRAM SCORES AND THE AEROSPACE CONCEPT INVENTORY POST-PROGRAM SCORES

Source	Number of Subjects	Mean Score	Standard Deviation	Degrees of Freedom	t Value
Pre-Program	48	36.375	15.143	94	2.802*
Post-Program	48	45.917	18.094		

*Significant at .01 level
Table t - 2.36 at .01

<u>Hypothesis 2</u>: there is no significant difference between the two sets of post program Aerospace Concept Inventory scores.

The computed t between the two sets of post program Aerospace Concept Inventory scores was 1.091 which is below the .05 level of significance. Therefore the hypothesis cannot be rejected and its possible that this nonsignificance may be attributable to the NASA-SSEP presentation. (See Table II).

TABLE II

T-TEST DATA BETWEEN THE TWO SETS OF POST PROGRAM AEROSPACE CONCEPT INVENTORY SCORES

Source	Number of Subjects	Mean Score	Standard Deviation	Degrees of Freedom	t Value
Pre/Post	48	45.917	18.094	94	1.091N.S.
Post Only	48	42.000	17.063		

Table t = 1.99 at .05

Hypothesis 3: there will be no significant difference between the two sets of post program Aerospace Concept Inventory scores of third grade boys and third grade girls.

The computed F ratio for sex was 4.08 ($p < .05$). Therefore, the null hypothesis is rejected and it is concluded that there is a significant difference between third grade boys with a mean of 56.33 and third grade girls with a mean of 44.08. (See Table III).

Hypothesis 4: there will be no significant difference between the two sets of post program Aerospace Concept Inventory scores of second grade boys and second grade girls.

The computed F ratio for sex was .27, a non-significant statistic. Therefore, the null hypothesis is accepted and it is concluded that there are no differences. The mean for second grade boys and girls were 46.58 and 48.50 respectively. (See Table IV).

TABLE III

ANALYSIS OF VARIANCE

Source	SS	DF	MS	F	P
Total	16038	47			
Post Test Type	320	1	320.33	1.02	N.S.
Sex	1381	1	1281.33	4.08	.05
Test Type X Sex	602	1	602.08	1.91	
Error	13834	44	314.41		

TABLE IV

ANALYSIS OF VARIANCE

Source	SS	DF	MS	F	P
Total	13289	47			
Post Test Type	4	1	4.08	.01	N.S.
Sex	75	1	75.00	.27	N.S.
Test Type X Sex	1045	1	1045.33	.27	N.S.
Error	12165	44	276.47		

FOOTNOTES

[1]James L. Bruning and B. L. Kintz, *Computational Handbook of Statistics* (Glenview, Illinois, 1968).

CHAPTER V

SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

Summary

The primary purpose of this study was to assess the development and expansion of selected aerospace concepts with second and third grade students by means of a NASA-SSEP school presentation. The sample consisted of one hundred forty-four randomly selected second and third grade students. The sample was randomly divided into two sets. One set, Set A, received the Aerospace Concept Inventory two weeks prior and two weeks after a NASA-SSEP school presentation. The other set, Set B, received the Aerospace Concept Inventory after the NASA-SSEP school presentation.

Four major hypotheses were tested. The hypotheses were all treated at the .05 level of confidence. It was found that there was a significant difference (p.05 and .01) between the pre and post program Aerospace Concept Inventory scores. This established a base by which other comparisons could be made between the two post testing groups. No significant differences were found between the total post groups or when comparing third grade boys and third grade girls. While the third grade boys did somewhat better than the third grade girls, this might be attributed more to a higher interest level than anything else. There were no significant differences between the second grade boys and second grade girls between the two post testing groups.

Conclusions

Although this study is only a beginning attempt to assess the development and expansion of aerospace concepts with lower-elementary students, the results indicate that it is indeed possible to develop and expand upon aerospace concepts by means of a NASA-SSEP school presentation. This is also consistent with some of the science curricula that have evolved with conceptual developmental base. It is also consistent with science educators who feel that science should begin in the lower grades with the emphasis placed upon a concepts approach at appropriate levels. If there is this kind of support for elementary science being taught by a concept-centered approach, then by logical extension, aerospace education on the lower-elementary level could also be presented by the same concept developmental approach.

If this is indeed the case, then, the implications for scheduling NASA-SSEP specialists in the lower elementary school becomes an area that has never fully explored and developed to the fullest advantage for NASA-SSEP.

It was also interesting to note, that while not included as a specific hypothesis, one comparison made was between seven year olds versus eight, nine, and ten year olds. The seven year olds did as well as the older students. This would seem to be advantageous for aerospace educators to use this factor for the integration of aerospace activities with all the other areas of the curriculum.

Recommendations

In light of the fact that some of today's curricula are rooted in developmental processes, incorporating an integration of the psychomotor, cognitive , and affective areas not only in the elementary ashool, but also in some early childhood programs coupled with the results of this study of specific kinds of aerospace concept development with second and third grade students has implications. Research has demonstrated that a process of concept development does occur at early ages and continues to be modified throughout the life process. Concept development has been defined, elaborated upon, measured, and implemented into meaningful, successful programs of education.

The preceding represents a logical basis and rationale for the following specific recommendations of possible alternatives for the direction, scope, and emphasis of NASA's Space Science Education Project.

1. Replicate the study in various areas of the country, both rural andurban.
2. Investigate the interactive effects of aerospace concept development and attitudes.
3. Repeat the study using different aerospace concepts and higher levels of questions.

4. A greater inclusion of lower elementary students when programming.
5. More time spent in working with elementary school systems. By definitions concept development implies a time span. This may improve upon the quality of NASA educational services as opposed to the generation of numbers for statistical purposes and a justification for a NASA educational program.
6. Supplemental to increased lower-elementary programming would be a greater involvement for teachers in the lower elementary school.
7. An on-going in-service educational program for Space Science Education Specialists to be up-dated in the following areas:
   a. developmental processes
   b. nature of the lower-elementary student
   c. revisions of the NASA program geared to the lower elementary student.
   d. development of an activity oriented NASA-SSEP presentation
   e. develop and integrate NASA-SSEP program with existing curricula.

A final note: Space science education specialists are extremely competent, professional educators in every sense. Informally, many would concur with the findings of this and other research in this area of conceptual development. It is hoped that some of these recommendations are acted upon to strengthen a fine educational service of NASA; but a service that must constantly ask, "where are we going, and what is the most effective way of getting there?"

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APPENDIX A

INSTRUMENTS

QUESTIONS

1. When we don't know about things as we grow up, we can always ask ______________________________.

2. This picture shows us that:

   A. We weigh the same on Earth as we do on the moon.

   B. We weigh more on Earth than we do on the moon.

   C. We weigh less on the Earth than we do on the moon.

3. You are going to be launched into space on a rocket named Titian II which is smaller than we usually use. Why would you have to think carefully about what you are going to take with you?

4. "____________________ killed the cat, satisfaction brought it back."

5. If I drop this book, it will fall to the floor. What pulls it down?

6. You are going to be left on the moon. On this table are some things that you would need in order to live on the moon. What would you pick out?

7. Here are two scale models of rockets. The Titian II and the Saturn V. Which of these two rockets would need the most power to get into space? Why?

8. Can you think of four things that you need in order to live in space?

9. Here are some weather pictures of the United States. How can pictures of weather in Colorado, New Mexico, and the Texas panhandle help us here in Oklahoma?

10. You and I are on a five year trip to a new planet and have been gone from Earth for three years. We find that all of our food has spoiled and cannot be eaten. What will probably happen to us?

11. Television pictures of news that happens can be sent around the world by unmanned spacecraft. Is this true or false?

12. Here is a box with some things in it. Do you wonder what might be in the box? _____________ The same thing that makes you wonder about what's in the box makes men wonder about space. Can you tell me what it is that makes us wonder about all things around us?

SELECTED AEROSPACE CONCEPTS AND THE RELATED QUESTIONS

Concept No. 1 - Concept of curiousity

Questions: 1-4-12

Concept No. 2 - Weight is a function of gravity

Questions: 2-3-5-7

Concept No. 3 - Different uses of spacecraft

Questions: 9-11

Concept No. 4 - Needs to live in space (food, water, oxygen, protection)

Questions: 6-8-10

MATERIALS USED WITH QUESTIONS

QUESTION 1	None.
QUESTION 2	A picture depicting 2 men standing on a scale. One man is on Earth, the other man is on the moon. The scales indicate different weights.
QUESTION 3	Scale models of a Titian II rocket and a Saturn V rocket.
QUESTION 4	None.
QUESTION 5	A book.
QUESTION 6	Items on a table. Radio, boots, food, tools (screwdriver, hammer, pliers), silverware (spoon, knife, fork), gun (air rifly), soap, toothbrush, toothpaste, matches, tank labeled air (oxygen), raincoat, pajamas, puzzle, deck of cards, dishes (bowl, small plate, glass) container of water, and a flashlite.
QUESTION 7	Scale models of a Titian II rocket and a Saturn V rocket.
QUESTION 8	None.
QUESTION 9	3 weather photos.
QUESTION 10	Spoiled food. Cottage cheese, bread, coconut.
QUESTION 11	None.
QUESTION 12	A box with rocks and pieces of metal in it.

RECORDING SHEET

Name: ______________________

Age: _______________________

Grade: _____________________

School: ____________________

Tape No.: __________________

1.

2.

3.

4.

5.

6.

7.

8.

9.

10.

11.

12.

APPENDIX B

AUDIENCE REPORTS OF NASA SCHOOL PRESENTATIONS 1969-1974

TABLE V

AUDIENCE REPORTS OF NASA
SCHOOL PRESENTATIONS
1974

Type of Audience	No. of Programs	Audience	% Total School Presentations
Upper Elem. Schools	1,237	308,607	21.86%
Jr. High Schools	978	351,732	17.28%
Sr. High Schools	809	333,816	14.30%
Classroom Visits	2,578	133,326	45.57%
College/Universities	55	4,432	.99%
	5,657	1,131,913	100%

TABLE VI

AUDIENCE REPORTS OF NASA
SCHOOL PRESENTATIONS
1973

Type of Audience	No. of Programs	Audience	% Total School Presentations
Upper Elem. Schools	1,429	399,202	21.65%
Jr. High Schools	1.046	418,360	15.88%
Sr. High Schools	1,012	418,825	15.33%
Classroom Visits	3,072	166,865	46.55%
College/Universities	39	2,716	.59%
	6,598	1,405,968	100%

TABLE VII

AUDIENCE REPORTS OF NASA
SCHOOL PRESENTATIONS
1972

Type of Audience	No. of Programs	Audience	% Total School Presentations
Upper Elem. Schools	1,479	416,674	18.36%
Jr. High Schools	1,314	583,694	16.55%
Sr. High Schools	1,343	643,864	16.93%
Classroom Visits	3,761	194,675	47.37%
Colleges/Universities	41	2,438	.52%
	7,938	1,841,345	100%

TABLE VIII

AUDIENCE REPORTS OF NASA
SCHOOL PRESENTATIONS
1971

Type of Audience	No. of Programs	Audience	% Total School Presentations
Upper Elem. Schools	1,499	433,405	20.83%
Jr. High Schools	1,183	489,261	16.43%
Sr. High Schools	1,382	638,382	19.20%
Classroom Visits	3,101	152,485	43.09%
College/Universities	31	1,593	.45%
	7,196	1,715,126	100%

TABLE IX

AUDIENCE REPORTS OF NASA
SCHOOL PRESENTATIONS
1970

Type of Audience	No. of Programs	Audience	% Total School Presentations
Upper Elem. Schools	1,578	444,505	20.83%
Jr. High School	1,178	544,249	15.55%
Sr. High School	1,576	836,361	20.80%
Classroom Visits	3,215	161,745	42.44%
College/Universities	28	4,276	.38%
	7,575	1,991,136	100%

TABLE X

AUDIENCE REPORTS OF NASA
SCHOOL PRESENTATIONS
1969

Type of Audience	No. of Programs	Audience	% Total School Presentations
Upper Elem. Schools	2,012	583,366	18.84%
Jr. High Schools	1,620	727,016	15.20%
Sr. High Schools	1,977	1,077,035	18.51%
Classroom Visits	5,031	263,356	47.11%
College/Universities	37	5,515	.34%
	10,677	2,656,288	100%

TABLE XI

REPORT OF NASA SCHOOL PRESENTATIONS
BY YEAR AND CATEGORY

Year	Upper Elem.	Jr. High	Sr. High	Classroom	College
1974	1,237	978	809	2,578	55
1973	1,429	1,046	1,012	3,072	39
1972	1,479	1,314	1,343	3,761	41
1971	1,499	1,183	1,382	3,101	31
1970	1,578	1,178	1,576	3,215	28
1969	2,021	1,620	1,977	5,013	37
	9,306	7,319	8,099	20,740	231

TABLE XII

NASA SCHOOL PRESENTATIONS
1969-1974

Total Upper Elem. Schools	9,234
Total Jr. High Schools	7,319
Total Sr. High Schools	8,099
Total Classroom Visits	20,758
Total College/Universities	231
Total School Presentations	45,641

APPENDIX C

NASA-SSEP PRESENTATION

PRESENTATION

Demonstration Model Used

Good afternoon boys and girls. What do you think we're going to be talking about this afternoon? (responses) That's right, we're going to talk about space and for as long as people have been living here on earth, they have looked to the sky and have asked questions. They asked questions because they were curious about what was out there and what was it like in space. But before they could travel in space they had to learn to fly in the atmosphere or the air around the earth. We fly through the atmosphere or air around the earth in things called planes. Some planes fly at high speeds and are experimental planes. We use experimental planes to try to answer questions we have not yet answered. This plane, the X-15, is an experimental plane and we use it to find out what happens to it when it flys at high speeds. Does it look like a fast plane? (Response) This plane can fly over 4,000 miles/hour. Planes that carry people around don't go this fast, they only to about 400 to 500 miles/hour and when you

X-15 (Hold-up)

fly on one of these planes it will land at an airport and most airports are outside of town and so, you have to take a cab or rent a car to get where you want to go. Another kind of

VSTOL (Demo)

airplane is a VSTOL. This plane doesn't need a long road or runway to get up into the air, it turns its wings up and rises like a helicopter and when it gets high enough, puts its wings down, flys through the air like a plane and when it gets to where its going, tilts its wings up and lands straight down. You can go from the airport to a downtown hotel, shopping center or perhaps to a school like yours. Some day, because people are still asking questions, you might fly on a plane

ATT

called the ATT - advanced technology transport. You can see that it has a "coke bottle" shape which helps it fly better than some of the planes we now use. Also, the shape of the wings is different. Most wings today have a

Cut-out of normal tear drop wing and super critical wing

tear drop shape (Demo), the new wing is called a super critical wing and has this shape (Demo). Also, we are changing some of our engines so that they won't be as noisy, we'll have quieter engines.

We use planes to fly through the air. Can we use planes to fly in space (response), no, we use something else to get into space. Can you tell me what we use to get into space? (Response) That's right, we use rockets to get into space. A rocket does only one thing. It takes something from here on Earth to some place in space and that's all it does. It's like a taxi cab, a cab takes you from one place to another. Some rockets are bigger than others because some things we send into space are heavier than others so the rockets need more power to put the heavier spacecraft into space. Gravity trys to pull things back to Earth, so we need enough power to overcome gravity.

Let me show you what I mean: do you all have a good imagination today? (Response)

Imagine that I have a tower, 100 miles high and this tower is in the North Pole. I am going up to the top of this tower with a ball and throw it out, what will pull it back to Earth? (Response) This time I'll throw it out faster and it will go further but again whatwhat will pull it back? (Response) This time I'll really throw it and it will go even further, but again what will pull it back? (Response) But, this time instead of falling back to Earth it will fall around the earth.

Globe Model
Tower-Ball

This is exactly what we do with spacecraft only we "throw" them on the tops of rockets.

You all know how rockets work, don't you? (Response) Of course you do. You have all seen them on TV. The engines are started, the flames come out, push against the Earth, push

(Demo)

against the air and push and push till we get out into space. Right? (Response) Wrong! If that's how a rocket worked, what would it push against out in space? There's nothing out there. The only thing a rocket pushes against is itself. Let's do an experiment, would you like me to build and launch a rocket

(Balloon Demo)

for you today - right in front of you? (Response) In order for me to do it, you will have to all close your eyes - no peeking. All right, you can open your eyes - that's right! The balloon works the same way as a rocket does. What's my fuel? (Response) When I let go of this end of the balloon, the air will come out in one direction, the force on the other end of the balloon will make it go in the other direction. Rockets work the same way but we don't use air for fuel, we use other things. The balloon goes all over the place because we don't have a way to steer it. Our rockets can be directed.

As I have already said, rockets are used to take things into space. These things are called spacecraft and may or may not have men on board. Most of the spacecraft sent up are unmanned and they do different jobs. Some

ATS

spacecraft, like ATS (application technology satellite) are used for communication. We use this spacecraft to send messages around the world. We also use it to send educational television to places that are hard to reach. Some spacecraft are used to send weather pictures back to earth. We can have weather

Nimbus

pictures of the whole United States. Since most weather travels from west to east we can predict what the wheather might be two or three days from now by using these weather pictures.

Mariner

Some spacecraft are scientific spacecraft. We use scientific space craft to help us answer questions that we ask. For example, the Mariner spacecraft helped us answer some of the questions that we had about the planets Venus and Mercury. Mariner gave us answers to many of our questions.

One thing that many people would like to know is how do we know what's doing on about a spacecraft. What's going on up in space?

Telemetry

We find out or communicate with a spacecraft by a means called telemetry. To show you what I mean, I have to find out something about you. Do you all have a good imagination today? (Response) OK, I want you to imagine that this green box at the end of the table is an unmanned spacecraft way out in space and we have some experiments aboard this spacecraft that we were going to do. Now I want to send this information somewhere, so, I am going to send it from my spacecraft (encoder) back to Earth using radio waves. Now I will turn on my spacecraft (turn on). Listen! The sounds stay the same. Let's see what happens if something hits my spacecraft. Could you hear the change in sound (response)? Let's see what happens if the temperature changes. This red tube "feels" temperature. Let's listen to the temperature right here today, where I am speaking. What happens? (Response) The sound goes up so we know that the temperature is going up and when the sound goes down, we know that the temperature is going down. In other words, when the sounds are changing, we know that something is happening aboard our spacecraft. We call communication with our spacecraft, telemetry. Can you all say telemetry? (response) We use telemetry for both manned and unmanned spacecraft. Most of the spacecraft we send up are unmanned, but some of the spacecraft have men on board.

Mercury Gemini Apollo

Project Mercury was where we sent one many up, project Gemini sent two men into space and with three men aboard project Apollo landed on the moon. One of the problems that we had was that the men in the spacecraft need to have exercise, just like down here and the spacecraft were not very large. So they did what are called isometric exercises. Would you like to try one? (Response) When I count to three, I want you all to stand on the tips of your toes and stretch your arms up and stretch your fingers up as far as they will go. If you do this you should be able to feel all your muscles pushing against each other. Ready? (Response) One--two--two-and-a-half--three (break 2 min.)

Now when we send men into space, we need to give them everything they need in order to live. What are some things that we all need in order to live? (Response)

We need food, water, oxygen and protection. Most of the protection comes from the spacecraft itself but they also have a space suit. The suit that I have is a mock-up but is quite like the real suit. They don't wear it all the time, only when they leave Earth, return to Earth, or when they open the spacecraft door or climb outside the spacecraft. Before I talk about the suit, let's see what

Suit Demo

goes with it. First we have a helmet, its called a fish bowl helmet and I think you can see why. It locks on to the lock on the suit.

Helmet

It has a visor which comes down over the front of it to protect their eyes from the bright

Gloves

sunlite. On their hands, they wear two pairs of gloves. Inside gloves and outside gloves. On their feet they wear two pairs of boots,

Boots

an inside pair and outside pair. Some people think that the boots have weights in them to hold them on the moon but, that's not true because there is gravity on the moon. It's not as strong as here on Earth, but there is still gravity to pull them down on the moon. There are attached to the main part of the suit. On the front of the suit, these blue connections hook up to the oxygen supply, the red connection is where what they breath out is carried away, cleaned and used over again. On the arms and legs are packets to carry different things. They don't wear the suit all the time, to climb out of the suit, there is an opening device which they open, climb out and underneath they are wearing a light pair of coveralls, which is what they wear most of the time when they are in space.

Food Demo

Now that we have protected them with the spacecraft and suit, we must now feed them. The foods that are used are put in special packages. Some of the foods need to have water added like this grape drink. To fix it we have a water gun and we stick the nozzle of the gun into the opening and put the right amount of water in the package and mix it up and place the valve end into your mouth and squeeze. The liquid will go into your mouth. Some of the other kinds of food are called freeze dried, like the coffee your mother may buy at the store. Some foods are bite size and you place a bite size piece in your mouth and the saliva or spit mixes with it and you swallow it. There are 75 foods to choose from. The foods are nourishing and provide the body with all the things that you need. For the

Skylab Model

Skylab Food tray

Sky Lab, each man had his own try and would pick out his meals in cans like this. He could heat his food, take off the covers and eat with these things (knife, fork, spoon).

The Skylab came after project Apollo which sent man to the moon and was like a house in space. Three groups of men went up and stayed for 29 days, 56 days and finally for 84 days. They did all kinds of experiments to try to find answers for some of the many questions that we have.

Apollor/Soyuz

After the Skylab program, the United States and the Soviet Union had a joint mission where an Apollo spacecraft and a Russian Soyuz spacecraft joined each other in space. They conducted more experiments, separated and returned to Earth.

Viking Model

You people are growing up in the space age and don't know what its like not to live in the space age. Some of the things coming up in our future are project Viking and the space shuttle. Right now as we are sitting here, two spacecraft called Viking are on the way to the red planet. Who can tell me what is the red planet? (Response) The red planet of Mars will be the landing site of Viking to find out if there is anything living on Mars. Also, in our future, we'll find that rockets won't look like rockets, they will be half

Shuttle Model

plane - half rocket. It will be launched like a rocket into space and return to Earth like a plane. We'll use the shuttle to carry people and equipment into space, again, to do experiments, carry new equipment into space, and perhaps do repair work on unmanned spacecraft. The biggest difference between rockets and the space shuttle is that with the shuttle we will use it over and over which we couldn't do with rockets. Why? The reason is that you could only use a rocket once.

So you can see that we are all in the same business, doing the same thing, be it in school or in space. We are all trying to find some answers to our many questions.

Question/Answer Session---------

OUTLINE

I. INTRODUCTION

II. AERONAUTICS

(a) X-15
(b) ATT
(c) VSTOL
(d) Quiet engines
(e) Shapes of planes
(f) Shapes of wings

III. ROCKETS

(a) Function
(b) How rockets work

IV. UNMANNED SPACE CRAFT

(a) Weather (Nimbus)
(b) Communications (ATS)
(c) Scientific (Mariner)

V. TELEMETRY

VI. MANNED SPACE CRAFT

(a)
1. Mercury
2. Gemini
3. Apollo
4. Skylab
5. Apollo/Soyuz

(b) Needs of space living
1. Food
2. O_2
3. H_2O
4. Protection
   a. Spacecraft
   b. Space suit

VII. FUTURE

(a) Viking project
(b) Space shuttle

APPENDIX D

ITEM POWER - ITEM DISCRIMINATION

Question 1	P = .89	D = .46
Question 2	P = .81	D = .41
Question 3	P = .49	D = .63
Question 4	P = .39	D = .23
Question 5	P = .94	D = .21
Question 6	P = .87	D = .77
Question 7	P = .80	D = .69
Question 8	P = .93	D = .51
Question 9	P = .58	D = .88
Question 10	P = .82	D = .59
Question 11	P = .90	D = .53
Question 12	P = .49	D = .91

VITA

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