AN ASSESSMENT OF CERTAIN SKILLS
POSSESSED BY FIFTH - GRADE STUDENTS
USED TO SUCCESSFULLY IDENTIFY
CONSTELLATIONS IN A PLANETARIUM

Dissertation for the Degree of Ph.D.

MICHIGAN STATE UNIVERSITY

RUSSELL LYNN BONDURANT, Jr.

1975

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ABSTRACT

AN ASSESSMENT OF CERTAIN SKILLS POSSESSED BY FIFTH-GRADE STUDENTS USED TO SUCCESSFULLY IDENTIFY CONSTELLATIONS IN A PLANETARIUM

By

Russell Lynn Bondurant, Jr.

The study was stimulated by the pressing need to determine how students learn to identify constellations. This was deemed important since a large portion of time in each planetarium presentation made to school groups is usually devoted to identifying constellations which are visible that evening in the real sky.

The purpose of this study was to construct a diagnostic test, made up of five subtests, to determine if fifth-grade students can demonstrate those particular skills that an individual must have in order to learn constellations, that is to be able to: 1. discriminate between the brightnesses of stars; 2. orientate himself relative to a given direction; 3. measure angular distances in the sky; 4. recognize a constellation against the background of the sky; and 5. detect relative changes of position of various star groups during observation, and 6. use a star chart to locate an object in the sky.

A forty-eight question examination (Planetarium Skills Evaluation Test) was constructed to be administered individually in the planetarium to test a fifth-grade student's understanding of these major areas. After an eye test for visual acuity, the subject was administered the Classroom Indirect Measurement Instrument. The purpose of this instrument was to provide a means of comparing planetarium performance of skills associated with constellation identification with the results of the classroom instrument. The Classroom Indirect Measurement Instrument was developed from available educational instruments or procedures accepted as being able to measure constellation identification skills.

After a short break, the examinee was given the Planetarium Skills Evaluation Test. The test was administered orally. During the entire test the examinees proceeded at their own rate, except where time limits were set for specific tests. An average time of one hour and ten minutes was required by the examinees to complete the entire testing session. The planetarium employed in this study was located in the Legg Junior High School in Coldwater, Michigan.

The sample subjects were drawn from the total fifth-grade enrollment of students in seven elementary schools in Coldwater, Michigan. All subjects used in this investigation had visited the planetarium at least once prior to their testing session. The total sample was 120. Twenty of these subjects were involved in the testing of the trial version of the test.

An item analysis, correlation analysis, and factor analysis were performed on the Planetarium Skills Evaluation Test scores to test the null hypotheses and other areas of concern.

It was concluded from this study that not all skills required to locate and identify a constellation in the planetarium sky are in the repertory of skills of fifth-grade students. Instruction is required to teach how to use these skills, especially in regards to spatial abilities and orientation skills. This instruction must involve the use of the sky itself rather than pictures or slides as indicated from the results of the factor analysis. Items or skills using the planetarium sky do not factor with those items or skills employing pencil-paper type items like those included in the Classroom Indirect Measurement Instrument.

AN ASSESSMENT OF CERTAIN SKILLS POSSESSED BY FIFTH-GRADE STUDENTS USED TO SUCCESSFULLY IDENTIFY CONSTELLATIONS IN A PLANETARIUM

By

Russell Lynn Bondurant, Jr.

A DISSERTATION

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Finally to his wife Kay and children Kenneth and Julia, who had to sacrifice to make this all possible, the writer proudly expresses his appreciation. Their love and support made it all worthwhile.

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CHAPTER I

THE PROBLEM

Introduction

In all ages the glories of the heavens on clear and moonless nights have filled the minds of men with awe. As man became more familiar with the scattered points of light--the stars--he began to translate his heroes, fears, and other fantasies onto the celestial sphere in the form of patterns of stars--constellations. Presently, there are 88 of these star groups recognized by the International Astronomical Union.

The lore, mythology, and knowledge of the stars used to form the various patterns have been passed faithfully from one generation to the next. Since the 1940's, a convenient means of learning about constellations has been provided by a piece of audiovisual equipment housed in a special chamber--a planetarium.

In 1973 there were more than 700 planetariums in the United States, most of them in public schools, and most of them built with funds authorized under Title III of the National Defense Education Act of 1958. The equipment for learning about constellations in a school setting has become available to millions of students.

The development of teaching materials and research on which to base these materials have come much more gradually. Planetariums are used most extensively by students who attend lecture-demonstrations from one to three times a year, and the preponderance of these students are from the fourth, fifth and sixth grades.

The problem of interest in this study deals with the effectiveness of this limited exposure in the planetarium in helping the fifth-grade student learn to identify and locate selected constellations in the night sky. Furthermore, in order for the learning to take place there are certain particular prerequisite skills which are needed by the learners. These skills include: 1. discrimination of the brightnesses of stars; 2. orientation relative to direction; 3. measurement of angular distances in the sky; 4. ability to recognize a constellation against the background of the sky; and 5. ability to detect the relative changes of position of various star groups during observation. Associated with these skills is the ability to use a star chart, i.e., to be able to match stars listed on the map with those visible in the planetarium or real sky.

There is evidence that fifth-grade students may or may not exhibit these skills. The lack of successful learning in the planetarium may be a result of a deficiency of one or more of these skills.

Formal Statement of the Problem

The purpose of this study was to construct a diagnostic test, made up of five subtests, to determine if fifth-grade students can demonstrate those particular prerequisite skills than an individual must have in order to learn constellations, that is to be able to: 1. discriminate between the brightnesses of stars; 2. orientate himself relative to a given direction; 3. measure angular distances in the sky; 4. recognize a constellation against the background of the sky; and 5. detect relative changes of position of various star groups during observation, and 6. use a star chart to locate an object in the sky.

Educational research on the learning process in the planetarium and related studies indicate the child in the fifth grade has capabilities for constellation identification skills. The question to be answered is whether these skills can be used in the planetarium without further instruction. The results of the test would enable the investigator to determine the level of performance exhibited by the fifth-grade subjects in this study.

Need for the Study

This is only a part of the extensive research needed to provide a sound base for the development of planetarium teaching materials. In this instance, the study was stimulated by the pressing need for materials to be used for grade school field trips to planetariums.

Pitluga[1] estimates that some fifteen million planetarium visits are made annually by school and college students. The majority of these students come to the planetarium for a single visit during a given academic year.

In addition, a large portion of time in each planetarium presentation is usually devoted to the constellations which are visible that evening in the "real" sky. Curtin[2] reports that approximately one-half of every planetarium presentation to school age children is a discussion of celestial objects in the local sky. Thus, it is important to know if the students can "see" the constellations. Then, too, Curtin reports that the greatest use of the planetarium lies with students of fourth, fifth, and sixth grades. Thus, it is especially important that the instructor needs to know the capabilities of these students to work with the stars.

A quick procedure is needed by planetarium instructors to determine the level of performance of different students. Because once he knows their capabilities, the planetarium instructor can develop specific methods or lessons to provide experiences to assist in the correction of any deficiencies or limitations present in the group.

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[1]George E. Pitluga, "The Planetarium Visit...An Evaluation by Teachers," Science Activities, VI (December, 1972), 15.

[2]John Curtin, "An Analysis of Planetarium Program Content and the Classification of Demonstration Questions," (Unpublished PhD dissertation, Wayne State University, 1967), p. 128.

Conventional wisdom, to judge by a review of curricula guides of different school planetariums, is that there is no difference in the planetarium capabilities of children of different ages. For example, the Mt. Clemens, Michigan, Community Schools Planetarium Guide states that an objective of the visit of third-grade students is to acquire a knowledge of the major constellations.[3] Whereas, the Marie Drake Planetarium in Juneau, Alaska, does not begin to emphasize constellations until the fourth grade.[4] Neither guide includes the procedure used to introduce and identify these sky objects.

To date there has been very little research attempted in the planetarium to determine how the students learn constellation identification skills or to determine what orientation skills the students possess that enable them to work successfully with the visual stimuli.

Procedure

An instrument was designed to diagnose individually the ability of fifth-grade students tested to:

1. Discriminate between the brightness of stars.

   (The students were given a star in the planetarium sky to use as a standard and then asked to compare the

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[3]Mt. Clemens Community Schools, 1967-68 Planetarium Curriculum, Mt. Clemens, Michigan: Mt. Clemens Community Schools.

[4]Marie Drake Planetarium, Planetarium Program K-6, Juneau, Alaska, 1966.

brightness of another star and tell whether it was brighter, not so bright, of the same brightness.)

2. Orient themselves in the planetarium chamber.

(The students were given the location of one of the cardinal points of direction in the chamber and then asked to determine the direction of the setting sun, the current position of a sky object, or name any direction required of them around the horizon.)

3. Measure distances in the planetarium sky.

(The students were given a distance between two stars to use as a standard and then asked to state if another distance between two stars was the same distance, a greater or less distance when compared to the standard.

Assumptions

To test a child individually using the planetarium is a very time consuming and expensive operation. What is needed by teachers is a quick test procedure which can be administered in the classroom and be employed as an accurate predictor of planetarium performance. Therefore, to serve this purpose the investigator developed a Classroom Indirect Measurement Instrument from available educational instruments or procedures accepted as being able to measure constellation identification skills. Five subtests were included in the Classroom Indirect Measurement Instrument.

The purpose of the Classroom Indirect Measurement Instrument was to provide a means of comparing the planetarium performance of skills associated with constellation identification with the results of the classroom instrument. If the results were similar, one would have available an instrument which could be administered in the classroom as a means to predict planetarium performance. If the results were different support would be provided to the thesis that pencil-paper type tests do not accurately measure planetarium performance of skills necessary to identify constellations.

Limitations

This research investigation was restricted through the use of only one planetarium facility, the Legg Junior High School Planetarium in Coldwater, Michigan. Because of this, only one type of instrument, a Spitz A3P with prime sky, was used to project the stars onto a thirty foot dome. In addition, only fifth-grade students with previous planetarium experience were used in the study. All of the participants in this investigation were members of one of the thirteen classes of fifth-grade students in Coldwater. Therefore, all of the participants in this investigation were the product of a rural school system which offers very little science training in the elementary grades.

Definition of Terms

To avoid semantic difficulties, the following terms were defined. These definitions as used in the context of this study were as follows:

1. Constellation Identification Skills - Those skills required of an observer to correctly identify a constellation or celestial object in the sky. The skills include: brightness discrimination, orientation skills, measuring skills, spatial abilities, and scanning skills.
2. Brightness Discrimination - The ability of a sky watcher to accurately compare the brightness of one star to another and to decide if the stars are of equal brightness or one star is brighter or dimmer than another.
3. Orientation Skills - Those skills needed by a sky observer to properly position himself in reference to the four cardinal points of north, south, east, or west. In addition, the ability to describe the location of other objects in relation to himself with reference to the cardinal points.
4. Measuring Skills - Those skills used by an observer of the stars to compare the angular distances between stars or the altitude of selected celestial objects.
5. Scanning Skills - Those skills used by an individual in the planetarium to examine a section of the sky for a given object or objects.
6. Spatial Abilities - Those skills needed by a sky observer to recognize the same star group in different sizes, to be able to recognize star groups in identical, rotated, or reversed positions, to locate stars or constellation groups from patterns on a star chart, to be able to tell which star has moved from other stationary objects, or to predict the setting positions of sky objects.

7. Planetarium Skills Evaluation Test - The instrument used to measure planetarium performance related to the constellation identification skills.

8. Classroom Indirect Measurement Instrument - The instrument used to evaluate constellation identification skills without the use of the planetarium.

9. Fifth-grade - The fifth-grade as defined in this study was the fifth grade level of students from the Coldwater Community School District of Coldwater, Michigan.

10. Planetarium - A multilearning center where a model of the sky is projected onto a hemispherical dome.

Organization of the Study

In Chapter I, the need for the study, its purpose, definitions of terms, assumptions, and limitations have been presented. Chapter II contains a survey of literature pertinent to this study, with regard to the planetarium and certain perceptual and orientation skills deemed necessary for successful constellation identification. In Chapter III the methodology is detailed, including instrumentation, sample population employed, and methods of collecting and analyzing the data. Chapter IV is a presentation and analysis of the data. Chapter V includes a summary of the study, a statement of conclusions, a list of implications, and suggestions for further research.

CHAPTER II

REVIEW OF THE LITERATURE

"The problem with astronomy is not so much one of creating interest as it is one of directing already existing interest, and of selecting proper subject matter to broaden this interest."[1] For many teachers, who include an astronomy unit as part of their science program in the elementary grades or visit a planetarium, some study of the constellations is generally part of their yearly programs. This does seem logical; as Gingery states, "Next to the daily motion of the sun and the phases of the moon probably the most obvious astronomical phenomena are the configuration of visible stars known as constellations."[2]

This chapter will be devoted to four major areas related to how children identify constellations: 1. a survey of the planetarium research completed to date; 2. a review of available sky guides to identify the skills required for

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[1] G. O. Blough, "Studying the Heavens," Instructor, XLVII (January, 1938), 42.

[2] Walter G. Gingery, "Astronomy for the Elementary Science Class," School Science and Mathematics, L (November, 1950), 602.

constellation identification; 3. a study of findings from general educational research on the skills of fifth-grade students; 4. to determine from other writings in professional journals what has been suggested as activities to do in the teaching of the constellations in the classroom.

Planetarium Research

Chamberlain conducted the first research connected with planetarium instruction in the early 1960's.[3] From the results of 1,454 replies to a questionnaire sent out by Chamberlain he believes that the chief value of a planetarium may be in forming attitudes:

> The retention of facts is but a temporary gain, and perhaps not too useful. The planetarium lecturer will have accomplished more if his students, whether children, adults, or scientists have been excited by the experience to want to learn more.[4]

In addition, Chamberlain indicates that the planetarium can be a highly effective device:

> The whole apparatus has several different speeds, all of which are several times faster than the motions of nature which are simulated. This feature makes it possible to condense a very long astronomical story, so that nearly any observant person can reach a clear understanding in a few minutes of the working of the heavenly bodies that actually occur over periods of a day, a year, or even thousands of years.[5]

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[3]J. M. Chamberlain, "The Administration of a Planetarium As An Educational Institution," (Unpublished PhD dissertation, Columbia University, 1962).

[4]Chamberlain, p. 54.

[5]Chamberlain, p. 15.

A descriptive survey method, using a questionnaire, was employed by Korey[6] for the purpose of investigating the development of planetariums in the United States. Item two of the questionnaire has implications for this investigation. Item two of the questionnaire asked, "In what ways does the planetarium program for younger children differ from that for older pupils?"

> Of the 99 respondents who used the long form, 57.6% replied that adaptions are made. Twenty directors stated that younger children are given a simplified presentation with easier concepts and less subject matter involved. An additional sixteen referred specifically to myths, legends, and constellations as the substance of primary-grade demonstrations.[7]

In addition, Korey called for further research to determine what grade placement is most effective for various topics in astronomy. Also, she noted that more research was needed to determine at what grade level class visits to the planetarium should begin.

The problem began during the 1964-65 academic year when the Elgin Public Schools wanted to know what could be taught with the planetarium? What concepts belonged at what grade level? What was the most effective time duration for the planetarium experience? To aid in providing answers

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[6]Ruth Anne Korey, "Contributions of Planetariums to Elementary Education," (Unpublished PhD dissertation, Fordham University, 1963).

[7]Korey, p. 62.

for these and other questions Tuttle[8] used sixth-grade classes matched according to I. Q., Chronological Age, and reading scores.

The experimental groups held all class sessions in the planetarium and on the same day the control class was presented the same lesson in the same amount of time in the classroom. Mr. Tuttle presented both lessons. Each class session was thirty minutes in length and each group met three times per week for ten weeks.

For evaluation the 2 and 3D spatial relations tests from the Multiple Aptitude Test Battery were given as pretest and again as posttest. A content test constructed by the investigator was also given as a posttest. A t-test was used to determine the level of significant difference between the experimental and control groups. "It appeared to be a striking victory for the planetarium in development of three dimensional spatial concepts. This indicates an emphasis on visualization and the higher thought processes."[9] As for two dimensions there was no significant difference between the two groups. "A study of two dimensions found it to involve one sense of orientation and the lower thought processes. The experiment, if valid, would imply that the planetarium does not tend to give one the sense of spatial orientation

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[8]Donald Tuttle, "Elgin's Research in Planetarium Curriculum," Projector, I (1968), 13-16.

[9]Tuttle, p. 13

that we might expect, and does not strengthen the lower thought processes."[10]

The project was repeated in 1965-66 using 200 matched pairs of sixth-grade students. Sixteen lessons were presented in the planetarium by the planetarium director and in the classroom by the classroom teachers. Constellations, use of star charts, and estimating the daily motion of the sun in addition to other lessons were performed based on the University of Illinois text materials <u>The Universe in Motion</u>. The classroom subjects used special models and transparencies as visual aids. Using statistical procedures involving student t-ratios the overall results indicated that there was no significant difference in performance on posttests between planetarium and non-planetarium students.

In addition, the frequency of visits had no effect. As suggested by Tuttle the use of visual methods and materials in the classroom during this investigation and not in the previous one might have removed the significance between the two groups as observed in the previous year. Tuttle also indicated that the project material was better understood by the Higher I. Q. student but there was no indication that the planetarium favored those of higher ability.

The purpose of the study conducted by Soroka[11] in the spring of 1966 was to determine if the planetarium program

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[10]Tuttle, p. 14.

[11]John J. Soroka, "The Planetarium and Science Education," <u>Projector</u>, I (1968), 18-20.

made a significant contribution to the achievement of eighth-grade students in the fields of space relations, astronomy, and geography as indicated from scores of students participating in planetarium programs to students only participating in the classroom presentation. Eighth-grade students were matched by school, teacher, sex, grade, age, DAT Space Relations quartile position, Master pretest and the Metropolitan Achievement Test in Science, Arithmetic Comprehension, and Arithmetic Problem Solving stanine scores at two different schools. Four different planetarium presentations were made to the experimental group as they concluded each portion of their six week astronomy unit while the control groups took part in a supervised study period in the classroom.

Topics discussed during the planetarium presentation included the co-ordinate system, directions, seasons, lunar motions, constellations and planetary motion.

A t-ratio was used to discover the level of significant difference between the means of the experimental and control groups for each test. Soroka's findings included the following:

1. The planetarium under the controls of the study was an effective teaching device in the fields of astronomy and geography.

2. The planetarium program did not make a significant contribution to the improvement of space relations aptitude as measured by the DAT Space Relations Aptitude Test.

An experimental study was carried out by Smith[12] to compare the achievement of two groups of sixth-grade students: (1) one group experienced a forty minute lecture-demonstration concerning selected astronomical concepts in a planetarium and (2) one group experienced a forty minute lecture-demonstration concerning the same selected astronomical concepts in the classroom. A posttest-only Control Group Design with the Randomized-Group Technique was used by the investigator.

Nineteen astronomical illustrations were prepared by the investigator to be used as visual aids in the classroom. An opaque projector was used to project the illustrations of the stars. A celestial globe and physical-political globe of the earth were also employed.

On the test which was administered to the groups 44 percent of the questions was related to constellation identification. The students were to pick out the correct choice as required from pictures in the test booklet. The students were asked to identify the following constellations from pictures: Ursa Major, Orion, Leo, Taurus, and Cygnus. No mention was given as to how the constellations were displayed in the planetarium.

Smith concluded that a classroom lecture-demonstration is more effective, in terms of achievement, than a planetarium-lecture demonstration. Also, Smith stated that a

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[12]Billy Smith, "An Experimental Comparison of Two Techniques (Planetarium Lecture-Demonstration and Classroom Lecture-Demonstration) of Teaching Selected Astronomical Concepts to Sixth-Grade Students," (Unpublished EdD dissertation, Arizona State University, 1966).

planetarium visit was not essential for sixth-grade students studying astronomy if achievement of astronomical concepts is the major objective of an elementary school teacher.

The chief purpose of the investigation carried out by Rosemergy[13] was to determine whether sixth-grade children developed a greater understanding of selected astronomical phenomena from instruction which included the use of a planetarium than from instruction which did not. Three different treatments were used in this investigation. One group had all five periods of instruction given in the classroom while the second had the first four periods of instruction in the classroom and the last in the planetarium. The third group made visits to the planetarium during their first and last periods of instruction and had the other three periods of instruction in the classroom. Each class period was forty-five minutes in duration.

Nineteen concepts were tested for both in a pre and posttest. The concepts involved a basic understanding of the apparent daily motion of the sky and the phases of the moon. As part of the instruction in the planetarium Rosemergy spent six minutes establishing that the children knew directions. The investigator stated, "It is probable that most of the children will already understand this, and it

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[13] John Rosemergy, "An Experimental Study of the Effectiveness of a Planetarium in Teaching Selected Astronomical Phenomena to Sixth-Grade Children," (Unpublished PhD dissertation, University of Michigan, 1968).

is highly important that they do."[14] From his test data it does seem that sixth-grade students do have some understanding of directions. After instruction seventy-four percent of the subjects could correctly state the setting location of the moon and eighty-five percent the rising position of the sun.

Rosemergy used analysis of covariance to test his data. He concluded that each of the three teaching arrangements is effective in increasing understanding of the apparent turning of the sky and phases of the moon, and that there is no significant difference in the understanding of selected astronomical phenomena between students who received instruction in the classroom and who made either one or two visits to the planetarium.

Astronomy content of tape recordings of thirty-eight school planetarium programs was analyzed by Curtin[15] to determine the answers to several key questions he posed. He wanted to know:

1. What specific grades visit planetariums?

2. Whether introductory literature is provided by planetariums which offer programs for school groups?

3. Whether follow-up literature is provided by planetariums?

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[14]Rosemergy, p. 135.

[15]John Curtin, "An Analysis of Planetarium Program Content and the Classification of Demonstrators Questions," (Unpublished PhD dissertation, Wayne State University, 1967).

4. Whether visiting classes are actually studying astronomy?

5. Furthermore, Curtin wanted to classify the type of question employed by planetarium demonstrators.

Several points of interest to this investigation, in addition to those cited in Chapter I, were discussed by Curtin. He stated that the time devoted to the display and discussion of constellations is approximately the same in programs presented to classes visiting a planetarium for the first time and in programs presented to those who have had previous planetarium visits. He further stated that although the time for constellation discussion is the same, there are more constellations displayed at programs offered to previous visitors.

In addition Curtin found that on an average there were 12.1 constellations identified per program. Curtin also pointed out that there was no consistent patterns discernable which would distinguish the display of individual constellations for grade level or type of visit - first or second. The following eleven constellations were the ones cited by Curtin as being the most often displayed by planetarium lecturers in the tapes he analyzed. The constellations are listed in order of most frequent mention by the thirty-eight planetarium demonstrators.

1. Big Dipper
2. Little Dipper
3. Orion

4. Pleiades
5. Gemini
6. Cassiopeia
7. Leo
8. Pegasus
9. Cygnus
10. Canis Major
11. Taurus

Wright undertook a research investigation in 1968 involving fifty-nine eighth-grade classes to study the effectiveness of teaching an astronomy unit with a planetarium visit as compared to teaching an astronomy unit without a planetarium visit.[16] The concepts taught in the planetarium were: celestial motion, constellations of the seasons, the appearance of the night sky from different latitudes and some principles of celestial navigation. The planetarium program, which lasted twenty minutes, was taped to insure uniformity of content and presentation.

It was concluded from the study that students made significantly larger gains on an astronomy achievement test by attending one planetarium program at the end of a classroom astronomy unit as compared to a classroom astronomy unit without a planetarium visit. Wright also called for

[16]D. L. C. Wright, "Effectiveness of the Planetarium and Different Methods of Its Utilization in Teaching Astronomy," (Unpublished PhD dissertation, University of Nebraska, 1968).

further research to investigate what concepts can be best presented in the planetarium and the grade levels at which these are most appropriately taught?

Reed[17] undertook his research in 1969 to evaluate the effectiveness of the planetarium as a teaching device. The planetarium teaching situation was compared to the classroom chalkboard and celestial globe teaching situation in the teaching of celestial astronomical concepts. The concepts presented were the diurnal and yearly motions of the stars, the superior planets and the sun, the celestial sphere and precession.

The experimental population consisted of 401 students enrolled in the one semester physical science course at West Chester State College. The population was divided into two parts - Total Planetarium Population and Total Lecture Population. Each of the above populations was further divided into subgroups. These subgroups were administered the Selected Astronomical Principles Test, developed by Reed, immediately following the presentation, or after a time interval of four, eight, or twelve weeks. The test results were analyzed statistically using a t-ratio.

From the results, the classroom chalkboard-globe situation was significantly superior to the planetarium teaching

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[17] George Reed, "A Comparison of the Effectiveness of the Planetarium and the Classroom Chalkboard and Celestial Globe in the Teaching of Specific Astronomical Concepts," (Unpublished PhD dissertation, University of Pennsylvania, 1970).

situation with respect to the immediate attainment of specified cognitive behavioral objectives and superior after intervals of time. In addition there was no difference in the affective domain between the chalkboard-globe teaching situation and the planetarium situation. Both teaching situations produced an increased interest and positive effort in the experiment topics.

The purpose of the study conducted by Battaglini[18] was to determine whether fourth-grade children enrolled in the Science Curriculum Improvement Study (SCIS)[19] program developed a greater understanding of concepts of relative position and motion than did non-SCIS fourth-grade children. For students being taught the SCIS program the concept of relativity at that time was usually presented at the fourth-grade level in an unit titled "Relativity." The unit consists of four parts. The first two parts deal with relative position and the last two with relative motion.

The study utilized a two group pretest-posttest design in which the experimental group had received the SCIS unit

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[18] Dennis Battaglini, "An Experimental Study of the Science Curriculum Improvement Study Involving Fourth Graders' Ability to Understand Concepts of Relative Position and Motion Using the Planetarium As a Testing Device," (Unpublished PhD dissertation, Michigan State University, 1971).

[19] The Science Curriculum Improvement Study is a course content improvement project supported by the National Science Foundation. The program was initiated in 1962 by Robert Karplus.

titled "Relativity" while the control group of fourth-grade pupils did not receive this unit of instruction.

In this study a planetarium orientated examination of thirty items was created by the investigator to test the students' abilities to understand the concepts of relative position and motion from examples that had not previously been seen in the classroom. The students were asked to imagine themselves in various viewing locations.

From the results of the investigation Battaglini concluded that the SCIS students as compared to their non-SCIS counterparts seemed to have a better comprehension of the astronomical concepts of relative position and motion as presented in the planetarium. In addition, the findings of this investigation confirmed previous research that the "Relativity" program orients children strongly toward spatial relationships.

The purpose of the study conducted by Ridky[20] was to determine the effect of planetarium instruction in terms of immediate attainment, attitude, and retention. One part of the study was to explore the possibility of a "mystic effect" associated with the planetarium. In his study "mystic effect" referred to a complex of attitudes and feelings

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[20]Robert Ridky, "A Study of Planetarium Effectiveness on Student Achievement, Perceptions and Retention," (Unpublished PhD dissertation, Syracuse University, 1973).

surrounding the planetarium facility and the conducted presentation, the awe and wonder of the experience.[21]

For this part of his investigation Ridky gave two comparable groups of students the Daily Motion Concept Test as a pretest to measure entering knowledge of the content objectives. One group was given an orientation session intended to familiarize students with the construction and operation of a planetarium. The following day both groups received a planetarium experience dealing with diurnal motion. Tape recordings were employed with the investigator operating the projector. The Daily Motion Concept Test was again administered and changes in content achievement scores were analyzed to determine the relative effectiveness of the orientation session on content achievement. From the data it was evident that the group which experienced the orientation session did significantly better than the group which did not. These results seem to support the hypothesis that a "mystic effect" is in operation which can significantly affect the achievement of content objectives.

In addition observations were made on three treatment groups at both the junior high school and college levels.

> Group I - Orientation session-three sessions dealing with concepts of celestial motion and two sessions dealing with time zones and the earth coordinate system.

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[21]Ridky, p. 10

Group II - Received instruction on the same concepts but through activity inquiries drawn from nationally prominent curriculum projects.

Group III - Experienced combined sessions of Groups I and II with concepts randomly assigned to the planetarium or classroom inquiry activities. The role of Group III was to determine if dimensions of retention, attitude and content achievement exist that can be reinforced by either treatments I and II.

Findings suggested that at the junior high school level a combined teaching approach utilizing student centered activities in conjunction with planetarium experiences is more effective than the exclusive use of either teaching procedure. In addition the study pointed out that the effectiveness of a planetarium appears not to lie in facilitating content achievement, but rather in effecting attitudinal changes. Student experiences in the planetarium should take into account the ability of the facility to positively change student perceptions or attitudes. These findings further suggest that it would be of greater benefit to develop planetarium experiences that deal primarily in the affective domain.

Ridky also called for further research to be made to ascertain which concepts to present at what grade level. "The appropriate procedures to employ should continue to be of practical benefit to those involved with the development of planetarium activities."[22]

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[22]Ridky, p. 102.

Sunal's[23] planetarium investigation centered around the need to evaluate goals of planetarium educators, which provide a basis for future decisions concerning the role and value of the planetarium in elementary education. That is to say to provide evidence to support the hypothesis, that preconceived goals of planetarium educators can be attained or, if not, to provide evidence to explain the nature of the influence resulting from a planetarium experience. The preconceived goals as stated by planetarium educators for elementary school age children involved in normal classroom instruction, as identified by Sunal, included the following:

1. Knowledge, Comprehension and Application areas of the Cognitive domain.

2. Receiving, Responding and Valuing areas of the Affective domain.

3. Inquiry Skills of Space Time Relations, Classifying, Communicating, and Inferring.

The conclusions reached in this study were based on the pre, post and delayed posttest performance scores obtained on a Planetarium Status Test developed by the investigator. Three different instruction experiences were tested involving 986 second grade students;

1. Experimental Group - Classes were involved in an astronomy unit and made one visit to the planetarium as part of the instruction. This was a two week unit.

2. Comparison Group - Classroom unit on astronomy only. This was a two week unit.

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[23]Dennis Sunal, "The Planetarium in Education: An Experimental Study of the Attainment of Perceived Goals," (Unpublished PhD dissertation, University of Michigan, 1973).

3. Control Group - No experience in an astronomy unit or planetarium unit.

Analysis of Covariance was used to analyze the data. The findings of the research investigation by Sunal include the following:

1. The students in the astronomy-planetarium unit experience, tested over a short period, showed significant gains in all goal areas when compared to students who had no instruction in astronomy or planetarium visit experience tested over a similar period. Thus, evidence was provided that children could attain the goals of planetarium educators.

2. The astronomy-planetarium unit experience did not produce results in any goal area which were significantly better than the astronomy unit experience.

3. Increased performance in higher order cognitive and affective goals occurred when the planetarium visit took place during the last half of a classroom astronomy unit, compared to other times.

4. The planetarium experience appears to perform as a remedial and reviewing agent changing student performance in a short period.

5. The planetarium affected equally significant change in all ability level students.

Dean and Lauck[24] did a planetarium investigation using two sixth-grade classes of students. They performed their investigation because they were skeptical of prior planetarium research which had used flat, two-dimensional, paper and pencil tests and so often had stated that the classroom was superior to the planetarium in teaching observational astronomy.

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[24]Norman Dean and Gregory Lauck, "Planetarium Instruction Using an Open-Sky Test," Science Teacher, XXXIX (May, 1972), 54-55.

For their investigation the control class was taught three consecutive lessons on observational astronomy using the chalkboard and celestial globe in the classroom. The same teacher presented the same lesson to the experimental group during three planetarium sessions. Each session in each treatment lasted forty-five minutes. Each test was administered orally and individually in the out-of-doors. In addition to other things each student was asked to point out with a flashlight: Cygnus, Pegasus, Lyra, and Cassiopeia.

The data was analyzed using the Fisher t. The results indicated a significant difference between the mean scores. The results in this case clearly demonstrate that the planetarium is superior in the teaching of observational astronomy when compared to the classroom.

Summary of Results of Planetarium Research Investigations

The results of planetarium education research to date are very puzzling. Several investigators including Dean, Lauck, and Wright offer results which indicate that the planetarium is more effective in teaching selected concepts of astronomy than a classroom and celestial globe teaching approach. Other investigators including Reed, Smith, Rosemergy, and Sunal concluded from their studies that the planetarium was no more effective as a teaching aid than the typical classroom, chalkboard and/or celestial globe.

Several factors could account for these differences. One is that the research investigations are constructed and executed by different individuals. It is theoretically possible for each of these investigators to exhibit behavioral tendencies potentially capable of influencing the experimental outcome toward preconceived judgements. In addition, the various researchers applied different treatments to the subjects. The time spent in the planetarium ranged from a limited number of visits to a more complete planetarium exposure for some of the groups. Another difference in the various investigations was that the subjects of the treatments varied greatly in age. This fact might imply that the effectiveness of the planetarium corresponds to patterns of age.

In addition, several conclusions, suggestions, and findings of importance to this investigation can be drawn from the results of planetarium education research conducted to date.

1. Constellations play a very important role in the planetarium presentations made to elementary school age children.

2. The identification of constellations has been used extensively in the testing of elementary school age children in various planetarium educational research studies.

3. No research has been performed to date to determine how elementary school age children learn to identify the constellations.

4. No research has been performed to date in the planetarium to assess the level of development of certain "skills" that are required of sky observers in the star chamber to identify the various star groups.

5. Some constellations are easier than others to identify by children.

6. There are an average of 12.1 constellations identified in a typical planetarium program.

7. All educational research completed to date in the planetarium has used group testing rather than testing individually.

8. The age groups which most frequently visit a planetarium are the fourth, fifth, and sixth-grade students.

9. Students enjoy studying the constellations.

10. The planetarium does make a significant contribution to the improvement of space relations aptitude.

11. Paper-pencil tests are often used as the primary instrument in investigating the effectiveness of the planetarium.

12. A "mystic" effect may have entered into the results of prior planetarium research.

13. Most of the planetarium research performed to date has been interested in comparing the effectiveness of the classroom to the planetarium in the teaching of astronomical concepts.

14. The planetarium can be used more effectively than the classroom to teach students to locate constellations in the out-of-doors.

Skills Required for Constellation Identification as Cited in Sky Guides

The results of planetarium education research indicate that children do enjoy studying constellations; however, no mention was given by any of the investigators as to the skills required by a student to identify the various star patterns. Therefore, the investigator had to survey various sky guides, which are often used by individuals seeking to find constellations in the night sky, as a means of ascertaining what skills are deemed necessary by the various writers for constellation identification.

The mastery of certain skills is necessary because whether one is looking at the real sky or in the planetarium at a replication of the night sky, confusion in working with the mass of visual stimuli will persist until certain skills are mastered by the sky observer that will aid him in the selective response to these stimuli. One of the first things that the sky watcher needs to become aware of is the number of stars that he can see. Most students overestimate the number of stars that they think that they can see in the sky.

Joseph and Lippincott state, "The experienced person with normal eyesight at a place where the sky is dark, can count about 2,500 stars during the course of a year. If your eyes are especially keen, you can count about 3,000 stars."[25] However, Bernhard purports, "Some 9,000 stars can be seen with the unaided eye all over the earth throughout the year, but only some 2,500-3,000 at any one time in any place."[26] Rey agrees with Bernhard's figures and adds, "That most of them are so faint they aren't even on our sky views."[27] Because of the variations in brightnesses of stars one of the first concepts that a student of the sky must master is an understanding of the brightnesses of stars.

Brightness Discrimination

In order to describe the brightness of stars, astronomers have divided those visible to the unaided eye into six magnitudes. This classification was devised by Hipparchus, who lived about 150 B.C. and made his observations on the island of Rhodes. "On a clear dark night, the unaided eye may detect stars as faint as magnitude five or six."[28] First magnifude stars are two and one-half times as bright on the average as those of the next group, which are called stars of the second magnitude, which are two and one-half times as bright as stars of the third magnitude, etc. "On the whole sky there are 65 stars of the second magnitude

[25]Joseph M. Joseph and Sarah L. Lippincott, Point to the Stars, (New York: McGraw-Hill Book Co., 1963), p. 7.

[26]Herbert J. Bernhard, Dorothy A. Bennett, and Hugh S. Rice, A New Handbook of the Heavens, (New York: McGraw-Hill Book Co., 1948), p. 16.

[27]H. A. Rey, Find the Constellations, (Boston: Houghton Mifflin Co., 1966), p. 27.

[28]Newton Mayall, Margaret Mayall, and Jerome Wyckoff, The Sky Observer's Guide, (New York: Golden Press, 1961), p. 22.

and there are 190 third magnitude stars."[29] Levitt[30] reports that brightnesses of stars are expressed even to the hundreth of a magnitude, although the eye can hardly distinguish differences of a tenth. Olcott[31] notes that in a short time the eye becomes trained to observe slight differences in the light of the stars, and the observer will be able to judge accurately the magnitude of any star in the sky. Baker identifies as one of the means of recognizing a star is by its apparent brightness. He writes, "If it was a very bright star, you can perhaps also remember its color, whether it appeared blue, or yellow, or red. The best way of all is to recall its place in a striking pattern."[32]

Orientation Skills

One of the most basic skills necessary for locating constellations is an understanding of directions. As Joseph and Lippincott state, "Once you are able to point to the 16 points of the compass at night, you will have mastered the most difficult part of pointing out the constellations."[33] Baker indicates that this is an easy task. He states, "If

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[29] Lou Williams, A Dipper Full of Stars, (New York: Follett Publishing Co., 1956), p. 20.

[30] I. M. Levitt and Roy K. Marshall, Star Maps for Beginners, (New York: Simon & Schuster, 1964), p. 11.

[31] William T. Olcott, Revised by R. N. Mayall and Margaret W. Mayall, Field Book of the Skies, (New York: G. P. Putnam's Sons, 1954), p. 45.

[32] Robert H. Baker, Introducing the Constellations, (New York: Viking Press, 1966), p. 26.

[33] Joseph and Lippincott, p. 20.

anyone is confused about directions at night when the stars are out, he has only to find the North Star. Facing this star, he is very nearly facing north, south is behind him; east to his right and west to his left."[34] Williams similarly asserts, "In order to find true north, we have merely to draw an imaginary quarter circle from the zenith, the point directly overhead, through the polestar down to earth. This will give the approximate location of true north. Having done this, we can easily find the other points of the compass."[35] Rey also feels that a sky watcher can find his directions at night without the help of a compass. "Leave your compass at home. You can find north easily without a compass if you know the Big Dipper. If you don't almost anybody can show it to you."[36]

Locating the constellations by use of directions is such a common practice that anyone serious about finding stellar objects has to go through various steps such as the following:

> Thus, to find star A, 16° 'south' of star B, draw an imaginary line from the pole star through B; then extend it 16°. East and West are at right angles to this line. West is always in the direction of a star's apparent motion as the evening progresses.[37]

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[34]Baker, p. 21.

[35]Williams, p. 13

[36]Rey, p. 19.

[37]Herbert S. Zimm and Robert H. Baker, Stars a Guide to the Constellations, Sun, Moon, Planets, and Other Features of the Heavens, (New York: Golden Press, 1966), p. 71.

> At nightfall in the early spring the Dipper stands on its handle in the northeast.[38]

> To find Sagittarius, locate a prominent constellation like Lyra with the first-magnitude star Vega. From there go due south until you have come close to the southern horizon. In that neighborhood you will see a group of stars that will remind you of the map of Sagittarius.[39]

It is interesting to note that the map that Reed refers to does not have any orientation given.

A few writers of observational astronomy use terms like above or below, right or left, up or down, when giving directions in the sky. These terms in themselves can be confusing in reference to the heavens. "Looking a good way below the belt we shall find Beta Orionis or Rigel."[40] In this case the correct position of Rigel may not necessarily be below the belt stars, the concept of below would vary depending on the constellation's location in reference to the meridian in the south.

Measuring Skills

Another basic skill that a sky observer must possess according to the writers of the sky guides is the ability to measure angular distances in the sky. If a constellation

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[38]Robert H. Baker, When the Stars Come Out, (New York: Viking Press, 1934), p. 28.

[39]Maxwell Reed, Patterns in the Sky, the Story of the Constellations, (New York: William Morrow & Co., 1951), p. 112.

[40]Julius Staal, Patterns in the Sky, (Atlanta: Econi-Co. Press, 1972), p. 59.

was to be named that was to serve as a standard in the sky for measurement it would have to be the Big Dipper. The angular distances between the stars of this star group are cited by numerous writers. As an example, Burritt writes:

> The names, positions, and relative distances of the stars in this cluster, should be well remembered, as they will be frequently averted to. The distances of Dubhe, or the Pointer nearest the north pole is 28 3/4°; the distance between the two upper stars in the Dipper is 10°; between the two lower ones is 8°; the distance from the brim to the bottom next to the handle is 4 1/2°; between Megrez and Alioth is 5 1/2°; between Alioth and Mizar 4 1/2°; and between Mizar and Benetnasch, 7°.[41]

Therefore, knowing a given angular distance, the observer is expected by the various writers to go from one object to another. Several examples will serve to point this out:

1. When the Pointers of the Dipper are near the meridian, the first-magnitude star Regulus is not far from that imaginary line. It is about 80° from Polaris.[42]

2. Follow the direction indicated by a line connecting these two stars and extending about five and one-half times as far beyond them, or about 28° and you arrive at Polaris, the North Star.[43]

3. From Rigel to Betelgeuse is 20°.[44]

4. A line drawn from δ to α Ursa Majoris and prolonged approximately 45°, ends near the brilliant first magnitude star Capella.[45]

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[41] A. N. Burritt, The Geography of the Heavens, (Hartford: F. J. Hunington, 1836), p. 86.

[42] Reed, p. 76.

[43] Williams, p. 9.

[44] Zimm, p. 71.

[45] Olcott, p. 79.

Not all distances are given in angular measurements. Sometimes the distances are stated in comparison of one distance to another. Olcott points out, "Procyon is equidistance from Betelgeuse in Orion and Sirius in Canis Major, and forms with these stars a large equilateral triangle."[46] A similar type statement is made by Bernhard as a means for locating the constellation Cassiopeia. "You might trace a line from the pointers to the pole and extend it an equal distance on the other side. There it will lead you close to a W-shaped group Cassiopeia."[47]

In addition, the sky observer is to understand the idea of altitude. Neely presents a method using the young sky observer's fist to estimate distances in the sky. "Your fist, correctly held, will measure 10 of these degrees. So you can use your fist to make a reasonable estimate of degrees either horizontally or vertically. Practice by getting 9 fists all the way up."[48]

As can be noted, many writers of the sky guides, that are used by sky watchers of all ages, expect an individual to have the ability to measure distances in the sky.

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[46]Olcott, p. 114.

[47]Bernhard, p. 18.

[48]Henry M. Neely, The Stars by Clock and Fist, (New York: Viking Press, 1966), p. 17.

Spatial Abilities

The investigator has evidence to support the statement that certain constellations are much easier to recognize than others in the planetarium sky by students. At the conclusion of a five week planetarium unit in astronomy conducted during October-November of 1972 in the Legg Junior High School Planetarium, Coldwater, Michigan, eighty-six percent of the 250 seventh-grade students involved in the unit could correctly identify the Pleiades while only twenty-three percent could name Sagittarius the Archer. Different degrees of difficulty were also observed for other constellations included in the study. The students were instructed in the planetarium three - forty minute sessions, each week during the unit. At this time various stars and constellations were pointed out with the pointer and various slide projections made to assist the students in learning the different companies of stars. In addition, each student received a vocabulary list of terms associated with their sky study.

To assist in determining what makes certain groups of stars easy to recognize, while others are more difficult, the students were given a survey to list their ideas at the end of the unit. Their responses as to easy versus hard as regards to constellation identification can be summed up in the following six categories.

	Easy	Difficult
1.	Clear and easy to see	Hidden away in the sky
2.	Shapes easy to recognize	Don't see shape
3.	Looks like what named	Don't look like they are supposed to
4.	Aren't a lot of stars in them	Has too many stars
5.	Quite little	Spread out so far
6.	Because they have small names	They have very long names which are hard to remember

That certain star groups stand out from others was also pointed out by Baker. "Certain star figures stand out prominently among their fellows."[49] He lists as most prominent the Big Dipper, Orion, the Pleiades, the Northern Cross, and the Scorpion. For the seventh-grade students involved in the astronomy unit seventy-nine percent could correctly identify the Big Dipper, seventy-six percent Orion, forty-nine percent the Northern Cross, and only forty percent Scorpius. Baker goes on to state, "Learning to know the stars is not unlike getting acquainted with people. Many people together look much alike at first. It is only as we meet the group of people a number of times that we distinguish between them, learn their names and ways, and make friends with them."[50]

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[49]Baker(1966), p. 76.

[50]Baker(1934), p. 25.

George Lovi asked, "What makes a constellation important? Is it brightness, size, a striking pattern, position in the sky, mythological lore, or astronomical features? Probably these all contribute especially in such superb groupings as Orion."[51] Roy K. Marshall[52] also believes that some of the constellations demand our attention by the brilliance of their stars alone while others are attractive because of their patterns of more modest stars.

There are many different opinions offered as to where an individual should begin their investigation of the skies. Porter[53] feels that an individual should begin his study with the zodiacal constellations since they follow each other in a continuous belt around the sky. Yet Baker[54] feels that an individual must choose some familiar pattern as a starting point and gradually work their way from one star group to another. He feels the Big Dipper is probably the best place to begin. Olcott[55] adds that the identification of each constellation depends on a knowledge of constellations that precede it in the order given.

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[51]George Lovi, "Rambling Through March Skies," Sky and Telescope, XLV (March, 1973), 170.

[52]Roy K. Marshall, "Rambling Through July Skies," Sky and Telescope, XLII (July, 1971), 30.

[53]Jermain Porter, The Stars in Song and Legend, (Boston: Ginn & Co., 1901), p. 26.

[54]Baker (1966), p. 104.

[55]Olcott, p. 41.

Several limiting factors have been cited by the various writers to bar the successful identification of a star figure. Ray[56] asserts that most of the constellations never come to life since they do not resemble their names. Neely adds the aspect of motion as a limiting factor to success when he writes, "The so-called 'fixed' stars seem constantly to be moving across the sky every night. They rise and circle and set much as the sun does. For that reason alone, every star would be in a different position every hour throughout the night."[57] This would involve the star watcher in the skills of search, detection, and in tracking the various star groups during the course of an evening's observations.

Another very important fact to consider is that star groups seem to do acrobatics in the sky. In referring to the Northern Cross Olcott relates, "...the Northern Cross rises lying on its side. It is a perfect cross and a beautiful figure. The cross is seen to best advantage in winter as it assumes an upright position."[58] Joseph and Lippincott warn their readers about the same problem by stating, "When a constellation is seen near the western horizon, it will appear upside down in comparison with the way it looks when

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[56]H. A. Pey, The Stars a New Way to See Them, (Boston: Houghton Mifflin Co., 1967), p. 10.

[57]Neely, p. 11.

[58]Olcott, p. 138.

it appears on the eastern horizon."[59] Still further comments on this problem, "Cassiopeia is an outstanding constellation low over the northern horizon in Spring in the shape of a W, but high in the zenith in the Autumn shaped like a letter M."[60]

In addition the searcher of the skies must understand such spatial concepts as right-left, above-below, and top-bottom. "The Dippers are so arranged that when one is upright the other is upside down, and their handles extend in opposite directions."[61] "...some star hero may be standing on his feet when he is rising in the east, and standing on his head when he sets in the west."[62] Confusion as to right-left orientation is apparent even in the minds of the sky guide writers. Bernhard[63] notes the fact that Betelgeuse is in the right shoulder or Orion while Rey[64] claims a left shoulder location for this bright stellar object. Perhaps Rey is confused about the front-back orientation of the pictures in the sky. For Betelgeuse is in the right shoulder of the Hunter.

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[59] Joseph and Lippincott, p. 22.

[60] Staal, p. 22.

[61] Bernhard, p. 18.

[62] Reed, p. 25.

[63] Bernhard, p. 34.

[64] Rey(1967), p. 46.

One additional thing needs to be mentioned in regards to hunting for the constellations in the sky. This deals with the aspect of size (bigger-smaller) in the sky. One only has to watch the sunset or the full moon rise to get the feeling that the sun, moon, and for that matter the constellations seem much larger near the horizon than when they are high up. Rey cautions the novice sky watchers of this when he writes, "Just watch, say, Cassiopeia at nightfall in August, low in the sky; it looks quite large; at midnight, about half way up in the sky, it will look smaller, and even smaller before dawn when it is almost overhead."[65] Also, the constellation hunters must realize that the constellations in the sky will appear huge in comparison with their tiny likenesses on star charts.

Star Maps

To become familiar with the heavens one needs to employ the use of some sort of sky chart. However, as pointed out by Zaddle and Smits,

> There is no end to star maps and devices purporting to acquaint the beginner with the constellations, without a knowledge of which enjoying the sky is impossible, but they are so designed that they are of value only to those who already know the constellations. Some of them serve their purpose, but generally lack a deffnitive system that would make the identification of the stars and constellations easy for the beginner.[66]

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[65] Rey (1967), p. 70.

[66] Arthur Zaddle and Theodore Smits, Making Friends With the Stars, (New York: Barnes & Noble, 1964), preface viii.

There are star maps such as the type developed by Zimm[67] which just show the shapes of individual constellations. All of the constellation figures displayed by Zimm are pictured upright and there is very little orientation given the reader. Other sky charts show the whole sky in two large wheels. This would be the view of the sky if you stood at the North or South Pole. Levitt comments on this type of chart, "Too many such charts showing all of the sky in circular form, with the pole or zenith in the center, or half the sky as half of a circular disk, with the zenith at the top, have been circulated with too little regard for the possibility of practical use by the beginner."[68]

In addition, many star charts add lines connecting the individual stars together. The various writers assert that this will aid the observer in the recognition of the star pattern. "The lines connecting the individual stars of the constellations have been put in to help you in the recognition and memorization of the outstanding patterns," relates Menzel.[69] Some writers, such as Rey[70] present each sky view as a double page. The left page in Rey's book shows the stars only, without lines, and the right-hand page shows exactly the same

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[67]Zimm, p. 51.

[68]Levitt, p. 6.

[69]Donald Menzel, A _Field Guide to the Stars and Planets_, (Boston: Houghton Mifflin Co., 1964), p. 6.

[70]Rey(1966).

stars but with lines connecting them. Rey reiterates the feelings of others as to the purpose of the lines connecting the stars.

Being able to orientate the star chart in relation to the sky in itself is a very difficult task. This is due in part to the constant shift of the star figures from hour to hour and from night to night. Therefore, the location of the star patterns in the sky will be different than what is noted on the majority of star maps. However, some beginners use a planisphere to compensate for the dynamic aspects of the sky in their learning of the constellations. "One type has a 'wheel' on which is printed a map of the constellations. The wheel is rotated within an envelope that has a window. When the wheel is set for any particular month, day, and hour, the window shows the positions of the constellations at that time."[71]

Another factor to consider in the use of a star map by a beginner is the requirement that you look up--not down--at a star map. This results in the directions noted on the star chart to be just the opposite of their position on a land map. That is east will be on the left side of a star map and west on the right.

The last task involving the use of maps is to match stars listed on the map with those visible in the sky. The

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[71]Mayall, p. 11.

observer must learn how to "see" the constellation group. "This is not easy to do, especially if your eyesight is keen and you are away from the city lights, an overwhelming number of stars are seen under these conditions."[72] The observer must be able to group the appropriate stars making up a particular stellar pattern in the sky. "It has been found that the human eye can be taught to discern an object hidden in a picture by directing the observer's attention to its outline."[73] The individual must be able to see the whole configuration to be successful.

Olcott feels, "The hours of darkness alone limit the speed with which a knowledge of the constellations can be acquired."[74]

Summary of Survey of Sky Guides

The skills most often identified by various writers of sky guides as necessary to successfully locate objects in the sky include the following: 1. the ability to discriminate between the brightnesses of stars, 2. the ability to work with the cardinal points of direction (orientation skills), 3. the ability to measure distances in the sky, 4. the ability to work with spatial concepts, and 5. the ability to scan the sky for a target. These are the skills that must be included and tested in the Planetarium Skills Evaluation Test.

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[72]Joseph and Lippincott, p. 18.

[73]Joseph and Lippincott, p. 19.

[74]Olcott, p. 41.

Educational Research

Five skills were identified by the various writers of the sky guides as necessary to successfully locate objects in the sky. Therefore, it is of utmost importance that a planetarium educator know if certain age groups already possess these skills or if he must make a special effort to teach them. Of interest to this investigation is the level of development of these skills in fifth-grade students. What has educational research to offer in relation to the five mentioned skills.

Brightness Discrimination

As a student looks around his environment, it becomes obvious that his visual world is made up of an array of objects, surfaces, and spaces that have different apparent brightnesses. The student of the sky soon realizes that the same star appears a different brightness depending on the circumstances under which it is viewed. The star Vega may appear dazzling bright at night and yet barely noticeable as dawn approaches. This same star may appear a different brightness yet at another viewing session when the child observes it with a full moon shining above the horizon.

"Brightness discrimination is the ability to determine the just noticeable difference between the gray of a solid shape and the gray of its background."[75] For that matter the

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[75]James J. Gibson, The Perception of the Visible World, (New York: Houghton Mifflin Co., 1950), p. 110.

ability to determine the just noticeable difference in brightness between two illuminated objects. Hurvich and Jameson report that the observer's sensitivity to luminance differences varies with increases in luminance, "...and we see that his difference sensitivity is high at the low luminances and drops rapidly as the luminance increases."[76]

Clifford and Calvin[77] did an investigation dealing with discrimination learning in elementary school children grades K-5. The subjects were tested with discrimination problems involving either color or brightness. The results indicate that problems with color were significantly more difficult for the students than those dealing with brightness. Fifty-eight percent of the kindergarten students failed the brightness test while only twenty-five percent of the third-graders did.

In addition Burg[78] studied 17,500 subjects to determine light sensitivity as a function of age and sex. Burg was interested in the visual function of the night driver. The subjects included in the investigation were age 16-92. Burg revealed that after a slight initial decrease there is

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[76]Leo M. Hurvich and Dorothea Jameson, The Perception of Brightness and Darkness, (Boston: Allyn & Bacon, 1966), p. 48.

[77]Thomas Clifford and Allen Calvin, "Effect of Age on the Discriminative Learning of Color and Brightness by Children," American Journal of Psychology, LXXI, 766-767.

[78]Albert Burg, "Light Sensitivity as Related to Age and Sex," Perceptual and Motor Skills, XXIV (June, 1967), 1279-1288.

a progressive increase in illumination level required for target detection as age increases. He noted no consistent difference in performance between males and females.

From the data surveyed there is no reason to believe that fifth-grade students can not discriminate between the brightness of stars. Also, it's reasonable to assume that there will be no sex differences in ability to discriminate the brightness of stars.

Orientation Skills

If one listens to the conversations of young students, he often hears them use expressions such as, "He went that a-way." Very rarely do students ever refer to the cardinal points of direction. One is led therefore to believe that students are unaware of or at least do not intentionally use the cardinal point reference system for describing the location of an object. Yet, the points of a compass provide a most usuable reference system for directions. Therefore, do students have an understanding of the compass points? If so, at what age does this become apparent? Do students use the position of the sun or a shadow to assist them in determining their position with reference to the cardinal points?

A study was conducted by Howe[79] to discover what knowledge elementary school children have of directions both in space and on a map. On sunny days kindergarten through

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[79]George F. Howe, "A Study of Children's Knowledge of Directions," Journal of Geography, XXX (October, 1931), 298-304.

third graders were taken out-of-doors and asked to point to the north, the child was then asked how he knew that the direction he pointed to was north and his reason recorded. Howe included this age group in his study to determine what concepts this age group had regarding directions before the subject was taken up in the third grade. Howe relates the following conclusions:

> 1. Children do not know directions as well as had commonly been supposed.
>
> 2. Children do not acquire a knowledge of directions to any great extent outside the school before taking up the study of geography, as shown by the fact that from kindergarten through the second grade there were more who did not know directions than those who did.
>
> 3. In grades three through six more children were right than wrong but there was a large number of errors. This would tend to show that children have not been taught directions systematically, thoroughly, and accurately.
>
> 4. Children seem to have acquired the wrong associations in determining directions, thinking in terms of local objects rather than natural phenomena.
>
> 5. Boys apparently know directions better than girls. However, this difference may be more apparent than real.[80]

Howe continued his study[81] by having several teachers instruct a ten week unit on direction finding to students in grades one, two, and three. The unit involved the use of the sun in determining one's position in relation to the cardinal

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[80] Howe, p. 303.

[81] George Howe, "The Teaching of Directions in Space," Journal of Geography, XXXI (May, 1932), 207-210.

points of the compass. The students were instructed in the out-of-doors away from the school building. At the end of the ten week unit the students were tested individually. More than fifty percent of the first grade pupils gave correct answers with an increase to seventy-five and eighty percent in grades two and three respectively. His results demonstrate that children can acquire a clear concept of direction in space. Howe concludes by purporting that he feels that directions should be taught outside of the classroom in order to exclude the probability of association with local objects and that third grade seems an ideal time to begin an introduction to the topic.

Smith[82] studied directional orientation in seventy-six children, ages 4-12, and ten adults with an average age of 31.7 years. The subjects (blindfolded and facing due north) were individually asked to give forty responses to the eight principal points of direction. The procedure consisted in moving a stylus as rapidly as possible from the center of a compass-like dial by means of which size and direction of errors could be recorded. Smith's results indicated that the four and five year old child is very poorly orientated to the cardinal points of the compass and that the greatest gain in understanding occurred during the seventh and eighth years. From age eleven onwards there is a very slight difference in

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[82]Wiley F. Smith, "Direction Orientation in Children," Journal of Genetic Psychology, LII (1933), 154-165.

the extent of errors between the eleven-year group and adult. The speed of response also increased with age.

Lord[83] conducted a study of geographical orientation in children, using 173 boys and 144 girls. She tested their ability (1) to point to cardinal compass points and distant localities, (2) to indicate the directions of local features in the town, (3) to draw maps, and (4) to maintain a sense of direction when traveling about. This last test was conducted by driving the children at 20 miles per hour round a two mile course in the city of Ann Arbor, stopping now and again to test the subjects' ability to indicate north and the directions of the previous stopping places. Half the children were 'lost' before the first stop. Boys performed better than girls on all tests. She also indicated that children who normally sat facing north in school performed better on the tests than children who sat facing other directions. Lord stressed the need for better teaching of geographical orientation.

It was reported from a study conducted by Gregg[84] at Nebraska Wesleyan University involving college students that when a subject is trying to respond to a question dealing with right-left directions, they either shift their body or move their eyeballs in processing their answers. The

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[83] F. E. Lord, "A Study of Spatial Orientation of Children," Journal of Education Research, XXXIV, 481-505.

[84] F. M. Gregg, "An Important Principle in Teaching Primary-Grade Geography," Elementary School Journal, XLI (May, 1941), 665-670.

investigator indicated that a movement of the eyeballs was done by the subjects who were very dependent on an imagined map aiding them in their responses.

Gregg continued his study, relating to directions, with primary school children in five elementary schools in Lincoln, Nebraska. One hundred kindergarten children were asked to point to the direction of their homes. Out of the hundred subjects all but five could point to the direction of their homes, but only seven knew all the cardinal points of direction, forty-eight knew two directions with certainty, while twenty-five knew only one direction. The author indicated that parental training was responsible for the seven subjects knowing their directions since they had received training at home. In addition, Gregg disclosed that somewhat fewer than half of the first-grade pupils knew the cardinal directions and only a little more than half of the second-grade pupils knew them.

Four hundred and fifty students of age nine years to fifteen years were involved in a study by Edwards[85] to determine how well intermediate school children are orientated to space. Only the part of the study dealing with the cardinal points of the compass is of importance to this investigation.

Thirty-three items based on the cardinal points of the compass were asked the students. A simple outline of

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[85]John Edwards, "How Well Are Intermediate Children Orientated in Space?" Journal of Geography, LII (April, 1953), 131-144.

Pennsylvania was used, with letters in the four corners and center, and five numbers. The following exemplify the type of questions asked by Edwards relating to the compass:
"The letters in the northern part of the map are..."[86]
"If an airplane flew from A to C, it would be flying..."[87]

Of the items concerned with the cardinal points of the compass there was sixty-five percent achievement by fourth, sixty-seven by fifth, and eighty-seven percent achievement by sixth graders.

A test of topographical orientation and seven other tests were administered by Clark and Malone[88] to 242 Naval Aviation Cadets to study the types of errors in orientation they make, to identify the factors which contribute to this type of disorientation, and to determine what relation there is between topographic orientation and certain other psychological factors. They found that topographical orientation appears to be an unique characteristic which is independent of factors such as mathematics, spatial orientation, and spatial visualization. In addition, Clark and Malone found that there was no relation between topographical orientation and age or intelligence of the cadets studied. Their results

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[86]Edwards, p. 135.

[87]Edwards, p. 136.

[88]Brant Clark and R. Daniel Malone, "Topographic Orientation in Naval Aviation Cadets," Journal of Educational Psychology, XLV (February, 1954), 91-109.

also indicated that the less the cadets had traveled prior to the tests the poorer they did when compared to the groups who traveled more. Another interesting point reported by the investigators was that persons with lesser amounts of schooling did better on the tests of topographical orientation.

Four questions were used by Preston[89] to compare the knowledge of directions in 400 German and 600 American sixth-grade children. The four questions were from a German group intelligence test known as Testheft B. The subjects were selected on the basis of intelligence to participate in the study. From the results of the study the American children exceeded the German children in knowledge related to bodily position, the cardinal directions, and the sun.

Even though the American children exceeded the German children in their ability to note directions, the American students' absolute knowledge was limited. Seventy-eight percent of the bright students and only 43 percent of the lower group of students could correctly state the direction that they would be traveling after having turned left onto a street from one on which they had been traveling toward the east.

When asked the question, "When I arise in the morning, the sun shines through my bedroom window upon a closet in the middle of the room facing the door, the closet is to my right.

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[89]Ralph C. Preston, "A Comparison of Knowledge of Directions in German and in American Children," The Elementary School Journal, LVII (December, 1956), 158-160.

In which wall is the door (north wall, east wall, south wall, west wall?)[90] Only 38 percent of the bright and 29 percent of the lower group could correctly identify the appropriate direction.

It can be concluded from the studies presented that many educators tend to overestimate the ability of a child to know the directions. Even within a given age group there is a wide variance in ability demonstrated. In addition, research indicates that the ability to know the directions must be taught and that instruction is best given in the out-of-doors. The third grade seems a reasonable place to initiate instruction. One study indicated that the greatest gains in the ability to find directions occurred during the ages of 7-8 and there was not much change in ability beyond the age of eleven. Several writers also indicated that the ability to know the directions was not related to intelligence but may or may not be related to sex, especially in the early stages.

Measuring Skills

Since the early 1960's several of the new programs initiated in elementary school science stress as a part of the total program the process of measurement. Many of the ideas included in these programs are a result of the research conducted by Jean Piaget. Jean Piaget has been very interested

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[90] Preston, p. 159.

in the topic related to the formation of concepts in children. Piaget employs a research technique which includes a combination of observations and interview. Piaget often follows the lead of the child's responses and makes a verbatim record of the interview. Piaget then uses his data to obtain age levels for the attainment of certain concepts by children.

"In assessing the degree to which a child has acquired a concept, Piaget often uses the criterion of conservation."[91] For Piaget conservation of a relationship means that once a relationship such as a one-to-one correspondence is constructed and acknowledged it remains valid even though it is no longer perceptual. It is permanent and does not change.

Measurement, like many of the other concepts developed by young children, depends upon certain conservation and awareness of units. Piaget makes a distinction between the terms distance and length in reference to measurement.[92] The space between two points which is empty is referred to as distance by Piaget and where occupied by some material he calls this length. Since most of the measurements made in the planetarium sky are between two stars with an empty space in between, the ability to measure distance by children is

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[91] Daiyo Sawada and L. Doyal Nelson, "Conservation of Length and the Teaching of Linear Measurement: A Methodological Critique," The Arithmetic Teacher, XIV (May, 1967), 345.

[92] Arthur Coxford, Jr., "Piaget Number and Measurement," The Arithmetic Teacher, X (November, 1963), 423.

very important. Coxford[93] sums up Piaget's findings related to the ability of children to measure distances in space. Coxford points out that up to approximately the age of five there is no conservation of distance made by children; however, between the ages of six and seven there is an occasional conservation of distance and by ages seven to eight there is a conservation of distance present. A child can finally recognize symmetry such as AB=BA.

Also important for planetarium educators to consider in relation to measurement is the idea related to visual transfer of length, that is judging two lengths to be the same by looking at them. Coxford also reports Piaget's findings regarding this. For the age group up to age five there is no visual transfer of length, all lengths look the same. By age eight however a child is able to transfer by means of an object (independent of his body) the association of longer or the same length as the object to be measured.

A great number of experimental studies have been carried out in the U.S. to verify the results of Piaget for American children. Through such studies many of Piaget's findings have been corroborated. As an example, Sawada and Nelson[94] conducted an experiment studying the property of conservation of length in young children. They found that

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[93]Coxford, p. 423.

[94]Daiyo Sawada and L. Doyal Nelson, p. 345-348.

nearly 100 percent of the children between the ages of 7 years, 2 months and 8 years, 0 months were conservers of length. They concluded from their study that the threshhold age for the acquisition of length is between five and six. From the results of this and many other investigations dealing with conservation of length and transitivity it seems reasonable to assume that fifth-grade boys and girls will be able to estimate and compare distances in the planetarium sky.

Spatial Abilities

The importance of a stable space world can scarcely be over-estimated. It is through space and spatial relationships that children observe the relationship between things or objects in their environment. Space is used to observe similarities and differences between objects. Children have no direct information concerning spatial relationships in their environment. All of their information concerning spatial localization comes to them through some clues which must be interpreted to give them concepts of space. Kephart states, "Space is essentially a concept developed in the brain."[95]

Ames and Learned[96] did an investigation that dealt with a child's verbalized manifestations of the sense of space from the ages of 18 through 48 months. These investigators observed

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[95]Newell C. Kephart, The Slow Learner in the Classroom, (Columbus, Ohio: Charles E. Merrill Publishing Co., 1971), p. 143.

[96]Louise Ames and Janet Learned, "The Development of Verbalized Space in the Young Child," The Journal of Genetic Psychology, LXXII (1948), 63-84.

young children at play in a nursery. They also asked these same young children individually a set of questions dealing with various aspects of space. Their findings are very interesting.

By eighteen months a child uses the space words up, down, and off. For the child these words are used in respect to his own basic movements in space. Words such as come, go, and gone refer to the presence or absence of objects in which he is directly interested. The use of the size word "big" appears in the vocabulary of the twenty-one month old child for the first time. Thirty-six month old children are beginning to use words that express an increased refinement in space perception: back, corner, over, from, by, up on top, and on top of. This age group is beginning to state direction as turn left and then turn right, etc. A four-year old child is beginning to use expansive space words as a group, words such as: on top of, far away, out in, down to, way up, and way up there. A new space dimension is suggested when the four-year-old child uses the word "behind." By four the child could tell the investigators the street and city where he lived.

According to Piaget and Inhelder[97] a child's concept of space develops in two main stages. In preschool years the child's ideas of space are primarily "topological." That is

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[97] J. Piaget and B. Inhelder, The Child's Conception of Space, (London: Routledge and Degan Paul, 1956).

to say, the child discriminates categories which include the concepts of proximity, separation, sequence, enclosure, and continuity. These categories provide the basis for perception of an object. The child may be able to distinguish perceptually between say, a square and a circle, but this does not mean the child can conceptualize this difference, or marshall the operations which are necessary for making anything more than a perceptual distinction. It is not until the second stage of development--referred to as the stage of "projective space"--that the child develops the ability to locate objects and their configurations relative to one another with a general system of relations, as well as being able to locate objects in terms of the co-ordinate axis. This second stage begins at about school age, and it is during this time that a child comes to understand such spatial concepts as below and above, left and right, before and behind.

Anastasi and Foley[98] report that in most tests involving verbal skills, and also in some tests involving memory, girls are consistently better than boys. But boys do better in most tests involving arithmetical or numerical manipulation and spatial relationships. Nash[99] reports a review made by Oetsel

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[98]A. Anastasi and J. P. Foley, Differential Psychology, (New York: Macmillan Co., 1953).

[99]J. Nash, Developmental Psychology: A Psychobiological Approach, (Englewoods Cliffs, New Jersey: Prentice-Hall, 1970).

in 1962 of twenty-six studies concerned with some aspect of cognitive development. Oetsel was interested in the sex differences in these studies. Oetsel found in these studies that in numerical reasoning and spatial abilities, boys were markedly and consistently superior than girls in these skills. Also, the sex differences are not peculiar to any social or economic class. The same sex differences have been found in West Kenya and Southwestern Kenyian boys and girls. (Monroe, 1971 and Nerlove, 1971).

By fifth grade a child has participated in many experiences that has added greatly to his concept of space. His idea of space has developed through interactions between gravity (the vertical axis), laterality (the horizontal axis), and depth perception (the fore and aft axis) of the Euclidean Spatial System. Therefore, the ability to work with spatial concepts should be manifested in fifth-grade children. In addition, from the findings of educational research boys should be superior to girls in performing space related tasks.

Scanning Skills

Another very important aspect to be considered in assessing the skills that one must possess to successfully locate the constellations is what is commonly referred to as visual search or detection of an object. This skill is not stressed by any of the writers of sky guides but must be included as one of the skills necessary for a student to be proficient. There have been no studies yet completed to determine how rapidly an elementary-school child can scan a section of the sky for an object or given set of objects required of him to locate. A planetarium educator must have knowledge of this in order to know how rapidly to present material to students of various ages in the planetarium sky.

Such things as brightness, density, or striking star patterns are some of the things the eye might fixate on as it searches for a given target in the planetarium sky. "The visual field shifts whenever the eyes are moved from one fixation point to another, since the eyes normally play over the visual environment in much the same way that a search light moves over a night sky except that light is being absorbed by this instead of emitted."[100]

Although there have been no studies completed that are directly related to the scanning abilities of school-age children in the planetarium, there have been numerous studies made directed to the topic of visual search and the results of such studies might be used to draw inferences which would be relevant to this investigation.

It was reported in a publication from the National Academy of Science[101] that as the difference in size of targets and non-targets decreased the search times increased for

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[100]Gibson, p. 29.

[101]National Academy of Science, Visual Search, Washington, D. C., 1973.

both regularly and irregularly arranged stimulus displays. In addition it was reported that the more different in value an object was from the target, the less often the eye fixated on it. It seems that targets at the high extreme of a continuum (e.g. largest or of greatest contrast) are most discriminable from other objects.

Leslie and Calfee[102] studied forty-eight second, fourth, and sixth-grade students of high and low reading ability and eight undergraduates in a visual-search task. The subjects scanned a list of ten words, looking for a target word which was changed every trial or remained constant through the session.

The investigators discovered that search time increased linearly with serial position. The search rate increased from 3.3 words per second in second grade to 8.4 words per second in college. It was also revealed that reading ability was not a significant factor in any comparisons.

Brown and Strongman report that the stimulus factors which might affect the process of visual search can be divided into three main categories: "1. type of target material, 2. type of context material, and 3. general mode of presentation of stimulus material."[103] Their

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[102]Ron Leslie and Robert Calfee, "Visual Search Through Word Lists as a Function of Grade Level, Reading Ability, and Target Repetition," Perception and Psychophysics, X (September, 1971), 169-171.

[103]Robert Brown and Kenneth Strongman, "Visual Search and Stimulus Orientation," Perceptual and Motor Skills, XXIII (October, 1966), 539-542.

investigation dealt with the last category. Their research investigation demonstrated that faster visual search times were produced using horizontal rather than vertical arrangement.

In addition Neisser and Beller[104] reported that visual search tasks that required memory examination when compared to a target which is a known word required a greater amount of time to accomplish.

The impetus for the last study to be described was the need for data related to the detection time associated with the onset of a point source of light seen against a star field with and without a veiling source present. The study was conducted by Haines[105] in the Abrams Planetarium at Michigan State University in 1967. The research topic had many applications for space flight.

Seventy-four males and fifty-three females of college age took part in the study. The subjects were to detect as rapidly as they could a point of light, as bright as a first magnitude star, projected in various locations in the planetarium sky. The stimuli which each group of observers had to detect were exposed individually at random intervals

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[104]U. Neisser and H. K. Beller, "Searching Through Word Lists," British Journal of Psychology, LVI (1965), 349-358.

[105]Richard F. Haines, "Detection Time to a Point Source of Light Appearing on a Star Field Background with and without a Glare Source Present," Human Factors, X (October, 1968), 523-530.

approximately every twenty seconds. Each point of light remained on for ten seconds. Each test spot image subtended a fifteen minute arc diameter. The glare source was a 110 watt projection lamp shown through a 30° arc diverging lens system in the direction of the group of observers.

Each observer held his own micro-switch and was instructed to release it the instant he detected a new "star" in his visual field. Three viewing conditions were studied by Haines: 1. No star background and no glare source present (control condition), 2. Star background and no glare source present, 3. Star background and a glare source present.

From the mean of all tests it was found that to detect a point of light with no star background and no glare resulted in the fastest time. On an average it took 530 milliseconds to detect a test object under these conditions. In a starfield a longer amount of time was required to locate the target, on an average 783 milliseconds, which was about one and one-half times the amount of time required for detection in total darkness. To locate an object in a starfield when observations were interferred with by the glare source took three times the amount of time required under control conditions, on an average of 1,674 milliseconds.

Haines points out that detection time should be less on the dark side of an orbit than that found on the day side of the orbit for an astronaut. "Finally it can be pointed out that if the star or target vehicle to be detected is stationary with respect to the star background the present study has shown that detection time increases significantly over that of the totally dark control condition. However, if the star or target vehicle is moving with respect to the star background there is evidence to show that detection time will decrease when compared to the stationary stimulus condition."[106]

From the results of the studies examined it can be seen that visual search times vary depending upon the requirements of the task. The more discriminable the objects the faster the visual search times. Also, when the memory is required as part of the task a greater amount of time is required. Then, too, visual search times decrease as age increases for many tasks. In addition, reading ability does not seem to be a significant factor in comparison of scanning rates. It seems plausible to assume that fifth-grade students can scan a portion of the planetarium sky for a given target or set of targets as required in a short amount of time.

Summary of Educational Research

Educational research has demonstrated that for a child to have an understanding of directions, he must be taught this; and many educators overestimate a child's ability to work with directions. The best instruction is made in the out-of-doors. Sex differences favoring males are probably present.

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[106]Haines, p. 528.

By fifth grade more than fifty percent of the children know directions. Brightness discrimination is learned at a very early age. There are no sex differences in ability and fifth-grade students can discriminate between the brightnesses of stars. Educational research also indicates that fifth-grade students are able to measure distances in the planetarium. Also, it can be noted from the findings of educational research that visual search times vary depending upon the requirements of the task. The more discriminable the objects the faster the visual search times. Visual search times decrease as age increases. Fifth-grade students can successfully scan the sky for objects. Then, too, the ability to work with spatial concepts is present by the age of the fifth graders. Therefore, fifth-grade boys and girls can work with spatial concepts in the planetarium; however, boys should be superior to girls in tasks that require spatial abilities in the planetarium.

The Teaching of Constellations in the Classroom

One has only to survey the professional literature for a short time to soon find that numerous articles have been written to suggest activities to employ when studying constellations in the classroom. The activities can be grouped into six categories.

Bulletin Boards and Displays

Spiero[107] suggests that different constellations be set up on a flannel board so that the students could study them. Lowey[108] mentions his success in putting constellations on the ceiling of the classroom. He wrote that each star was of proper color and size to correspond to magnitude. The use of a frieze showing some well-known constellations and city sky line was offered by Coffin[109] and Spiero[110] for use by students in learning the constellations. An additional activity involving the use of a bulletin board was suggested in the Teacher's Guide to the Strassenburg Planetarium.[111] It was suggested that different constellations be placed on a bulletin board and the students race to match the names with the constellation pictures.

Viewers

Coffin and Heisman[112] told of involving their students in the construction of individual constellation peep boxes.

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[107] G. O. Spiero, "Star Gazing with a Purpose," Instructor, LXIV (March, 1955), 81.

[108] Stan Lowey, "The Stars Overhead," Science Education, XLVI (March, 1962), 145.

[109] Florence Coffin and Richard Heisman, "Astronomy," Grade Teacher, LXXIII (January, 1956), 49.

[110] Spiero, p. 81

[111] Teacher's Guide to the Strassenburg Planetarium, (1968), p. 71.

[112] Coffin and Hesiman, p. 49.

Blitz[113] had students make slide cards for different constellations and then build a constellation viewer out of an oatmeal box. Furthermore, Coffin and Heisman[114] suggested construction of a planetarium. They indicated that it was necessary to build it large enough to permit students to enter. They also recommended for teachers to make reproductions of the seasonal skies with luminous paint to aid children in the study of star positions.

Projections

Another idea to use in the study of constellations was offered by Coffin and Heisman.[115] They suggested that students make tin can projectors of different star patterns. Another idea involving the drawing of the constellations on a sheet of paper and then punching small holes for stars to be projected with the overhead projector was advocated by the Strassenburg Planetarium.[116] Hainfield[117] urged teachers to photograph constellations from india ink drawings and then show them in the classroom. Outlining constellation shapes according to legends and then projecting

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[113] Theodore Blitz, "Let Stars Get In Their Eyes," Grade Teacher, LXXVI (November, 1958), 122-123.

[114] Coffin and Heisman, p. 49.

[115] Coffin and Heisman, p. 49.

[116] Strassenburg Planetarium, p. 72.

[117] Harold Hainfield, "Seeing Stars," Journal of Education, CXXXVII (November, 1954), 19.

them with the opaque projector was suggested as an activity by Spiero.[118]

Races

Spiero[119] suggested as a constellation activity a star relay. For the relay each child in each of two teams has a large paper star. The teacher calls out a familiar constellation, and the teams then race to see who can first form the constellation correctly. On the other hand Darnell[120] had the students form constellations by use of flashlights. In this activity each student had a flashlight and took their position as the name of the constellation was called.

Telling Time

Branley[121] in an article dealing with the Big Dipper suggested the use of the Big Dipper in telling time in the out-of-doors. Spiero,[122] indicated her preference for the use of the Little Dipper in telling time. From the information provided in the articles it would be very difficult for students to employ either constellation in the determination of time.

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[118] Spiero, p. 81.

[119] Spiero, p. 81.

[120] Lillian H. Darnell, "Sky Above," Grade Teacher, LXXI (March, 1954), 46-47.

[121] Franklyn Branley, "The Big Dipper," Grade Teacher, LXXIX (February, 1962), 46.

[122] Spiero, p. 49.

Night Sky Observations

Several authors: Utley,[123] Hansen,[124] and Posso[125] recommended that students observe the night skies. The two constellations that were emphasized by the writers for students to find were the Big Dipper and the Little Dipper. Songry[126] added to the list of recommendations that a visit to an observatory was a must for students if at all feasible. All in all the literature calling for the observation of the real sky was very scanty.

Elementary School Astronomy

Most science textbooks used by elementary school children up until the end of the 1950's presented various astronomical topics in a very descriptive manner. The solar system was described in some detail. The planets were often listed in order of size and distances from the sun. Natural satellites were often tabulated. Seasonal changes and eclipses were discussed. Many constellations were identified and mention was made of galaxies. In addition, information was presented on such concepts as what makes night and day, and

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[123] Celia Utley, "We Study the Skies," Grade Teacher, LXXI (December, 1953), 45.

[124] Violet Hansen, "Sky Study - A Unit of Activity Based on the Study of the Heavens," Grade Teacher, LV (January, 1938), 12-13.

[125] Mary Posso, "Two Units on Astronomy for Upper Grades," Instructor, LXII (February, 1953), 30.

[126] Clarisse Songry, "Young Scientists See Stars," The Catholic School Journal, LIV (March, 1954), 104.

the concept of time was elaborated upon. Beginning in the early 1960's new curriculum materials in astronomy were being developed and tested for use with elementary school students. The most famous of the astronomy programs to be developed is the Elementary School Science Project.

The Elementary School Science Project is one of the course and curriculum improvement projects sponsored by the National Science Foundation. The project, which is now complete after eight years of research and development, was under the direction of the University of Illinois. The main emphasis of the project was to revive the curriculum in astronomy along the lines approved by modern astronomers for use with elementary students.

The starting point of the project was the review by the professional astronomers of many sections of children's textbooks covering astronomy. Their findings suggested at least in the area of astronomy that science was solely descriptive as taught to elementary students. Next, the astronomers drew up a list of topics and problem areas fundamental in the field of astronomy. Future development of the project centered around these topics as reported by Atkin,[127] Project Director:

(1) measuring distances in space.

(2) constructing models of the movement of objects in the solar system based on observation and differing assumptions.

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[127] J. Myron Atkin, "Teaching Concepts of Modern Astronomy to Elementary Children," Science Education, XLV (February, 1961), 56.

(3) gravitation.

(4) theories regarding origin of the universe.

(5) stellar evolution.

From cooperating teacher interviews and from written tests administered to children involved in the project the following findings were made:

1. Children's interest was quite high during the astronomy sessions.

2. The children were able to conceptualize many significant topics that were studied.

3. Most classroom teachers who observed the experimental sessions, while enthusiastic about the project, expressed their uncertainty about being able to teach the content identified for the study by children.

4. Most children could learn the concepts fundamental to the science of astronomy even though these concepts are not perceived as closely related to their personal and social needs.

5. A 'discovery' approach is feasible in teaching some concepts of modern astronomy to elementary school children.[128]

The end product of the project was the development of a sequential series of six books dealing with six major ideas in astronomy. The following is a brief description of each of the books as described by Stecher:[129]

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[128]Atkin, p. 58.

[129]Joann Stecher, "Astronomy for Grades Five Through Eight," Science and Children, II (February, 1965), 23-24.

Book	Title	Main Idea
I	CHARTING the UNIVERSE	Topics included are measuring distances in the solar system and beyond - size and shape of the earth
II	THE UNIVERSE in MOTION	Outlines conceptual models to account for observed motion
III	GRAVITATION	Deals with concepts of velocity, acceleration, mass, and force
IV	MESSAGE of STARLIGHT	Explores methods astronomers use in analyzing starlight to obtain information about the composition of stars
V	LIFE STORY of a STAR	Deals with stellar evolution
VI	GALAXIES and the UNIVERSE	Introduces the student to our galaxy, other galaxies, and cosmology

Teachers who have used the program describe it as difficult and probably most interesting to the upper quartile students.[130] Because of teacher difficulties and the advanced reading ability and mathematics required to do some of the books, the original idea of using the materials for fourth, fifth, and sixth graders has been abandoned. The project is now intended for classroom use of students in grades 5-9. A review of the difficulty of the books is given in an article by John F. Newport.[131]

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[130]"The Necessary Nine," Grade Teacher, LXXXVIII (January, 1968), 88.

[131]John Newport, "A Look at the University of Illinois Astronomy Materials," School Science and Mathematics, LXV (February, 1965), 145-147.

This project has never swept across the United States with a great deal of enthusiasm. This could be a result of the science background required of the teachers to teach and implement the project adequately. Then, too, besides the teachers involved directly in the project very little was done to implement and train teachers to teach the materials. There seems to be very little evidence in the current literature to assume the products of the ESSP project are used by many schools.

Classroom ideas relating to the study of constellations as cited in the literature involved the use of bulletin boards, making projections of the constellations, making viewers, having constellation races to form the various constellations, and viewing the real sky. It was noted that the last aspect, urging the teachers to use the real sky, was the least emphasized by the writers. In addition, it was observed that most of the articles pertaining to constellation activities were written before the 1960's when the planetarium began to bourgeon in school systems throughout the United States. It is also interesting to note that none of the writers of classroom activities emphasized any of the skills deemed important and necessary by the writers of the sky guides; nor did the writers, suggesting the various activities, make mention of any differences in ability of the various age groups of children to learn constellations.

CHAPTER III

PROCEDURE AND METHODOLOGY

Evidence from the review of literature related to skills necessary to identify constellations leave the answers to important questions in doubt. Educational research on the learning process in the planetarium and related studies indicate the child in the fifth grade has the capabilities for constellation identification skills. The question to be answered is whether these skills can be used in the planetarium without further instruction. The purpose of this study was to construct a diagnostic test, made up of five subtests, to determine if fifth-grade students can demonstrate those particular prerequisite skills that an individual must have in order to learn the constellations. The test results could be used to determine which of the constellation identification skills the fifth-grade students involved in this study can and cannot successfully employ.

In addition, a Classroom Indirect Measurement Instrument was prepared from available educational instruments or procedures accepted as being able to measure constellation identification skills. The purpose of the Classroom Indirect Measurement Instrument was to provide a means of comparing the planetarium performance of skills associated with constellation identification with the results of the classroom instrument.

In this chapter, the procedures are presented in the following sequence: (1) the methods used in the construction of test items; (2) the nature of the group to which the test was administered; (3) the methods used in the validation of the test; (4) the planetarium facility; (5) the administration of the test; and (6) the methods used in the statistical analysis of the test.

Construction of Test Items

Initially, the investigator surveyed numerous sky guides to determine the various skills that writers cited as necessary to identify or work with the various star patterns in the sky. From the results of the survey five skills were identified:

1. Brightness Discrimination
2. Orientation Skills
3. Measuring Skills
4. Spatial Abilities
5. Scanning Skills

After the survey of the sky guides was completed, a rough draft of the Planetarium Skill Evaluation Test was constructed. The test was constructed in such a manner as to insure that each of the skill areas was adequately covered by the various test items. The items were stated so as to involve the subject in the planetarium testing session in performing the same processes and procedures that he would use in the out-of-doors in identifying or searching out constellations. In addition, the test was designed to be administered orally and an oral response was to be given in return by the subject for each test item. This format was decided upon to eliminate the possibility that reading difficulties might affect the results and to make the test as personal and non-threatening as possible. Also, the test administrator was responsible for recording each of the examinee's responses for each item on the appropriate blank on the answer sheet.

Validation of the Pretrial Test

After construction of the rough draft of the test was completed, face validity and content validity were established.

Face Validity - Face validity was considered in formulating the test items of the Planetarium Skill Evaluation Test. For face validity the items must be worded in terms of fifth-grade students' experiences and vocabulary they can understand. A panel consisting of three elementary teachers and one principal (See Appendix A) met to review each test item for face validity and to insure appropriateness for fifth-grade students.

Content Validity - In formulating the test items for the Planetarium Skill Evaluation Test careful analysis of various sky guides was undertaken to insure that the test would have content validity. "Content validity refers to the degree to which a test samples the content area which is to be measured."[1] The content areas to be tested were systematically analyzed to make certain that all major aspects of sky skills necessary for constellation identification were included and were scientifically accurate. A panel of planetarium personnel (See Appendix B) reviewed the rough draft of the test to insure content validity and to insure also that each test item was scientifically accurate.

Trial Version

The recommendations of the fifth-grade teachers and planetarium personnel were considered in the rewriting of the test items to be incorporated into the trial version of the test. The trial version was composed of five subtests each with varying numbers of items:

Subtest A.	Scanning Abilities	6 items
Subtest B.	Orientation Skills	7 items
Subtest C.	Brightness Discrimination	3 items
Subtest D.	Measuring Skills	12 items
Subtest E.	Spatial Abilities	32 items

The Spatial Abilities Subtest had the greatest number of items. This was due to the numerous types of spatial skills that needed to be evaluated: up-down, right-left, above-below, use of star charts, etc. The Brightness Discrimination Subtest had the fewest test items since a survey of the literature had indicated that this skill was acquired early in life.

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[1]Donald Ary, Lucy Jacobs, and Asghas Razavich, Introduction to Research in Education. Holt, Rinehart, and Winston. New York, 1972, p. 191.

Once the trial version was drafted, the investigator then focused his attention on two remaining tasks to be completed before the test could be administered. The first task to be completed was the photography of the visual materials required for use in the test, and the other was to set up the equipment and to decide upon the lighting conditions for the testing session.

Photography of Materials

Mr. LeRon Cobia, Planetarium Specialist, Michigan State University, prepared the visuals from materials furnished by the investigator. A Canon 35mm slide camera with a 50mm lens was used. A film plane to subject distance of 21 cm was used in most instances. The type of film used to prepare the black and white slides was Kodalith Ortho with an ASA of 5. Where color slides were needed, Ektachrome film with an ASA of 64 was employed.

Set Up of Equipment and Lighting Requirements

Since each subject was to be tested individually, it was decided to begin each testing session of the trial version with the lights on and fade into darkness during the administration of the Orientation Subtest. This would permit each subject a period of adjustment before being placed in total darkness. The test items were arranged to ask the first two test items of the Orientation Subtest with the lights on and then fade the lights during the remainder of the subtest.

For the testing session all subjects were seated in the same seat which was located in the center of the planetarium chamber. This was done to insure that all subjects would view the sky from the same location.

The two slide projectors required to project the slides were positioned at a distance of 32 feet from the dome. The projectors were set up so that the projected image from both projectors (spaced 12 feet apart) were identical in size and intensity as viewed on the dome. Remote controls from the projectors were extended to reach the planetarium console. With this type of set-up the investigator could operate each projector independently with the remote control switch.

With all of the test construction completed and equipment set up in the planetarium, the test was then administered individually to twenty fifth-grade students (10 males and 10 females) during January, 1974.

The Item Analysis

After the trial version was administered to all twenty subjects, the answer sheets were taken to the Office of Evaluation Services at Michigan State University where the answer sheets were scored electronically using the Opscan 100. The input data from the Opscan 100 was used by the IBM 360 to perform an item analysis. The index of discrimination and the index of difficulty were of importance for revision of the test to final form.

The index of difficulty represents the percentage of the total group who got the item incorrect. A high index indicates a difficult item and a low index an easy item. The procedure employed for the determination of the index of difficulty was as follows.

The scored tests were arranged in order of scores from high to low. Next, two subgroups of the test papers were formed, an upper group which consisted of twenty-seven percent of the group who received the highest scores on the test (in this case six tests, .27 x 20 = 5.4, which was rounded off to 6) and a lower group which consisted of an equal number of papers from those who received the lowest scores.

A count was then made for the number of times each possible response to each item was chosen on the answer sheets of the upper and lower groups. The counts for each group were added together. This sum was subtracted from the maximum number of papers in the upper and lower groups. In this case 12. The difference was then divided by the maximum possible sum. This quotient represented the index of difficulty.

The process continued for the determination of the index of discrimination. The index of discrimination is the difference between the percentage of the upper group making the right answer and the percentage of the lower group making the right answer. The lower groups' count of correct responses was subtracted from the upper groups' count of correct responses for each item. This difference was divided by the maximum possible difference -- the number of scored tests included in the upper group. The quotient, expressed as a decimal factor, was the index of discrimination.

Based on the index of difficulty and index of discrimination, the ranges for each item were then carefully studied. Though no absolute criterion points indices for discrimination and difficulty were established for eliminating items, the following criteria served as a guide.

1. Items with negative indice of discrimination were dropped or revision was made to the item so as to retain it in the final version.

2. Items were eliminated if they had a discrimination index of zero or revision was made to the item so as to retain it in the final version. It was expected that some low discrimination indices would be found in grade five, because of high percentage of subjects getting some of the answers correct.

3. Items were eliminated if they had difficulty values of 1.00 or zero. It was again expected that items would demonstrate a wide range of difficulty for fifth graders.

For the trial version of the test the Mean Item Difficulty was .41. The Mean Item Discrimination was .29 and the Reliability of the total test based on the Kuder Richardson Reliability #20 Test was .75. The Standard Error of Measurement was 2.696. The results of the Item Analysis of the trial version are presented in Table 1. It can be noted that the difficulty of the subtests vary with Scanning Abilities being the most difficult and Brightness Discrimination the easiest. Discrimination was best achieved in the Orientation Skills Subtest while the Brightness Discrimination Subtest was the least discriminative.

TABLE 1

Item Analysis Results of Trial Version of Planetarium Skill Evaluation Test

Subtest	Difficulty		Discrimination	
	Range	Average	Range	Average
Brightness Discrimination	0 - .70	.28	0	0
Orientation Skills	.45 - .85	.56	.20 - .60	.37
Spatial Abilities	0 - .90	.34	-.20 - 1.00	.31
Measuring Skills	0 - .90	.42	0 - .80	.29
Scanning Abilities	.45 - .85	.73	-.20 - .60	.30

In the light of the item analysis and some experience gained in the trial version, the test was revised to final form. (See Appendix C) The item distribution for each subtest is given in Table 2. A total of forty-eight items were included in the final form.

TABLE 2

Item Distribution of Final Version of
Planetarium Skill Evaluation Test

Subtest	Number of Items
Scanning Abilities	4
Orientation Skills	6
Brightness Discrimination	2
Measuring Skills	9
Spatial Abilities	27
Total:	48

Validation of the Test

In addition to content validity and face validity cited earlier in this chapter, Concurrent Validation was also used to validate the final form of the test. A Classroom Indirect Measurement Instrument, composed of five subtests, was prepared to compare the planetarium performance--results of the various subtests of the Planetarium Skills Evaluation Test--with several tests or procedures purported to measure the ability to perform these same skills while not requiring the use of the planetarium sky.

Concurrent Validity

Concurrent Validity refers to the relationship between scores on a measuring instrument and a criterion available at the same time. "Concurrent validity is important for those tests designed for use in the diagnosis of existing status."[2] The major areas to have concurrent validity established in the Planetarium Skills Evaluation Test were:

1. Scanning Abilities
2. Orientation Skills
3. Brightness Discrimination
4. Measuring Skills
5. Spatial Abilities

Scanning Validation Subtest

The Scanning Subtest used in the concurrent validation procedure and included in the Classroom Indirect Measurement Instrument was developed from material included in the book titled: Word Tracking.[3] This book contained numerous sentences that subjects could be given to find words and draw circles around them. The circles words made up sentences. The subjects were given a reference sentence to read, and then required to search for each of the words in the reference sentence in the three or four lines of words just below the reference sentence. As an example, the following sentence is given:

Reference Sentence: I saw bats.

Scanning Lines A I It As
was say way saw
tabs bits bats boats.

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[2]Donald Ary, Lucy Jacobs, and Asghas Razavich, p. 196.

[3]Donald E. P. Smith, Editor. Word Tracking. Ann Arbor Publishers, Ann Arbor, Michigan, 1967.

The subjects were given six sentences to scan. The sentences ranged from 5 - 9 words, while the lists of words to scan ranged from 20 - 26 words. The subjects were given 15 seconds to complete each sentence. The combined average male-female difficulty index for this subtest was .53 while the discrimination index was .40.

Orientation Skills Validation Subtest

The portion of the Stanford-Binet Intelligence Scale[4] that pertained to the determination of directions was included in the Classroom Indirect Measurement Instrument and was used in the concurrent validation of the Orientation Skills Subtest of the Planetarium Skills Evaluation Test. All five items from the Direction 1 subtest were asked of the subjects. The questions required the subjects to determine what cardinal point of direction they would be facing after turning left, right, or any combination thereof from a point of reference given to them in each test item. Each test was administered orally.

The Stanford Revision in 1960 incorporated in a single form, designated as the L-M Form, the best subtests from the 1937 scales. The selection of subtests to be included in the 1960 scale was based on records of tests administered during the five year period from 1950-1954. "Criteria for selection of test items were (1) increase in percent passing

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[4]Lewis Terman and Maud A. Merrill. Stanford-Binet Intelligence Scale, Manual for the Third Revision Form L-M. Houghton Mifflin Co., Boston, 1960, pp. 107-108.

with age; and (2) validity determined by biserial correlation of item with total score."[5] The biserial correlation for the 1937 and 1960 Direction 1 Subtest was .57.[6] In addition, changes from the 1937 scale consisted of elimination or relocation of tests which were found to have changed significantly in difficulty since the original standardization. Also, tests were eliminated which were no longer suitable by reason of cultural changes.

Brightness Discrimination Validation Subtest

To perform this subtest of the Classroom Indirect Measurement Instrument the subjects were asked to compare the apparent brightness of two dots of light projected simultaneously onto the planetarium dome. Two identical slide projectors (Ektagraphic f 2.5) were used. The subjects were seated near the center of the planetarium chamber to make the comparisons.

The slides employed to project the dots of light were prepared in two steps. First, the Gray Scale Wedges[7] were photographed with Ektachrome film. "The wedge consists of a positive transparency that has wedges, or segments of

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[5]Terman and Merrill, p. 40.

[6]Terman and Merrill, p. 346.

[7]Eastman Kodak Co., Kodak Color Dataguide. Eastman Kodak Co., Rochester, N.Y., 1972, p. 11.

tonal values from white to black on it."[8] Next the different Gray Scale Wedges were sandwiched with transparent dots of equal size to complete the production of the slides.

The Brightness Discrimination Validation Subtest was administered using the following procedure. Two dots of light were projected simultaneously onto the planetarium dome and the following statement read to the subject.

> You are to tell me whether the dot of light that you see on the right hand side, (Point Out Right Hand Dot), is brighter, the same brightness, or not as bright as the dot of light on the left. (Point Out the Left Hand Dot) As an example look at the two dots of light being shown at this time. How does the dot of light on the right appear when compared to the dot on the left? (Pause for Answer) It is brighter. Do you have any questions? (After subject responds to a question, proceed on to the next.)

TABLE 3

Set Up of Equipment for
Brightness Discrimination Validation Test

Tray B	Tray A	Item on Answer Sheet	Correct Response
2 - 8	2 - 4	Example	Brighter
2 - 10	2 - 9	12	Brighter
2 - 2	2 - 1	13	Brighter
2 - 5	2 - 5	14	Same Brightness
2 - 4	2 - 2	15	Brighter

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[8]Dan Daniels. Photography From A to Z. Chilton Book Co., New York, 1968, p. 116.

The numbers 2 - 1 ... 2 - 10 in Table 3 refer to the slide identification numbers. The lower the number (2 - 1) the brighter the dot appears on the dome. The brightness ratio was such than an identification number located two steps from another would appear twice as bright on the dome. That is to say, slide 2 - 2 would appear twice as bright as the dot of slide 2 - 4 projected simultaneously on the dome.

Measuring Skills Validation Subtest

Twelve items related to measurement were asked of the subjects in this subtest of the Classroom Indirect Measurement Instrument. The items asked were selected or modified from those listed in the Iowa Every Pupil Tests of Basic Skills, Test D.[9] This test provides the examinees the opportunity to show the extent of their technical arithmetic vocabulary and of their ability to apply math reasoning when they perform certain fundamental operations.

> Specific skills involved include reading and writing numbers, understanding the number system, the common processes, quantitative measures, and numerical facts, terms, and ability to identify common geometric figures, to make quantitative estimates, and to compare the size of numbers and fractional parts."[10]

Each test item was illustrated on a 5 x 8 inch index card. This investigator held up one test item card at a

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[9] H. F. Spitzer, Ernest Hoan, Maude McBroom, H. A. Greene, and E. F. Linquist. Iowa Every Pupil Tests of Basic Skills, Test D. Houghton Mifflin Co., New York, 1947.

[10] Oscar Buros, Editor. The Fourth Mental Measurements Yearbook. Gryphon Press. Highland Park, New Jersey, 1953, p. 39.

time for the subject to respond to orally. There were no mathematical computations or reading required of the subjects. Before administering this subtest the following statement was read.

> I am going to read to you several questions. Four possible answer choices will be read. Only one of the answer choices is correct or better than any of the others. All that you have to do is to tell me the answer you think is best.

An example was then given the subject. The first card of this set was held up; pictured on it was a ruler. The test item was then read, "How many inches are in one foot? 1, 5, 8 or 12?" "Twelve is correct." The remaining questions of which there were twelve dealt with different concepts related to measurement--estimation of angles, recognition of different geometrical patterns, and one item related to time.

Space Abilities Validation Subtest

Three different sources were combined in the Classroom Indirect Measurement Instrument to develop the criterion for validating the Spatial Abilities Subtest of the Planetarium Skills Evaluation Test. Five items of varying difficulty were selected from the Space Relations Test of the Differential Aptitude Test.[11] (Items 1, 2, 5, 8, and 10) The Space Relations Test of the Differential Aptitude Test presents two-dimensional patterns with some of the sections of the patterns having special markings. Each pattern is accompanied by five

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[11] K. Bennett, H. G. Seashore, and A. C. Wesman. Differential Aptitude Tests. The Psychological Corporation, New York, 1959.

sketches of three-dimensional figures. The examinee was to select those figures which could be made from the original pattern. In each test item at least one figure was correct and in some instances all five alternatives were correct. The figures in the Space Relations Test are related requiring the subject to imagine the movement of parts in the development of solids from the flat patterns.

This test appears to require the subject to recognize the identify of an object when it is seen from different angles, to imagine the movement or internal displacement among the parts of the configuration, to perceive the spatial pattern accurately, and to remain unconfused by the varying orientations in which the pattern is presented.

Kuhlmann-Anderson Test

Listed in Test CD7 of the Kuhlmann-Anderson Test[12] are rows of figures that look something like jigsaw puzzles. At the beginning of each row is a smaller figure that just matches a part or piece in one of the five figures in the rest of the row. Test items 5, 8, 11, and 14 were selected to be included in the validation subtest. For Test CD7 the range and median of the correlation of the item with criterion was: range .27 - .52 with a median of .33.[13] The validity criterion for item-test correlation was the median

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[12] Kuhlmann-Anderson Test, Seventh Edition. Booklet CD. Personnel Press, Inc. Princeton, New Jersey, 1964.

[13] Technical Manual, Kuhlmann-Anderson Test, 7th Edition. Personnel Press, Inc., Princeton, New Jersey, 1964, p. 7.

mental age on the sixth edition test.[14] The correlation of Test 7 with the total score was .638 for grade 3 and .538 for grade 4.[15]

Mr. O's Relative Position

Ten questions were included in this portion of the validation subtest based on the book Relative Position and Motion developed by the Science Curriculum Improvement Study[16] and the Doctoral research investigation conducted by Dennis Battaglini at Michigan State University in 1971.[17]

A one foot tall Mr. O was constructed out of heavy construction paper. Figure 1 is a pictorial representation of Mr. O with his various spatial positions labeled. Mr. O was held up as the following statement was read to the subject:

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[14] Technical Manual, p. 6.

[15] Technical Manual, p. 23.

[16] Science Curriculum Improvement Study. Relative Position and Motion, Rand McNally & Co., Chicago, Illinois, 1972.

[17] Dennis Battaglini, "An Experimental Study of the Science Curriculum Improvement Study Involving Fourth Graders' Ability to Understand Concepts of Relative Position and Motion Using the Planetarium as a Testing Device." Unpublished PhD dissertation, Michigan State University, 1971.

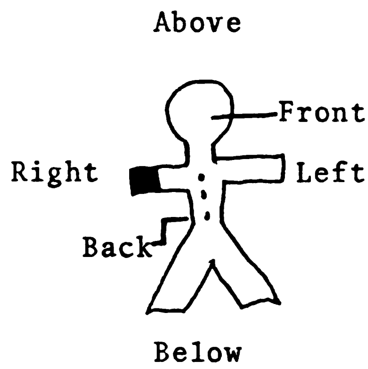


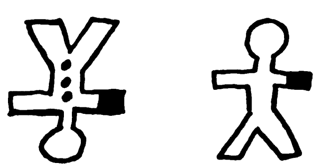
Figure 1

Mr. O

Mr. O is an artificial observer who reports the positions of objects relative to his own body. Mr. O's right arm is marked and buttons identify his front. Mr. O is able to recognize six basic directions. (Point them out as you state) front, back, right, left, above, below in relation to himself. In his manner of reporting, below and above are not related to earth and sky, or to the direction of the force of gravity. Mr. O identifies the position of everything in reference to his own body.

Drawings of Mr. O were made on index cards and one card was presented to the subject at a time. Two examples were given the subject before proceeding with the remainder of this subtest. The two examples are given in Figure 2.

Example A
Answer: Right



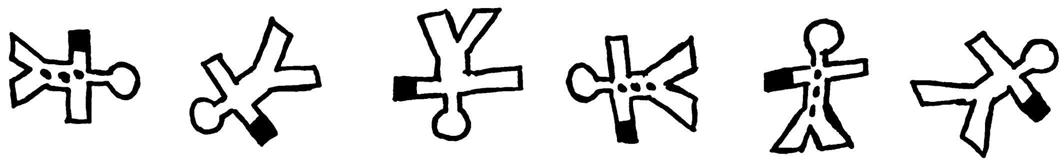
Example B
Answer: Right

Figure 2

Drawings of Mr. O Used to Explain Procedure for Answering Items

The following statement was read for each example: "Look carefully for Mr. O's buttons. You are to tell me whether Mr. O has a dark right or left arm?"

Then the following six drawings shown in Figure 3 were held up one at a time and the subject was to respond as to which hand was colored -- either right or left.



Answer: Right	Answer: Left	Answer: Right	Answer: Right	Answer: Right	Answer: Right

Figure 3

Test Items for Mr. O

Next the following drawing, reproduced in Figure 4, was held up and the subjects were to answer the following test items based on the drawing. Each item in the explanation was carefully identified.

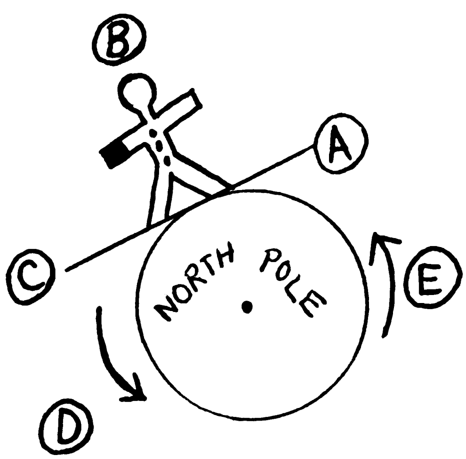


Figure 4

Mr. O Standing on the Side of the Earth

The following statement was read:

> Pretend that you are in an airplane flying over the top of the earth, the North Pole, and you see Mr. O standing on the earth. Notice Mr. O goes around the sky in a motion that is opposite the motion of the hands of a clock. See the arrows? Objects in the sky seem to rise or come up to Mr. O's right and go down or set on his left. Notice that there are five stars drawn -- named A, B, C, D, and E. Mr. O can see any of these stars when they are above the straight line.

The following question was then asked:

> To Mr. O standing on the earth which star has just risen? A, B, C, D, or E? Answer: C. Which star is just about to set for Mr. O? A, B, C, D, or E? Answer: A. Which star is next to rise for Mr. O? A, B, C, D, or E? Answer: D. Star B is overhead for Mr. O. Which star will be next to be seen overhead for Mr. O? A, B, C, D, or E? Answer: C.

The test items in this section of the Spatial Abilities Validation Subtest had an average difficulty of .54 and a discrimination index of .38.

Sample

The sample subjects were drawn from the total fifth-grade enrollment of students in seven elementary schools in Coldwater, Michigan, during January - March of 1974. All subjects used in the investigation had visited the planetarium at least once prior to their testing session. The age range of the subjects was from 122 months to 144 months. The average age of the subjects was 131 months with a standard deviation of $\pm$ 4.3 months.

The total number of subjects encompassed in this study was 120. Twenty of the subjects were involved in the testing of the trial version of the test. All of the subjects were chosen randomly and parental consent was given.

Both sexes were included in the population and sample, and there were equal numbers of boys and girls used in the study. The subjects were members of schools setting in a rural surrounding. There were 4,000 students in grades K - 12 in the school district. The socio-economic range in the community is broad; however, there is a preponderance in members of the working class. The community's population is approximately 10,000. The elementary schools in which the sample was drawn reflected in their student bodies the varied economic levels, home environments and life styles of the total community.

Planetarium Facility

The planetarium facility used in this study is located in the Legg Junior High School in Coldwater, Michigan. The star projector is the Spitz - A-3P housed under a 30 foot dome. With the projector a realistic representation of the night sky can be produced for any desired latitude on earth.

The seating in the planetarium is unidirectional and there are 76 seats. However, during the testing session, each subject was seated near the center of the chamber. From this location the subject had an excellent view of the entire chamber. Also, from this position the subject used a CAPRO

PROJECTION POINTER[18] to point out the various objects on the dome as required.

Other equipment used in the planetarium during the testing session was a sun projector and two carousel projectors for 35mm slides. All of the visuals were projected onto the dome. The test administrator remained by the console which contained the controls for the various equipment used in the test. The console was located on the perimeter of the chamber to the rear of the subject.

Administering the Test

The final form of the test was administered individually to one hundred subjects in the planetarium of Legg Junior High School in Coldwater, Michigan, during February - March, 1974.

Upon arriving at the planetarium, the examinee was first given an eye test to check for visual acuity. The visual acuity was checked at a distance of twenty feet using Snellen's Letter "E" Chart. The visual acuity of each subject was checked with both eyes open (with or without glasses) depending upon whether the individual to be checked had corrected vision. The procedure described in *Diagnostic Examination of the Eye Step by Step Procedure*[19] was followed.

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[18]Marketed by: Ehrenreich Photo-Optical Industries
623 Stewart Avenue
Garden City, New York 11530

[19]Conrad Berens and Joshua Zuckerman. *Diagnostic Examination of the Eye Step by Step Procedure*. J. B. Lippincott Co., 1946.

Additional training assistance for this procedure was provided by an Optometrist in Coldwater.

Anyone determined to possess less than 20/30 visual acuity was eliminated from the testing program as poor visual acuity might have interferred with the examinee's ability to properly "see" the myriad of visual stimuli. The number 20/30 represented an individual with 90 percent visual acuity while a person with 20/20 vision has a 100 percent visual acuity based on the Snellen Chart.

Upon completion of the eye test the examinee then moved to a table located in the front of the planetarium chamber. At this time anecdotal information pertaining to the subject was collected. Next the examinee was administered, one question at a time, all of the sections of the Classroom Indirect Measurement Instrument except for the Scanning and Brightness Discrimination Subtests. The examiner recorded the subject's responses on the appropriate blank on the answer sheet. The subject was then given a sheet which contained six sentences to scan. The detailed procedure describing the administration of this subtest was cited earlier under the section Scanning Validation Subtest.

The last section of the Classroom Indirect Measurement Instrument -- Brightness Discrimination Subtest -- was administered orally with the subject located in the center of the planetarium chamber. The lights were turned off during the duration of this subtest. Upon completion of this section of the data collection session the lights were turned up again. At this time the subject was given a five minute rest period.

After the break the subject was once again seated in the center of the chamber to be administered the Planetarium Skills Evaluation Test. As before, the test was administered orally with the examiner recording the examinee's responses on the appropriate blank on the answer sheet. In addition, the examiner operated the planetarium equipment and made the necessary changes as required for each test item. As part of the testing procedure, the subject was given a protable pointer to use to point out the different celestial objects as required.

For the last part of the Spatial Abilities Subtest, items 84-95, the examinee moved to the console to employ the use of the reading light in order to see the various star charts in the darkened chamber so that they could point out the required objects on the star chart in the planetarium sky.

During the entire test, the examinees proceeded at their own rate, except where time limits were set for specific test items. An average time of one hour and ten minutes was required by the examinees to complete the entire test.

Statistical Analysis of Data

Upon completion of the administration of the Planetarium Skills Evaluation Test, the answer sheets were taken to the Office of Evaluation Services at Michigan State University to be electronically scored. The test scores were then used to perform an item-analysis of the test. The results of the item-analysis could be used to identify which subtest(s) and/or items that over 50 percent of the subjects could not correctly answer. Any item or subtest with an average difficulty of greater than .50 would indicate which skills were not sufficiently mastered to be in the repertory of abilities of the majority of fifth-grade subjects used in this investigation. It would be these skills that it would be necessary to provide learning experiences for before a majority of students could successfully use these skills in the planetarium. The procedure for doing an item-analysis was described earlier in this chapter.

Also, individual items in each subtest were correlated with every other item in the subtest. Correlation matrices were constructed to correlate each item and subtest scores with every other item in the entire test and Classroom Indirect Measurement Instrument subtests. One would expect a fairly high correlation between items in the same subtest and validation subtest purported to measure the same skill and a much lower correlation with other subtests and the individual items making up each of these subtests. The higher correlations would be indicative of items measuring the same thing. Likewise, a low correlation would indicate that the items being correlated were measuring different things. The various correlations, arranged in a correlation matrix, would provide the investigator the opportunity to note any significant patterns of items in the test.

Also, a group factor analysis was performed on the test items to determine if the new groups (subtests) which were formed after factor analysis would be the same as the original groupings of test items in the Planetarium Skills Evaluation Test. From the results of the factor analysis items would be grouped together that were accounted for by varience, the largest first and so on.

Statements of the Hypotheses

In addition to the previous areas identified to be analyzed the following seven hypotheses were developed in order to test some of the implications related to constellation identification skills and subtest validation arising from the review of the literature. Each hypothesis is first stated in operational terms, followed in turn, by the null form of each operational hypothesis. Each null hypothesis was tested.

H_1: Fifth-grade boys will do significantly better than fifth-grade girls in being able to correctly identify directions on the Orientation Skills Subtest of the Planetarium Test.

Ho_1: There is no significant difference in the abilities of fifth-grade boys and girls to correctly identify directions on the Orientation Skills Subtest of the Planetarium Test.

H_2: There will be a correlation between the scores obtained with the Planetarium Orientation Skills Subtest and the scores obtained with the Orientation Skills Subtest included in the Classroom Indirect Measurement Instrument for both males and females.

Ho_2: There will be no correlation between the scores obtained with the Planetarium Orientation Skills Subtest and the scores obtained with the Orientation Skills Subtest included in the Classroom Indirect Measurement Instrument for both males and females.

H_3: There will be a correlation between the scores obtained with the Planetarium Measuring Skills Subtest and the scores obtained with the Measuring Skills Subtest included in the Classroom Indirect Measurement Instrument for both males and females.

Ho_3: There will be no correlation between the scores obtained with the Planetarium Measuring Skills Subtest and the scores obtained with the Measuring Skills Subtest included in the Classroom Indirect Measurement Instrument for both males and females.

H_4: Fifth-grade boys will do significantly better than fifth-grade girls in being able to correctly identify spatial relationships on the Spatial Abilities Subtest of the Planetarium Test.

Ho_4: There is no significant difference in the abilities of fifth-grade boys and girls in being able to correctly identify spatial relationships on the Spatial Abilities Subtest of the Planetarium Test.

H_5: There will be a correlation between the scores obtained with the Planetarium Spatial Abilities Subtest and the scores obtained with the Spatial Abilities Subtest included in the Classroom Indirect Measurement Instrument for both males and females.

Ho_5: There will be no correlation between the scores obtained with the Planetarium Spatial Abilities Subtest and the scores obtained with the Spatial Abilities Subtest included in the Classroom Indirect Measurement Instrument for both males and females.

H_6: There will be a correlation between the scores obtained with the Planetarium Scanning Abilities Subtest and the scores obtained with the Scanning Abilities Subtest included in the Classroom Indirect Measurement Instrument for both males and females.

Ho_6: There will be no correlation between the scores obtained with the Planetarium Scanning Abilities Subtest and the scores obtained with the Scanning Abilities Subtest included in the Classroom Indirect Measurement Instrument for both males and females.

H_7: There will be a correlation between the scores of the Planetarium Brightness Discrimination Subtest and the scores obtained with the Brightness Discrimination Subtest included in the Classroom Indirect Measurement Instrument for both males and females.

Ho_7: There will be no correlation between the scores of the Planetarium Brightness Discrimination Subtest and the scores obtained with the Brightness Discrimination Subtest included in the Classroom Indirect Measurement Instrument for both males and females.

Significance Level

The .05 level of significance was chosen for the analysis involving inferential statistical procedures. The selection was made somewhat arbitrarily, but is supported by convention in educational research, and by the fact that observed differences at this level (more readily detectable than at the .01 level) might provide direction for future research despite the increased risk of committing a Type I error.

FACTRB

FACTRB[20] was employed in the statistical analysis of the data. FACTRB consisted of several routines designed to

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[20]John E. Hunter. FACTRB. Computer Institute for Social Science Research. Michigan State University, E. Lansing, Michigan. 1974.

compute means, standard deviations, and correlations among variables, and the results were presented in a correlation matrix. In addition, FACTRB contained a routine which would perform a principal components factor analysis followed by varimax rotations. "All of the variables with their largest loading on a given factor are grouped together. The factors are reflected to maximize the number of large positive loadings. The factors are listed in the order of the amount of variance which they account for; the largest first and so on."[21] Following the last varimax rotation, FACTRB automatically performed a cluster analysis. The clusters formed in this analysis were based on the last varimax solution. Each cluster consisted of the set of variables which had their largest factor loading on a given varimax rotation.

Statistical assistance in the interpretation of the data was provided by William Brown of the Computer Center at Michigan State University. The computer cards were typed by Key Punch Operators at the Computer Center and the program was run on the Control Data 360 Computer.

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[21]John E. Hunter. Preliminary User's Manual. Computer Institute for Social Science Research. Michigan State University, E. Lansing, Michigan, 1974, p. 1.

CHAPTER IV

ANALYSIS AND INTERPRETATION OF DATA

This chapter, pertaining to the data collected in this study, is divided into four sections: (1) the item analysis of the final version of the Planetarium Skills Evaluation Test, (2) the correlational analysis of the test, (3) factor analysis of the test, and (4) analysis of the data concerning the hypotheses.

The purpose of this study was to construct a diagnostic test, made up of five subtests, to determine if fifth-grade students can demonstrate those particular prerequisite skills that an individual must have to learn the constellations.

Item Analysis of the Final Form of the Planetarium Skills Evaluation Test

After the final version was administered individually to one hundred subjects (50 males - 50 females) the answer sheets were taken to the Office of Evaluation Services at Michigan State University. The answer sheets were then scored electronically using the Opscan 100. The input data from the Opscan 100 was used by the IBM 360 to perform an item analysis. The procedure used to perform the item analysis was described in Chapter III.

From the results of the item analysis any item or subtest with a difficulty index greater than .50 indicated which areas were not sufficiently mastered to be in the repertory of abilities of the majority of fifth-grade subjects used in this investigation. A high index of difficulty indicated a difficult item or subtest while a low index indicated an easy item or subtest. The index of discrimination was used as a means to evaluate the performance of an item as it discriminated between high achieving students and low achieving students.

Scanning Abilities Subtest

Table 4 displays the results of the item analysis for the Scanning Abilities Subtest. The range of the index of difficulty for the combined scores was from .07 to .73.

TABLE 4

Item Analysis of Planetarium Skills Evaluation Test -- Scanning Abilities Subtest

Item	Index of Difficulty			Index of Discrimination		
	M	F	Combined	M	F	Combined
48	.04	.10	.07	.08	-.08	0
49	.42	.40	.41	0	.23	.19
50	.78	.68	.73	.30	.23	.26
51	.62	.64	.63	.23	.16	.23

Items 48 and 51 were easier for the males than the females while items 49 and 50 were easier for the females. The average index of difficulty for all four items by the males was .46 and .45 for the females. Therefore, more than fifty percent of the fifth-grade subjects included in this study were able to perform those tasks included as part of the Scanning Abilities Subtest.

Items 50 and 51 were the most difficult items. Item 50 which was the most difficult required the subjects to scan a slide for letter a's. Item 51 required the subjects to scan a slide for dots of equal size to the one projected in the slide on the right.

The index of discrimination was low for all of the items. The range for the combined scores was from 0 to 26. Item 48 had a negative index of discrimination for the females. This meant that more females in the lower group got the item correct than did the females included in the upper group.

Orientation Skills Subtest

Table 5 shows the results of the item analysis for the Orientation Skills Subtest. The range of the combined groups' index of difficulty was from .34 to .88. The average index of difficulty for males was .58 and for females .60 with an average for the combined groups of .59. This skill was present in less than fifty percent of the students involved in this study. Therefore, this skill

TABLE 5

Item Analysis of Planetarium Skills Evaluation Test -- Orientation Skills Subtest

Item	Index of Difficulty			Index of Discrimination		
	M	F	Combined	M	F	Combined
52	.44	.34	.39	.31	.47	.41
53	.64	.66	.65	.77	.39	.51
54	.74	.80	.77	.61	.30	.45
55	.40	.28	.34	.54	.46	.56
56	.80	.96	.88	.69	.15	.44
57	.46	.58	.52	.54	.08	.41

must be taught to bring the groups' performance to a higher level. Of the six items included in this subtest four of them (item numbers 53, 54, 56, and 57) were easier for males. Item 55 was the easiest for the combined groups. To get this item correct the subject had to state when the rising sun reached a position of south in the planetarium sky. Item 56, which was the most difficult item, required the subjects to state the setting direction of the sun which was in the northwest.

The average index of discrimination for the combined groups was .46. The average index of discrimination for the males was .57 and only .31 for the females. Therefore, this subtest was more discriminative for the males. The lower index of discrimination for the females was due to the higher number of females getting the items correct in the lower group and the fewer number getting the items correct in the upper group.

Brightness Discrimination Subtest

Only two items were included in the Brightness Discrimination Subtest. The results of the item analysis of this subtest are shown in Table 6. It can be noted that the index of difficulty was very low for both groups. The average index of difficulty for the males was .12, .14 for the females, and .13 for the combined scores. Item 59, which required the subjects to arrange the stars of the bowl of the Little Dipper in order of their brightnesses, was easier for the subjects than matching a given brightness of one star with another.

TABLE 6

Item Analysis of Planetarium Skills Evaluation Test -- Brightness Discrimination Subtest

Item	Index of Difficulty			Index of Discrimination		
	M	F	Combined	M	F	Combined
58	.16	.22	.19	.31	.30	.15
59	.08	.06	.07	0	0	0

The index of discrimination for this subtest was very low with an average for the combined groups being only .07. The skill of being able to discriminate between the brightnesses of stars seems to be well mastered by fifth-grade students from the results of the item analysis.

Measuring Skills Subtest

Table 7 shows the results of the item analysis of the items included in the Measuring Skills Subtest. The range of the index of difficulty for the combined scores of the nine items included in the subtest was from .12 to .79.

TABLE 7

Item Analysis of Planetarium Skills Evaluation Test -- Measuring Skills Subtest

Item	Index of Difficulty			Index of Discrimination		
	M	F	Combined	M	F	Combined
60	.20	.34	.27	.30	.31	.26
61	.64	.52	.58	.23	.16	.19
62	.46	.54	.50	.24	.61	.37
63	.52	.60	.56	0	-.07	-.03
64	.80	.78	.79	0	-.15	0
65	.74	.46	.60	0	0	.03
66	.06	.18	.12	.08	.08	.08
67	.16	.38	.33	.17	.37	.38
68	.34	.42	.38	.54	.15	.37

The average index of difficulty for the males for all nine items was .44 and for the females .47. For the combined scores the average index of difficulty was .46. The findings indicate that more than fifty percent of the subjects included in this study were able to perform successfully those items related to measurement. Items 60, 62, 63, 66, 67, and

68 were easier for males than females. Item 66 which had the lowest index of difficulty for both groups required the subjects to point out in the planetarium sky the shortest side of the summer triangle. Item 64 which was the most difficult for the group required the subjects to compare the sides of the winter triangle in the planetarium sky. The compared sides of this triangle were of equal length. All of the items in this subtest required the use of the planetarium sky.

The index of discrimination for each of the items included in the Measuring Skills Subtest was very low. In fact, for items 63 and 64 more persons in the lower group got the item correct than in the upper group, thus, the negative index of discrimination. Three items -- 62, 67, and 68 had a modest index of discrimination. Item 62 required the subjects to compare the distance between the pointer stars of the Big Dipper with the distance to the north star. Items 67 and 68 involved the use of the sun in the planetarium sky. The average index of discrimination for the males was .17, the females .15, and .18 for the combined scores.

Spatial Abilities Subtest

Twenty-seven items were included in the Spatial Abilities Subtest. The results of the item analysis of this subtest are included in Table 8. Seven of the items (69, 70, 71, 92, 93, 94, and 95) required the use of the

TABLE 8

Item Analysis of Planetarium Skills Evaluation Test -- Spatial Abilities Subtest

Item	Index of Difficulty			Index of Discrimination		
	M	F	Combined	M	F	Combined
69	.68	.72	.70	.31	.08	.22
70	.76	.70	.73	.23	.23	.18
71	.62	.82	.72	.15	.08	.11
72	.40	.38	.39	.69	.08	.30
73	.68	.72	.70	.69	.23	.45
74	.30	.38	.34	.54	.31	.45
75	.52	.52	.52	.46	.38	.37
76	.52	.42	.47	.62	.62	.62
77	0	.02	.01	0	.08	.04
78	.76	.80	.78	.46	.38	.44
79	.64	.48	.56	.69	.38	.52
80	.60	.64	.62	.77	-.15	.37
81	.22	.12	.17	.23	.23	.26
82	.70	.72	.71	.39	.23	.26
83	.04	.20	.12	.15	.46	.30
84	.14	.26	.20	.31	.23	.22
85	.20	.30	.25	.07	.54	.23
86	.42	.42	.42	.31	.54	.33
87	.16	.22	.19	.23	.23	.23
88	.32	.36	.34	.38	.54	.40
89	.18	.10	.14	.46	.23	.33
90	.10	.04	.07	.08	.08	.08
91	.24	.28	.26	.61	-.07	.22
92	.42	.42	.42	.31	.24	.30
93	.42	.44	.43	.23	.23	.26
94	.22	.12	.17	.38	.23	.26
95	.88	1.00	.94	.15	0	.07

planetarium sky. Item 69 evaluated the ability to determine upside down and item 70, which evaluated the ability to determine exactly left of the Big Dipper's position after being rotated, were both difficult for the subjects. Item 71, which was also difficult for the subjects, required them to predict the setting position of a star. The average index of difficulty for the combined scores for these three items was .71. Thus, it seems reasonable to assume that the procedure for doing this type of skill needs to be demonstrated.

The final four items, which required use of a star chart and planetarium sky, had varying degrees of difficulty. Item 95 which required the subjects to locate the star Castor in the planetarium sky was extremely difficult. Yet, item 94 which involved the same procedure was very easy. This item had an index of difficulty of only .17. The average index of difficulty for the last four items was -- males .49, females .50, and combined scores .49.

For items 72 and 73 the subject was to imagine that he could get behind a projection and look at it. Then from four projections the subject was to state which was the correct view as seen from this 'new' vantage point. Item 72, which used the constellation Aries outlined by three stars, was much easier to interpret correctly by the students than the constellation Leo used in item 73. The average index of difficulty for the combined scores was .54. Therefore, less than fifty percent of the subjects were able to perform this type of task. Therefore, instruction is needed to acquire this skill.

For items 74-76 the subject had to compare locations with a standard. The average index of difficulty for these three items was -- males .45, females .44, and combined scores .44. Being able to determine from comparison slides which one indicated that the subject had traveled farthest from the standard was easiest of the required tasks, while determining which slide indicated to them that they had traveled nearest the standard was the most difficult. An index of .52 for combined scores was obtained. Since the dots were the same size in all of the comparison slides, brightness could not be used by the subject as a clue for proximity.

Item 77, which involved the subject in determining which star in the right slide was larger than the one in the same place in the left slide, was very easy. The index of difficulty was only .01 for the combined scores. Item 78, which required the same type skill, was more difficult. Its index of difficulty was .78. The major difference between the two items was that the orientation of the two projections was identical for item 78 and rotated 90° clockwise for item 79.

The same trend held true for items 81 and 82. When the orientation of the two projections was identical, the index of difficulty was much lower (.17 vs. .71) for the item which required the subject to point out in the right hand slide which star had moved from the position it had in the left. The orientation of the right slide in item 82 was 90° counter-clockwise of the left hand slide.

Items 83-91 were test items that employed projections that required the use of star charts to determine a response. The average index of difficulty for these items was .18 for males, .25 for females, and .22 for the combined scores. Item 86 had the highest index of difficulty for these nine items. The explanation for this may be related to the fact that this was the first slide that the subjects were to use with a star chart after the two slides were no longer projected side by side. Item 90 had the lowest index of difficulty -- .07 for the combined scores. Two factors may have accounted for this. One was the fact that the star which was to be identified was isolated, not near many other stars, on the chart. The other factor may have been that the subjects were becoming competent in the use of a star chart to locate a required object in the three-hundred square degrees of projected area.

The average index of difficulty for the Spatial Abilities Subtest were as follows: males .41, females .43, and combined scores .42. The ability to work with spatial problems seemed to be in the repertory of skills of the fifth-grade subjects used in this investigation; however, the ability to locate stars in the planetarium was marginal.

The average index of discrimination for the combined scores of the Spatial Abilities Subtest was .29, for the males .37, and females .25. Item 76 had the highest index of discrimination while item 77 was the least discriminative. Two items, 80 and 91, had negative indices of discrimination. This was due to more of the individuals in the lower group getting the item correct than in the upper group. Several of the items (69, 72, 73, 79, 80, 91, and 95) were much more discriminative for males than females. This suggested that there was more variation in the males' abilities in the upper and lower groups than the females in order to get the differences to account for the higher index of discrimination. If below .19 is considered as the upper limit for an index of discrimination for poor items, the following items are classified as poor -- 70, 71, 77, 90, and 95. These five items were either too easy or difficult to account for much variation between the upper and lower groups on which the index of discrimination is based. If an index of .40 and above represent very good items, six items qualify -- 73, 74, 76, 78, 79, and 88.

Interpretation

From previous education research it was expected that by fifth grade many of the skills required to work with the constellations should be present in the repertory of skills available to fifth graders. This was generally supported by the results of the item analysis. As Table 9 indicates the mean item difficulty for the combined groups for the entire test was .44 which means that over fifty percent of the subjects could correctly respond to the items included in the Planetarium Skills Evaluation Test. Yet, the subtests varied as far as difficulty. The Brightness Discrimination Subtest was by far the easiest. The average index of difficulty for the combined scores was only .13. The Orientation Skills Subtest was the most difficult subtest. Its average index of difficulty was .59. The Scanning Abilities Subtest and Measuring Skills Subtests both had average indices of difficulty of .46. In each of the four tests the difference in difficulty for the males and females was slight.

TABLE 9

Item Analysis Summary Data

	Distribution of Item Difficulty Indices			Distribution of Discrimination Indices		
	M	F	C	M	F	C
.91-100		2	1			
.81-.90	1	1	1			
.71-.80	7	6	7	2		
.61-.70	8	5	5	7	2	1
.51-.60	4	6	7	4	3	3
.41-.50	8	7	6	3	3	7
.31-.40	4	6	6	9	7	8
.21-.30	4	6	3	9	14	15
.11-.20	6	4	8	4	4	5
.00-.10	6	5	4	10	10	8
Less than .00					5	1

	M	F	C
Mean Item Difficulty	.44	.45	.44
Mean Item Distribution	.32	.22	.27
Kuder Richardson Reliability #20	.79	.61	.72

When comparing the indices of difficulty for all of those test items which involved the use of the planetarium sky, the results are very interesting. The Brightness Discrimination Subtest items were lower than the total test average of .44 for the combined scores. The Orientation Skills Subtest Average of .58 was above the test average as was the Measuring Skills Subtest combined scores average of .46. The Spatial Abilities Subtest average of .59 for the combined groups was also higher than the .44 test average. If the two items included in the Brightness Discrimination Subtest are not included the average index of difficulty for the remainder of the items which involved the stars, the average is .54. This suggests that the skills required to do the planetarium tasks are not included in the repertory of abilities of most of the subjects included in this study. The distribution of the item difficulty indices is also included in Table 9.

Table 9 also shows the distribution of the discrimination indices. The average index of discrimination for the combined scores was .27. As far as quality of test items, this places the average in the marginal area. For items to be reasonably good they should have a range of .30 - .39, and to be very good discriminative items they should have an index of discrimination greater than .40. As Table 9 shows only 19 items in the Planetarium Skills Evaluation Test had indices of discrimination greater than .30 for the combined scores. Again this suggests that the skills being tested were present in the upper group and to some degree in the lower group.

The lower index of discrimination seems acceptable in this test since one of the primary objectives was to determine how many tasks related to constellation identification the subjects could perform. The low discrimination in most instances was either due to the extreme ease or difficulty of the items.

In addition, Ebel purports that scores on content mastery tests (such as the Planetarium Skills Evaluation Test) tend to be considerably less reliable than tests of relative achievement for equivalent number of items. Ebel states, "This lower reliability is a result of including items in the content mastery test regardless of their discrimination power and hence regardless of their contribution to reliability."[1]

Based on Kuder Richardson Formula #20 the reliability for the combined scores of the Planetarium Skills Evaluation Test was .7189. The following formula was used to calculate the Reliability Coefficient.

$$r = \frac{k}{k-1} \left[1 - \frac{\sum pq}{\sigma^2} \right]$$

k = the number of items in the test
p = portion of the responses to one item which is correct
q = portion of the responses to one item which is incorrect
σ^2 = variance of the scores on the test or subtest

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[1]Robert L. Ebel. Essentials of Education Measurement. Prentice Hall: Englewoods Cliffs, New Jersey, 1972, p. 394.

The p, q values for each item were determined and then multiplied by the proportion of responses which were not correct. The pq values for each item were then added for all items. The resulting sum was then divided by the variance and subtracted from one. This number was then multiplied by the fraction $\frac{k}{k-1}$.

The resulting answer was the reliability of the test scores. The reliability of each of the subtests included in the planetarium test was as follows:

Scanning Abilities Subtest	.20
Orientation Skills Subtest	.54
Brightness Discrimination Subtest	-.52
Measuring Skills Subtest	-.10
Spatial Abilities Subtest	.69

The Brightness Discrimination Subtest had a negative reliability coefficient. This can be partially explained by the fact that there were only two items in this subtest. As Ebel reports, "One of the ways of making test scores more reliable is to lengthen the test on which they are based, that is, to include more questions or items in it and to allow more time."[2] The other factor that accounted for the low reliability coefficient for this subtest was the fact that tasks which are too easy or too difficult are not likely to yield highly reliable scores. The same reasoning is also applicable to the Scanning Abilities and Measuring Skills Subtests, also with low reliability coefficients.

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[2]Ebel, p. 408.

The reliability of the Spatial Abilities and Orientation Skills Subtests was higher than for the other subtests. The Spatial Abilities Subtest which had a reliability of .69 included twenty-seven items. One of the reasons for this larger coefficient of reliability was due to the greater length of this subtest. Even though the Orientation Skills Subtest was shorter it also had a higher reliability coefficient than for several of the other subtests. This higher reliability coefficient was due to the greater range of abilities of the talent able to perform this subtest. As Ebel points out, "The more appropriate a test is to the level of abilities in the group, the higher the reliability of scores it will yield. The wider the range of talent in a group, the higher the reliability of the scores yielded by a test of that talent."[3]

Correlational Analysis of the Planetarium Skills Evaluation Test

A correlational analysis was made on all the items and subtests included in the Planetarium Skills Evaluation Test. This analysis was performed to determine the relationship between the various items and subtests. Any items or subtests observed to be significant at the .05 level might provide a basis for further investigations related to how children learn in the planetarium. All statistical computations were made with the Control Data 360 processing equipment in the Computer Center of Michigan State University.

[3]Ebel, p. 410.

The correlational analysis was performed as a part of the FACTRB program. The results were displayed in a 108 x 108 matrix. The following procedure was employed to determine the different correlations.

		Item B or Subtest B		
		High Score or Correct Response	Low Score or Incorrect Response	
Item A or Subtest A		a	b	High Score or Correct Response
		c	d	Low Score or Incorrect Response

Figure 5

Scatter Diagram for Correlation of Items or Subtests

Two items were correlated simultaneously. For discussion purposes they will be referred to as Items A and B. For each of the items there was either a correct or incorrect response. When the two items were correlated with each other, there were four possibilities for pairings -- both items correct, box a -- Item A correct and Item B incorrect, box b -- Item A incorrect and Item B correct, box c -- and both items incorrect, box d. A scatter diagram

(see Figure 5) was formed to total the number of tally marks for each of the four possibilities.

If a perfect correlation (1) was to occur, all of the tally marks in the scatter diagram would be in boxes a and d. A perfect negative correlation (-1) would be expected to occur when all of the tally marks were included in boxes c and b. When there was an equal distribution of tally marks in each of the boxes, a zero correlation would be observed.

A similar procedure was involved in making the correlations of the subtests; however, instead of correlating correct-incorrect responses, high-low scores for each of the subtests were correlated. For each subtest the subjects were divided into two groups depending upon their test scores -- high scores or low scores. The pairings were plotted in a scatter diagram as described above. The Tetrachoric Correlation Coefficient was then determined for each item-item and subtest-subtest correlation.

The Tetrachoric Coefficient was determined by use of the following equation.

$$r_t = \sin 90° \cdot \frac{(a + d - b - c)}{N}$$

r_t = Tetrachoric Correlation Coefficient

$\sin 90° = 1$

a, b, c, d represent frequency of tally marks in each box of the scatter diagram.

N = total number (a + b + c + d)

In FACTRB each item was correlated with every other item in the test. In addition, each subtest was correlated with each item, other subtests, and items included within the subtests were correlated with the scale score of the subtest.

Item and subtest correlations significant at the .05 level were noted. This meant that, if a large number of samples of the given size were drawn from an uncorrelated population (i.e., p population which = 0), five percent of such samples would be expected to produce a value of r at least as large numerically as the observed value. The correlations which were significant were noted to provide a possible basis for future investigations. To be significant at the .05 level a correlation value must be greater than .28 for the groups containing fifty males or females. A value greater than .20 was necessary to be significant at the .05 level when the correlation values for the combined groups were considered.

Scanning Abilities Subtest Item Correlations

The correlations of the items included in the Scanning Abilities Subtest are shown in Tables 10 and 11. As can be noted in Table 10 only one item correlation for males was significant at the .05 level. This was for the correlation of item 49 with 51. Item 49 required the subjects to scan a slide for small m's. To scan a slide for dots of the same size as the projected standard on the right was the requirement of item 51. As shown in Table 11 there was only

TABLE 10

Correlations of Test Items in Scanning Abilities Subtest for Males

	48	49	50	51
48	100	.02	.11	.16
49		100	.08	.28[a]
50			100	.20
51				100

[a]Correlation significant at the .05 level.

TABLE 11

Correlations of Test Items in Scanning Abilities Subtest for Females

	48	49	50	51
48	100	.14	.09	.11
49		100	.30[a]	.02
50			100	.20
51				100

[a]Correlation significant at the .05 level.

one item showing a significant correlation for females. This was for the correlation of item 49 with 50. Item 50 required the subjects to scan a slide for small a's.

The correlations for the remainder of the item correlations for both groups were very low. This was a result of very little consistency in the abilities of the group toward this skill. The low coefficients of correlation resulted from an almost equal distribution of individuals in the four sections of the scatter diagram which was described earlier. When this distribution occurred, a near zero Coefficient of Correlation could be expected.

Brightness Discrimination Subtest Item Correlations

There were only two items to be correlated for the Brightness Discrimination Subtest -- items 58 and 59. The Coefficient of Correlation for the males was -.12 and .43 for the females. The latter coefficient was significant at the .05 level. For the males to get a negative coefficient they had to correctly answer one item while incorrectly responding to the other more times than getting both items correct or incorrect. The females were more consistent in their responses. They either answered both items correctly or incorrectly to get their positive Coefficient of Correlation.

Orientation Skills Subtest Item Correlations

The coefficients of correlation for the items included in the Orientation Skills Subtest are shown in Tables 12 and 13. As can be noted in Table 12, there were five coefficients significant at the .05 level. Item 53 had significant correlations with items 54, 55, and 56. Items 53 and 54 required the subjects to state a given direction after making turns right or left of the known direction. Item 55 required

TABLE 12

Correlations of Test Items in Orientation Skills Subtest for Males

	52	53	54	55	56	57
52	100	.08	.07	.06	.34[a]	.14
53		100	.32[a]	.38[a]	.46[a]	.22
54			100	.13	.39[a]	.04
55				100	.43[a]	.18
56					100	.12
57						100

[a]Correlation significant at the .05 level.

TABLE 13

Correlations of Test Items in Orientation Skills Subtest for Females

	52	53	54	55	56	57
52	100	-.02	.04	.12	-.07	-.18
53		100	.17	.26	.28[a]	.02
54			100	.20	.41[a]	.14
55				100	.13	.22
56					100	.22
57						100

[a]Correlation significant at the .05 level.

the subjects to state when the rising sun had arrived at a position of south in the planetarium sky. The subjects had to state the setting direction of the sun for item 56. The correct response was northwest.

In addition, item 56 had significant correlations with items 52, 53, and 55. Item 52 was very similar to items 53 and 54 described earlier. The other items have been previously discussed.

There were only two significant item correlations for the females. These are included in Table 13. Item 56 had a significant correlation at the .05 level with items 53 and 54. All three items were described above. In addition, item 52 had three negative correlations with items 53, 56, and 57. This suggested that while getting one of these items correct more females incorrectly responded to the other test item hence the negative correlation.

A great many of the correlations for this subtest were quite low suggesting a lack of consistency among the abilities of the students.

Measuring Skills Subtest Item Correlations

Nine items were correlated in the Measuring Skills Subtest as shown in Tables 14 and 15. As Table 14 shows only two correlations were significant at the .05 level for males -- item 62 with 66 and item 64 with 67. Item 62 when correlated with 65 had a negative correlation of -.28. Item 62 required the subjects to measure the distance from the pointer

TABLE 14

Correlations of Test Items in Measuring Skills Subtest for Males

	60	61	62	63	64	65	66	67	68
60	100	.02	.12	-.14	.13	-.11	.22	.12	.33
61		100	.09	-.05	-.02	.15	-.20	.09	-.09
62			100	.08	-.02	-.07	-.28[a]	-.04	.16
63				100	-.16	-.08	.12	-.08	.14
64					100	-.11	.15	.28[a]	-.02
65						100	-.13	-.07	-.03
66							100	.01	.07
67								100	-.01
68									100

[a]Correlation significant at the .05 level.

stars to the north star, while item 65 required the subjects to compare the two sides of the summer triangle. The latter item was much more difficult for the males. When correlated, item 64 with item 67 had a Coefficient of Correlation of .28. To correctly perform item 64 the subjects had to compare the sides of the winter triangle. Item 67 required the subjects to state what part of a circle the sun had moved through from its rising position to a position in the south in the planetarium sky.

As shown in Table 15 four item correlations were significant for the females -- items 60-61, 61-62, 62-67, and

TABLE 15

Correlations of Test Items in Measuring Skills Subtest for Females

	60	61	62	63	64	65	66	67	68
60	100	.49[a]	.24	-.02	.01	-.15	-.01	-.02	-.18
61		100	.28[a]	.15	-.14	-.19	-.09	.03	-.11
62			100	-.10	-.24	-.03	-.19	.28[a]	.13
63				100	.02	.10	.06	-.26	.03
64					100	.24	.02	-.05	-.19
65						100	-.01	-.19	-.05
66							100	-.09	-.08
67								100	.30[a]
68									100

[a]Correlation significant at the .05 level.

67-68. Items 60 and 61 required the subjects to determine the altitude of the north star above the horizon. Item 62 described above had significant correlations with items 61 and 67 also described previously. In addition, item 67 had a significant correlation with item 68. To perform correctly for item 68 the subject had to state how many hours it would be before the sun returned once again to the meridian.

It is interesting to note that approximately one-half of all the correlations are negative for both groups. This suggests that being able to correctly respond to one item does not guarantee that the subject would correctly answer another. For example, successfully comparing the distance between the stars of the winter triangle and the stars of the spring triangle had a negative correlation of -.11 for the males. Both items 64 and 65 were quite difficult for the males as shown in Table 7.

Spatial Abilities Subtest Item Correlations

Tables 16 and 17 show the results of the correlational analysis of the Spatial Abilities Subtests. As can be seen, there were more significant item correlations for the males than females. There were eight for the females and twenty-eight for the males. Item 69 had significant correlations with the following items -- for the females item 71, for the males items 75, 80, and 88. Item 69 required the subjects to note the position of the Big Dipper in the sky and state when it was upside down of its upright position above the horizon. Item 71 required the subjects to predict the setting location of the sun. Item 75 required the subject to determine from four choices which slide being projected indicated to them that they had traveled nearest the standard. The subjects had to determine which star was extra in the right slide that was not present in the left for item 80. Item 88 employed the use of a star chart to locate a star in the projected slide. Item 70 had a significant correlation with two items -- 82 (females) and 76 (males). Item 70 evaluated the abilities of the subjects

TABLE 16

Correlation of Test Items in Spatial Abilities Subtest for Males

	69	70	71	72	73	74	75	76	77	78	79	80	81	82
69	100	.22	-.01	-.05	.11	.07	.28[a]	.26		.05	,17	.32[a]	-.15	.11
70		100	-.15	.08	.26	.06	.12	.28[a]		-.04	-.05	.02	.07	.04
71			100	.30[a]	.01	-.03	.16	-.12		.06	-.10	.03	.12	.21
72				100	.36[a]	0	.21	.16		.24	.13	.33[a]	.06	.18
73					100	-.05	.20	.25		0	.10	.15	.10	.24
74						100	.10	.13		.21	.33[a]	.27	-.03	-.05
75							100	.24		.02	.16	.20	-.17	-.02
76								100		.18	.12	.16	-.14	-.04
77									100					
78										100	.34[a]	.49[a]	.12	.17
79											100	.45[a]	.12	.30
80												100	.24	.27
81													100	.14
82														100
83														
84														
85														
86														
87														
88														
89														
90														
91														
92														
93														
94														
95														

[a]Correlation significant at the .05 level.

TABLE 16 (Continued)

	83	84	85	86	87	88	89	90	91	92	93	94	95
69	-.08	.03	.02	-.20	.18	-.45[a]	.10	-.20	-.02	.32[a]	.04	-.15	-.12
70	-.12	-.18	-.19	0	.12	-.12	-.10	-.12	.21	.10	-.02	.19	.08
71	.16	.32[a]	.19	0	-.11	.10	.05	.12	.15	.17	-.20	-.08	-.04
72	.04	.14	0	.22	.20	.32[a]	.04	0	.31[a]	.05	.17	.26	.05
73	.15	.18	.06	.13	.10	.16	.24	-.17	.13	.13	.10	.20	.11
74	-.13	-.01	0	-.03	.19	-.07	.03	.07	.25	.06	.09	.07	.11
75	.20	.16	.18	.17	.09	.06	.03	-.08	-.02	.17	.13	.03	.01
76	0	-.06	-.10	.12	0	0	.26	-.33[a]	.09	.36[a]	.08	.14	.25
77													
78	.13	.25	.09	-.01	.03	.24	.29[a]	-.09	-.07	-.01	.05	.22	.04
79	.16	.08	-.02	.08	.34[a]	.10	.37[a]	.12	.05	.17	.13	-.08	.22
80	.17	.33[a]	.10	.03	.02	-.05	.28[a]	0	.17	.03	.08	.04	.08
81	.38[a]	.20	.10	-.16	-.10	.05	.13	.47[a]	.27	-.06	-.14	-.17	.20
82	.13	.14	-.11	-.06	.17	-.02	.19	.07	.06	.11	.09	.03	.30[a]
83	100	.21	.15	.24	-.09	.08	.44[a]	.27	.12	.03	.04	-.11	.08
84		100	.37[a]	.01	-.02	.34[a]	.26	.25	.31[a]	.01	-.21	.20	-.03
85			100	.18	-.08	.19	-.10	.17	.07	-.12	0	-.02	.03
86				100	.07	.20	.13	.12	.09	.10	.22	.13	-.18
87					100	.17	.08	.04	.14	.07	.20	.16	.16
88						100	.12	.06	.22	-.06	.14	.36[a]	.12
89							100	.02	.10	.23	.04	0	.17
90								100	.44[a]	-.15	-.14	-.18	.12
91									100	.09	.11	.15	.21
92										100	.05	.04	-.06
93											100	.26	.05
94												100	.05
95													100

[a]Correlation significant at the .05 level.

TABLE 17

Correlations of Test Items in Spatial Abilities Subtest for Females

	69	70	71	72	73	74	75	76	77	78	79	80	81	82
69	100	.17	.29[a]	-.06	-.02	.03	.02	.08	.09	-.14	-.11	0	-.18	.21
70		100	.03	-.12	.14	-.12	-.02	.11	.09	.14	-.07	-.04	-.16	.37[a]
71			100	-.06	.03	.05	-.03	.29[a]	.07	-.14	-.07	.19	.17	-.06
72				100	.15	.07	-.16	.09	-.11	.25	-.01	-.19	.22	.03
73					100	.06	.24	.20	.09	.14	.02	-.04	-.03	-.12
74						100	.17	.34[a]	.18	.15	.07	-.01	-.04	-.06
75							100	.09	.14	.12	.12	-.05	.11	.02
76								100	.17	.19	-.01	.13	.06	.08
77									100	.08	-.14	.11	-.05	.09
78										100	.16	-.13	.21	.07
79											100	.14	.26	.24
80												100	.02	.18
81													100	.09
82														100
83														
84														
85														
86														
87														
88														
89														
90														
91														
92														
93														
94														
95														

[a]Correlation significant at the .05 level.

TABLE 17 (Continued)

	83	84	85	86	87	88	89	90	91	92	93	94	95
69	-.02	.17	-.01	-.18	.09	-.22	.08	-.08	-.06	.11	-.09	-.11	-.03
70	0	.09	.21	.07	.12	-.04	-.08	-.01	0	.06	-.06	.10	.15
71	.23	.04	-.17	0	.02	.02	-.01	.08	.06	.12	-.04	-.07	.06
72	.12	.10	-.03	.18	.14	.12	-.03	.02	.18	.11	.18	.07	-.07
73	.11	.09	.12	.14	.18	.10	.10	-.06	.13	.04	.05	.09	.11
74	.12	.10	-.03	.02	.14	-.07	.01	.13	.10	-.01	.02	.12	.06
75	.08	.02	-.11	.27	.06	.10	.10	.03	-.02	.05	.13	.06	.09
76	.38[a]	.23	.01	.17	.17	-.03	.15	-.10	0	.19	.15	.17	.12
77	-.07	.24	.23	-.09	-.05	.14	-.04	-.03	.17	.12	-.08	-.05	.03
78	.28[a]	.01	.35[a]	.10	0	.23	.17	-.02	-.12	0	.07	.09	.08
79	.12	.16	.11	.05	.18	.06	.25	.09	.03	.08	.12	.03	.18
80	.17	.25	-.09	-.03	.01	-.09	.14	.05	.04	.04	.01	-.03	0
81	.43[a]	.06	-.09	.04	.05	.01	.05	.29	.16	.05	.01	-.13	.13
82	-.02	.17	.29[a]	.02	.03	-.15	.07	0	-.02	.14	.12	-.06	.14
83	100	.27	.13	.24	.21	.06	.21	.26	.13	.06	.14	.08	.11
84		100	.14	.07	.08	.12	.09	.25	.27	-.02	-.20	.04	-.04
85			100	.13	-.03	.19	-.09	.03	-.01	.09	-.03	0	.08
86				100	.15	.19	.12	.16	-.01	.12	.16	.09	-.04
87					100	.14	.02	.07	.12	.10	.07	.19	.14
88						100	.14	.05	.01	-.01	.06	.24	.13
89							100	.12	.09	.12	.08	.20	.12
90								100	.28	-.07	-.06	-.02	.08
91									100	.14	.07	.16	.09
92										100	.13	.05	-.12
93											100	.17	.02
94												100	.04
95													100

[a]Correlation significant at the .05 level.

to determine when the Big Dipper had arrived exactly left of its noted position. Item 82 required the subjects to detect which star had moved from its position in the left slide. Item 76 required the subjects to determine which projection out of four choices indicated to them that they had not moved from the projected standard.

Item 71 had five correlations on it. (Item 76 females, 72, 84, 88, and 91, males) Items 71, 76, and 88 have been previously described. Item 72 required the subjects to imagine they were behind the projection and to state how it would look from four possible choices. Items 84 and 91 employed the use of a star chart to locate a star in the projected area covering 300 square degrees.

Item 72 had two correlations for males -- items 73 and 80. Item 72 and 80 were discussed earlier. Item 73 required the subjects to imagine that they were looking at the projection from behind it and were to state how it would look.

Item 74 had the correlations -- item 76, females and item 79, males. Item 74 required the subjects to determine which of four projections would indicate to them that they had not moved from the vicinity of the standard. Item 76 was described earlier. To perform correctly on item 79 the subject had to point out the extra star in the right hand slide which he was to compare to the projection on the left.

Item 76 described earlier had correlations with three items -- 83, females, items 90 and 92, males. Item 83

required the subjects to locate a star identified on the left slide in the right slide. Items 90 and 92 both required the use of a star chart to locate a star; however, item 90 used a projected area and 92 the planetarium sky.

Item 78 had significant correlations with four items -- females, 85, -- males items 79, 80, and 89. Item 78 required the subjects to identify which star in the right slide seemed to be larger than the one in the left. The requirements for items 79 and 80 have been discussed previously. Item 85 and 89 required the subjects to use a star chart to locate a given star in the projected area.

Item 79 had three significant correlations for the males -- items 80, 87, and 89. All items except for 87 have been described earlier. Item 87 required the subjects to use a star chart to find an identified star on the star chart among the stars being projected.

Item 80 had two significant item correlations for the males -- items 84 and 89. All of the requirements for each item have been described earlier.

Item 81, which required the subjects to determine which star had moved in the right slide from the position it had in the left, had two significant correlations -- item 83 for both groups and item 90 for the males. Items 83 and 90 have been described elsewhere in this section.

Item 82 had only one significant item correlation and was the remaining significant correlation for the females. It was item 85. Item 85 required the subject to use a star

chart to locate the required star in the projected area.

For the males item 84 was significantly correlated with items 85, 88, and 91. The requirements for items 84, 85, and 88 have been described earlier. Item 91 required the subjects to use a star chart to locate a star in a projected area of 300 square degrees.

Item 88 described earlier was significantly correlated for the males with item 94. Item 94, which used the planetarium sky and star chart, required the subject to locate the star Rigel.

Item 90 was also significantly correlated with item 91. Both of these test items required the use of a star chart to locate a particular star in the projected area.

The coefficients of correlation between the scores on the items included in the Spatial Abilities Subtest were low. These low coefficients mean that the measures bear little or no consistent relationship to each other. The low coefficients for the correlations on individual items included in the Planetarium Skills Evaluation Test was as expected. Ebel states, "Coefficients of Correlation between the scores on individual items of an objective test average about .10 but often range from about -.30 to about 0.50."[4]

The males had over three times the number of significant correlations that the females did. This suggests that

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[4]Ebel, p. 303.

the males were more consistent in their responses, i.e., they tended to either answer both items correct or incorrect rather than getting one item correct while missing the other.

Also, there was only one significant correlation for the items requiring the use of a star chart and a projected slide and those items involving a star chart and the planetarium sky. It can be concluded from these results that these type items bear little consistent relationship to each other, that is to say, that being able to locate a star in a projected slide does not guarantee that an individual will be able to do so in the planetarium sky.

Correlation of Subtest Total Scores with Each Item in Subtest

Table 18 shows the intercorrelations of the items included in each subtest with the scale score of that subtest. From the table it can be noted that almost everyone of the correlations was significant at the .05 level of significance. It can also be observed that there were not any negative correlations present. This suggests that for the most part those individuals getting a high or low score on the subtest were fairly consistent in either correctly answering the item and being in the high group or incorrectly answering it and being in the low group for that subtest.

TABLE 18

Correlation of Subtest Total Scores with Each Item in Subtest

Scanning Abilities Subtest

Item	48	49	50	51	
	.36[a]	.69[a]	.49[a]	.67[a]	Males
Correlation	.44[a]	.64[a]	.70[a]	.58[a]	Females
	.40[a]	.66[a]	.60[a]	.62[a]	Combined

Orientation Skills Subtest

	52	53	54	55	56	57	
	.49[a]	.67[a]	.55[a]	.61[a]	.75[a]	.46[a]	Males
Correlation	.32[a]	.55[a]	.60[a]	.65[a]	.50[a]	.45[a]	Females
	.41[a]	.61[a]	.57[a]	.61[a]	.66[a]	.45[a]	Combined

Brightness Discrimination Subtest

	58	59	
	.71[a]	.45[a]	Males
Correlation	.89[a]	.66[a]	Females
	.82[a]	.56[a]	Combined

Measuring Skills Subtest

	60	61	62	63	64	65	66	67	68	
	.47[a]	.35[a]	.35[a]	.28[a]	.30[a]	.21	.15	.47[a]	.49[a]	Males
Correlation	.45[a]	.48[a]	.51[a]	.29[a]	.18	.23	.09	.38[a]	.33[a]	Females
	.45[a]	.42[a]	.44[a]	.29[a]	.23[a]	.20[a]	.12	.42[a]	.41[a]	Combined

Spatial Abilities Subtest

	69	70	71	72	73	74	75	76	77	78	
	.23	.23	.24	.55[a]	.44[a]	.32[a]	.42[a]	.41[a]	--	.43[a]	Males
Correlation	.10	.21	.27	.16	.35[a]	.23	.31[a]	.53[a]	.25	.36[a]	Females
	.17	.22[a]	.25[a]	.38[a]	.40[a]	.28[a]	.37[a]	.46[a]	.16	.40[a]	Combined

	79	80	81	82	83	84	85	86	87	88	
	.50[a]	.58[a]	.23	.37[a]	.32[a]	.41[a]	.19	.28[a]	.32[a]	.34[a]	Males
Correlation	.30[a]	.25	.21	.27[a]	.52[a]	.33[a]	.33[a]	.41[a]	.34[a]	.22	Females
	.40[a]	.43[a]	.22[a]	.32[a]	.40[a]	.26[a]	.26[a]	.34[a]	.33[a]	.28[a]	Combined

	89	90	91	92	93	94	95	
	.43[a]	.14	.50[a]	.34[a]	.28[a]	.33[a]	.30[a]	Males
Correlation	.21	.49[a]	.05	.28[a]	.02	.28[a]	.12	Females
	.34[a]	.25[a]	.30[a]	.31[a]	.26[a]	.30[a]	.24[a]	Combined

[a]Correlation significant at the .05 level.

As a part of the validation process for the Planetarium Skills Evaluation Test, it was necessary to compare the subtests in the Planetarium test with those of the Classroom Indirect Measurement Instrument purported to measure identical skills. If a significant correlation at the .05 level of significance was found between the subtests assumed to measure the same skills, further evidence would be provided to support the validation of the Planetarium Skills Evaluation Test and provide evidence that the Classroom Indirect Measurement Instrument could be used as a predictor of planetarium performance. Tables 19 and 20 include the correlations for the various subtests with each other.

When the scores of the Scanning Abilities Subtest of the Classroom Indirect Measurement Instrument were correlated with the various subtests of the planetarium test, significant correlations were noted for both sexes. The Scanning Skills Subtest made a significant correlation with the Spatial Abilities Subtest of the planetarium test for males. For the females this classroom subtest had a significant correlation with the Orientation Skills Subtest.

However, there was no significant correlation between the two Scanning Skills Subtests. In fact there was only a one percent correlation for the males and an eight percent correlation for the females for the two subtests. Therefore, the ability to scan for a word in a sentence does not seem to be significantly correlated with the ability to search for and count letters or dots on a projected slide.

TABLE 19

Correlations of Classroom Indirect Measurement Instrument and Planetarium Skills Evaluation Subtests for Males

	*Sc1	*D1	*Br1	*M1	*Sp1	*Tot1	Sc2	D2	Br2	M2	Sp2	Tot2
Sc1	100	.02	-.06	.17	.30	.49[a]	.01	.24	.06	.05	.29[a]	.27
D1		100	-.11	.24	.47[a]	.59[a]	.34[a]	.46[a]	0	.02	.44[a]	.47[a]
Br1			100	-.04	.02	.11	.31[a]	-.02	.45[a]	-.27	.02	.02
M1				100	.30[a]	.59[a]	.20	.30[a]	.27	.14	.36[a]	.40[a]
Sp1					100	.88[a]	.29[a]	.46[a]	.06	.10	.55[a]	.56[a]
Tot1						100	.37[a]	.54[a]	.20	.08	.63[a]	.65[a]
Sc2							100	.26	.08	-.18	.23	.33[a]
D2								100	.03	.26	.66[a]	.80[a]
Br2									100	-.10	.32[a]	.27
M2										100	.24	.43[a]
Sp2											100	.94[a]
Tot2												100

[a]Correlation significant at the .05 level.

*Sc - Scanning Abilities Subtest

*D - Orientation Skills Subtest

*Br - Brightness Discrimination Subtest

*M - Measuring Skills Subtest

*Sp - Spatial Abilities Subtest

*Tot - Total Score

TABLE 20

Correlations of Classroom Indirect Measurement Instrument and Planetarium Skills Evaluation Subtests for Females

	*Sc1	*D1	*Br1	*M1	*Sp1	*Tot1	Sc2	D2	Br2	M2	Sp2	Tot2
Sc1	100	.30[a]	.14	.29[a]	.31[a]	.68[a]	.08	.39[a]	-.07	.15	.25	.42[a]
D1		100	-.02	.02	.23	.48[a]	-.17	.30[a]	-.15	.14	.11	.21
Br1			100	.04	-.02	.23	.07	-.09	.02	-.09	.12	-.10
M1				100	.24	.55[a]	.28[a]	.28[a]	.02	.23	.24	.38[a]
Sp1					100	.79[a]	.08	.40[a]	-.02	.08	.59[a]	.60[a]
Tot1						100	.13	.50[a]	-.06	.18	.49[a]	.62[a]
Sc2							100	-.04	.20	-.18	.06	.19
D2								100	.04	.02	.33[a]	.51[a]
Br2									100	-.01	-.06	.10
M2										100	.23	.49[a]
Sp2											100	.83[a]
Tot2												100

[a]Correlation significant at the .05 level.

*Sc - Scanning Abilities Subtest

*D - Orientation Skills Subtest

*Br - Brightness Discrimination Subtest

*M - Measuring Skills Subtest

*Sp - Spatial Abilities Subtest

*Tot - Total Score

The significant correlations with the Orientation Skills and Spatial Abilities Subtests seem to indicate that the ability to successfully scan or not scan for words in sentences is related to being able to perform the many tasks associated with the Spatial Abilities Subtest and the various maneuvers required to ascertain directions.

The Orientation Skills Subtest of the Classroom Indirect Measurement Instrument was significantly correlated with the Orientation Skills Subtest included in the planetarium test. Thus, this subtest included in the planetarium test does evaluate the abilities to determine directions. The coefficients of correlation for the subtests was .46 for the males and .30 for the females. In addition, the Orientation Skills Subtest was also significantly correlated with the Spatial Abilities Subtest of the males. This suggests that the ability to determine directions was also important for being able to do the various tasks required in the Spatial Abilities Subtest.

The Brightness Discrimination Subtest of the Classroom Indirect Measurement Instrument and Planetarium Skills Evaluation Test had a significant correlation for the males. As Table 19 shows there was a .45 correlation; however, Table 20 indicates only a .02 correlation for females. The low correlation for the females suggests that there was almost an equal distribution of females getting high or low scores on both tests and individuals getting a high score on one subtest and a low score on the other.

The Measuring Skills Subtest of the Classroom Indirect Measurement Instrument was not significantly correlated with the Measuring Skills Subtest of the Planetarium Skills Evaluation Test for either group. There was only a .14 correlation for the males and .23 correlation for the females. It is interesting to note that the Measuring Skills Subtest of the Classroom Indirect Measurement Instrument was significantly correlated with the Orientation Skills and Spatial Abilities Subtests for the males. For the females the Measuring Abilities Subtest was significantly correlated with the Scanning Skills and Orientation Skills Subtests.

Perhaps a reason for the low correlations for both groups on the two measuring subtests was that different aspects of measurement skills were being tested for in each test. Recognizing angles, etc. in the Classroom Indirect Measurement Instrument was considerably different than actually measuring and comparing distances in the planetarium sky.

The Spatial Abilities Subtests were significantly correlated for both males and females. A correlation of .55 was obtained for the males and .59 for the females. Thus, the Spatial Abilities Subtest of the Planetarium Skills Evaluation Test is evaluating the ability to perform tasks related to spatial abilities.

As Tables 19 and 20 show the Spatial Abilities Subtest of the Classroom Indirect Measurement Instrument was also significantly correlated with the Orientation Skills Subtest. This suggests that the subjects who scored high or low on the

Spatial Abilities Subtest also did so for the Orientation Skills Subtest.

When each of the subtests of the planetarium test was correlated with other subtests included in the planetarium test, several significant correlations were obtained. For the males the orientation subtest had a significant correlation with the Spatial Abilities Subtest. In addition, the Brightness Discrimination Subtest had a significant correlation with the Spatial Abilities Subtest. There was only one significant subtest correlation for the females. This was for the correlation of the Orientation Skills Subtest with the Spatial Abilities Subtest.

Generally, most of the obtained correlations for the various subtests were positive indicating that most of the subtests had either both high or low scores on each of the compared subtests rather than having a high score on one subtest and a low score on the other. To obtain a negative correlation would be just the opposite. As Tables 19 and 20 show there were a few negative correlations present for both groups with the females having more negative correlations than the males. It seems the females were not as consistent in receiving both high or low scores on each of the subtests.

The Spatial Abilities and Orientation Skills Subtests had the most significant correlations with the other subtests. These two subtests produced more variation in scores than did the other subtests. This affected the size of the coefficients of correlation.

The low correlations between subtests purported to measure the same skills may be a result of the differences evoked between the Classroom and Planetarium Subtests. The Classroom Indirect Measurement Instrument, which was in a more familiar paper-pencil type format, was vastly different in some aspects than working in the dark with myriad of stars. This difference might have affected the results. Also, it seems reasonable to asume that the skills required to do the Classroom Indirect Measurement Instrument are indeed different from those employed to locate the stars in the planetarium sky.

Correlation of All Items Included in the Classroom Indirect Measurement Instrument with all Items Included in the Planetarium Skills Evaluation Test

In addition to correlating each item included in each subtest with every other item in the subtest and the total score of each subtest with every other subtest total scores; a correlational analysis was made of each item with every other item included in both tests. The findings indicated that there were no significant correlations outside of the items which were in the subtests. These results demonstrate the strength of the subtests and the lack of strength anticipated for support of the thesis that the Classroom Indirect Measurement Instrument can be used as a predictor of planetarium performance. A factor analysis was next performed to determine high loadings on given factors.

Factor Analysis

A factor analysis was made on the data because it has the potential to bring out the basic factors in a test and can assist in providing a greater understanding as to why a test works. When items in the planetarium and classroom tests have loadings on a common factor, it can be assumed that they are measuring the same thing but the degree to which they measure will be shown by the size of the factor loading. Two items which measure the same thing must give similar results, and two items which involve some common abilities will give results which agree to the extent of the common abilities involved.

Two factor analyses were performed on the test scores of the total group. First, a factor analysis was performed on all of the test items included in both the Classroom Indirect Measurement Instrument and Planetarium Skills Evaluation Test. In addition, a factor analysis was performed on only those items included in the Planetarium Skills Evaluation Test.

In the factor analysis performed as a part of the FACTRB operation the production of twenty factors was requested for each analysis. In FACTRB the analysis was performed with each variable's largest correlation as its communality. After each rotation each of the variables was recorded and grouped according to their largest factor loading. The twenty groups formed were based on the variable's largest factor loading in the last varimax rotation.

The factors produced from the two factor analyses are presented in Appendices D and E. Generally the results demonstrated that high loadings of test items that employed stars rarely were associated in factors that contained items that used slides and star charts to locate a star.

Twenty factors were requested and obtained in the factor analysis of the Planetarium Skills Evaluation Test. These factors are presented in Appendix D. The factors were related to: scanning abilities, orientation skills, spatial abilities, comparison abilities, angular measurement abilities and measurement abilities.

Twenty factors were requested but only eight were obtained in the factor analysis of the Planetarium Skills Evaluation Test. These factors are listed in Appendix E. The factors were associated with: orientation skills, measurement and spatial abilities, comparison skills, spatial abilities, and first item evaluation.

Analysis of Data Concerning the Hypotheses

Seven hypotheses were developed in order to test several implications related to planetarium skills of fifth-grade students and to assist in the concurrent validation of the subtests included in the Planetarium Skills Evaluation Test. Each of the hypotheses is stated in the null form and is discussed separately.

> Ho_1: There is no significant difference in the abilities of fifth-grade boys and girls to correctly identify directions on the Orientation Skills Subtest of the Planetarium Skills Evaluation Test.

When the Orientation Skills Subtest scores for males and females was correlated, a -.05 Coefficient of Correlation was obtained. From the design of the program to test this hypothesis a positive coefficient favored males and a negative coefficient females. The -.05 Coefficient of Correlation indicated that the test scores favored females; however, this coefficient was not large enough to be significant at the .05 level of significance. A coefficient greater than .20 was required for the correlation to be significant at the .05 level of significance with 98 degrees of freedom. Therefore, these findings indicated that the null hypothesis of no significant difference in abilities of fifth-grade boys and girls to correctly identify directions on the Orientation Skills Subtest of the Planetarium Skills Evaluation Test cannot be rejected.

> Ho_2: There will be no correlation between the scores obtained with the Planetarium Orientation Skills Subtest and the scores obtained with the Orientation Skills Subtest included in the Classroom Indirect Measurement Instrument for both males and females.

When the test scores of the Orientation Skills Subtests of the planetarium and classroom tests were correlated, the following findings were noted:

Coefficient of Correlation, Males -- .46
Coefficient of Correlation, Females -- .30

Both of these coefficients were significant at the .05 level of significance. A Coefficient of Correlation greater than .28 was needed to obtain a significant correlation for 48 degrees of freedom. The null hypothesis can be rejected for both males and females since there was a significant correlation between the two subtests for both groups. The findings suggested that there was a consistency between the test scores for each of the subtests = individuals scoring high or low on one subtest also did so on the other.

> Ho_3: There will be no correlation between the scores obtained with the Planetarium Measuring Skills Subtest and the scores obtained with the Measuring Skills Subtest included in the Classroom Indirect Measurement Instrument for both males and females.

When the subtest scores for males and females were correlated, the following results were obtained:

Coefficient of Correlation, Males -- .14
Coefficient of Correlation, Females -- .23

Neither of these coefficients was large enough to be significant at the .05 level. Therefore, the null hypothesis cannot be rejected for either group. It seems that the Measuring Skills Subtest included in the Classroom Indirect Measurement Instrument, which required the students to be able to recognize angles from drawings or compare parts to the whole, was not evaluating the same skills as the measuring subtest of the planetarium test. This subtest required the students to measure the altitude of stars and to compare the distance between stars in the planetarium sky.

> Ho_4: There is no significant difference in the abilities of fifth-grade boys and girls in being able to correctly identify spatial relationships on the Spatial Abilities Subtest of the Planetarium Skills Evaluation Test.

When the Spatial Abilities Subtest scores for males and females were correlated, a -.03 Coefficient of Correlation was obtained. As stated previously, a negative coefficient with sex comparisons indicated that the subtest scores favored the females; however, a -.03 Coefficient of Correlation was too low to be significant at the .05 level of significance. Therefore, the null hypothesis cannot be rejected.

> Ho_5: There will be no correlation between the scores obtained with the Planetarium Spatial Abilities Subtest and the scores obtained with the Spatial Abilities Subtest included in the Classroom Indirect Measurement Instrument for both males and females.

When the subtest scores for the two spatial abilities subtests were correlated, a Coefficient of Correlation of .55 was obtained for males and .59 for females. Therefore, the Coefficients of Correlation were significant for both sexes at the .05 level. Thus, the null hypothesis can be rejected for both groups as there is a significant correlation between both subtests. The findings indicated that those individuals who scored either high or low on the Classroom Indirect Measurement Instrument Spatial Abilities Subtest also tended to receive a similar test score on the Spatial Abilities Subtest of the planetarium test.

> Ho_6: There will be no correlation between the scores obtained with the Planetarium Scanning Abilities Subtest and the scores obtained with the Scanning Abilities Subtest included in the Classroom Indirect Measurement Instrument for both males and females.

When the scores obtained on the Classroom Indirect Measurement Instrument and planetarium subtests related to scanning skills were correlated, the following results were obtained:

Coefficient of Correlation, Males -- .01
Coefficient of Correlation, Females -- .08

Both of these correlations were not significant at the .05 level. Therefore, the null hypothesis can not be rejected for either sex. A low Coefficient of Correlation indicated that the students were not consistent in their abilities for these two subtests. The number of individuals scoring either high or low on both subtests was approximately equal to the number that received a high score on one test and a low score on the other.

It seems from the findings that the ability to scan a sentence for words (Classroom Test) does not require the same skills as those required to scan a projected area for letters of the alphabet or dots of the same size (Planetarium Skills Evaluation Test).

Ho_7: There will be no correlation between the scores obtained with the planetarium Brightness Discrimination Subtest and the scores obtained with the Brightness Discrimination Subtest of the Classroom Indirect Measurement Instrument for both males and females.

When the subtest scores of the males and females for the Brightness Discrimination Subtests were correlated, the following Coefficients of Correlation were obtained:

Coefficient of Correlation, Males -- .45
Coefficient of Correlation, Females -- .02

The Coefficient of Correlation for the males was significant at the .05 level while that of the females was not. Therefore, the null hypothesis can be rejected for the males but not for the females.

The scores of the females might have been influenced by the fact that to perform this Classroom Indirect Measurement Instrument subtest required them to be placed in total darkness except for two dots of light being projected. Since this portion of the Classroom Test was the first portion of the entire test requiring the subjects to be placed in the dark, the females were more uneasy than the males and did not give these items their full attention. However, by the time the females took the planetarium subtest they were getting used to working in the dark and may have responded differently to the Brightness Discrimination items.

CHAPTER V

SUMMARY, CONCLUSIONS, AND RECOMMENDATIONS

Summary

This study was stimulated by the pressing need to determine how students learn to identify constellations. This was deemed important since a large portion of time in each planetarium presentation made to school groups is usually devoted to identifying constellations which are visible that evening in the real sky.

The purpose of this study was to construct a diagnostic test, made up of five subtests, to determine if the fifth-grade students used in the investigation can demonstrate those particular prerequisite skills that an individual must have in order to learn constellations. From the skills commonly identified by writers of sky guides as being required for identifying or working with constellations the investigator identified six major areas that are important for identification of constellations. These are the ability to: 1. scan the sky for a specific or group of targets; 2. orientate themselves relative to direction; 3. discriminate between the brightnesses of stars; 4. measure angular distance in the sky; 5. recognize a constellation against a background of the sky; and 6. detect the relative changes of position of various star groups during observation. Associated with these skills is the ability to use a star chart, i.e., to be able to match stars listed with those visible in the planetarium or real sky.

To test an individual's understanding of these skills in the planetarium, a forty-eight question examination (Planetarium Skills Evaluation Test) was constructed by the investigator. Face and content validity were established by two panels of reviewing experts.

A Classroom Indirect Measurement Instrument was also developed from available educational instruments or procedures accepted as being able to test for constellation identification skills. This instrument would provide concurrent validity, and would allow for a means of comparing planetarium performance of constellation identification skills with the results of the classroom instrument.

The sample subjects were drawn from the total fifth-grade enrollment of students in seven elementary schools in Coldwater, Michigan. All of the subjects used in the investigation had visited the planetarium at least once prior to their testing session. The total sample was 120. Twenty of these subjects were involved in the testing of the trial version of the test.

The planetarium employed in this study is located in the Legg Junior High School in Coldwater, Michigan. The star projector is the Spitz A-3P which is housed under a thirty foot dome. The investigator is experienced in the use of the planetarium equipment, and he has instructed about sixty thousand elementary and junior high school children there during the past six years.

The Planetarium Skills Evaluation Test was administered individually. The examinee was first given an eye test to check for visual acuity. Next the examinee moved to a table located in the front of the planetarium chamber where he was administered the Classroom Indirect Measurement Instrument. After a short break, the examinee was given the Planetarium Skills Evaluation Test. The test was administered orally. As a part of the testing procedure, the examinee was provided with a portable pointer to use to point out the different celestial objects as required. During the entire test, the examinees proceeded at their own rate, except where time limits were set for specific test items. An average time of one hour and ten minutes was required by the examinees to complete the entire testing session.

The test items were read and the responses recorded by the investigator. In addition, the equipment was operated by the investigator to insure that each testing session was as identical as possible. Each subject was placed at the same location in the chamber for the testing session.

An item analysis, correlation analysis, and factor analysis were performed on the Planetarium Skills Evaluation Test and Classroom Indirect Measurement Instrument scores to test the null hypotheses and other areas of concern.

Conclusions

The following conclusions can be drawn from this study:

1. More than fifty percent of the fifth-grade subjects involved in this investigation were able to successfully scan a slide for a target.

2. The Orientation Skills Subtest was the most difficult subtest. Less than fifty percent of the subjects were able to correctly identify the cardinal points of direction which were required of them.

3. The Brightness Discrimination Subtest was the easiest subtest to perform of those included in the Planetarium Skills Evaluation Test.

4. More than fifty percent of the subjects included in this study were able to perform successfully those items included in the Measuring Skills Subtest.

5. Less than fifty percent of the subjects could perform the spatial skills requiring use of stars for a response.

6. Finding a given star in a projection was much easier than finding a star in the planetarium sky.

7. Most of the item correlations were not significant at the .05 level of significance.

8. Almost all of the items included in the various subtests had significant correlations at the .05 level of significance when correlated with the subtest scale scores for the subtest in which they were included.

9. The Spatial Abilities and Orientation Skills Subtests had the greatest number of significant correlations at the .05 level.

10. The males had more significant correlations with the Spatial Abilities and Orientation Skills Subtests included in the planetarium test than did the females.

11. The Scanning Abilities Subtest of the Classroom Indirect Measurement Instrument had significant correlation with the Spatial Abilities and Orientation Skills Subtests included in the Planetarium Skills Evaluation Test.

12. The Orientation Skills Subtest included in the Classroom Indirect Measurement Instrument had a significant correlation with the Orientation Skills and Spatial Abilities Subtests of the Planetarium Skills Evaluation Test.

13. The Brightness Discrimination Subtest of the Classroom Indirect Measurement Instrument and Planetarium Skills Evaluation Test had a significant correlation at the .05 level for the males.

14. The Measuring Skills Subtest of the Classroom Indirect Measurement Instrument had a significant correlation with the Orientation Skills and Spatial Abilities Subtests of the planetarium test for males and the Scanning Abilities and Orientation Skills Subtests for females.

15. The Spatial Abilities Subtests had a significant correlation at the .05 level of significance for both sexes. The Spatial Abilities Subtest included in the Classroom Indirect Measurement Instrument was also significantly correlated with the Orientation Skills Subtest of the planetarium test.

16. The Orientation Skills Subtest of the Planetarium Skills Evaluation Test had a significant correlation with the Spatial Abilities Subtest of the planetarium test for both sexes and the Brightness Discrimination Subtest for males.

17. Generally the high loadings included in the factors which resulted from the factor analysis of the Classroom Indirect Measurement Instrument and Planetarium Skills Evaluation Test were grouped in such a manner that Classroom Indirect Measurement Instrument items grouped with each other more often than with the items included in the planetarium test; however, the high loadings were not necessarily from any one subtest.

18. High loadings related to test items that employed the stars rarely were grouped with items that used slides and star charts to locate a star.

19. Twenty factors were requested and obtained in the factor analysis of the Planetarium Skills Evaluation Test. The factors were related to: scanning abilities, orientation skills, spatial abilities, comparison abilities, angular measurement abilities and measurement abilities.

20. Twenty factors were requested but only eight were obtained in the factor analysis of the Planetarium Skills Evaluation Test. The factors were associated with: orientation skills, measurement and spatial abilities, comparison skills, spatial abilities, and first item evaluation.

21. Seven null hypotheses were tested, but only three were rejected: Ho_2 and Ho_5 for both sexes and Ho_6 for males.

Ho_2: There will be no correlation between the scores obtained with the planetarium Orientation Skills Subtest and the scores obtained with the Orientation Skills Subtest included in the Classroom Indirect Measurement Instrument for both males and females.

Ho_5: There will be no correlation between the scores obtained with the planetarium Spatial Abilities Subtest and the scores obtained with the Spatial Abilities Subtest included in the Classroom Indirect Measurement Instrument for both males and females.

Ho_6: There will be no correlation between the scores obtained with the planetarium Brightness Discrimination Subtest and the scores obtained with the Brightness Discrimination Subtest of the Classroom Indirect Measurement Instrument for both males and females.

Recommendations

The following recommendations are submitted:

1. It is recommended that additional studies be conducted to determine the best procedures to utilize in the planetarium to increase the competencies of students in their understandings of orientation and spatial related skills. Furthermore a study to compare the effectiveness of the planetarium and the classroom in the teaching of skills necessary to orientate oneself in the out-of-doors should be made. This investigator is inclined to believe that the planetarium is more effective; he recommends that this hypothesis be tested.

2. It is also recommended that a test comparable to the Planetarium Skills Evaluation Test be constructed to be administered on a group basis to evaluate student planetarium skills. The test should be given to students in the third through sixth grades. In addition, it is also suggested that

a more diverse group of examinees be used, i.e., students in cities, rural locations, etc. A test of this type would permit the researcher to gain further insight as to when certain planetarium related skills appear in elementary school age children. This knowledge is important for the design of planetarium lessons.

3. It is especially recommended that an instrument or lesson be developed to evaluate the performance of skills used in the planetarium and the out-of-doors to identify the constellations or work with the stars. A factor analysis should be performed on the data to determine what type of high loadings factor out together. This type of information is of great importance for the development of lessons and materials necessary to employ in the planetarium teaching for successful transfer of skills to the out-of-doors for use with the real sky.

4. The findings of this study indicate that not all skills required to locate and identify a constellation in the planetarium sky are in the repertory of skills of fifth-grade students. Instruction is required to teach how to use these skills, especially in regards to spatial abilities and orientation skills. This instruction must involve the use of the sky itself rather than pictures or slides as indicated from the results of the factor analysis. Items or skills using the planetarium sky do not factor with those items or skills employing paper-pencil type items.

Care must be given in the evaluation of these skills since the ability to recognize a drawing of Orion on a star chart or slide does not guarantee that the individual can locate it or recognize it in the sky. Consideration of this fact should be given in future planetarium investigations that require students to identify constellations as a part of the testing procedure.

APPENDICES

APPENDIX A

FACE VALIDITY PANEL

APPENDIX A

FACE VALIDITY PANEL

Ms. Sharon Franz,	Fifth-grade teacher Edison School Coldwater, Michigan
Ms. Alice McKinney,	Fifth-grade teacher Edison School Coldwater, Michigan
Ms. Joyce Bemis,	Fifth-grade teacher Edison School Coldwater, Michigan
Mr. James Miller,	Principal Franklin School Coldwater, Michigan

APPENDIX B

CONTENT VALIDITY PANEL

APPENDIX B

CONTENT VALIDITY PANEL

D. David Batch	Planetarium Specialist Abrams Planetarium Michigan State University East Lansing, Michigan
Ron Cobia	Planetarium Specialist Abrams Planetarium Michigan State University East Lansing, Michigan
Robert Victor	Staff Astronomer Abrams Planetarium Michigan State University East Lansing, Michigan

APPENDIX C

THE EXAMINATION

APPENDIX C

THE EXAMINATION

The Planetarium Skills Evaluation Test was made up of five subtests. The test was administered individually in the planetarium. The directions for equipment set-up and procedures for administration of the test are included for each of the items. The scoring procedures for each of the subtests are listed in each of the sections of the different subtests.

Subtest A. Scanning Abilities

Directions: For this part of the examination the examiner is to project slides 6-10 in Carousel Tray B and slides 7 and 8 in Carousel Tray A. Give the subject 15 seconds to scan each slide, then ask for his response. Record his response before projecting the next slide. For a correct response, mark BLANK A on the appropriate question on the answer sheet, for an incorrect response mark BLANK B. The slides are to be projected onto the planetarium dome. The identification number for each of the slides are as follows:

Tray B				Tray A			
Slide	Ident Number	Quest.	Correct Response	Slide	Ident Number	Quest.	Correct Response
6	A						
7	1-1	Example	2				
8	1-2	48	3 C's				
9	1-5	49	13 M's				
10	1-6	50	10 A's				
11	1-6			7	12-4	Example	1
				8	12-3	51	5

PROJECT SLIDE 6 - TRAY B

State, "DURING THIS PART OF THE EXERCISE I AM GOING TO SHOW SEVERAL SLIDES. FOR EACH SLIDE I AM GOING TO GIVE YOU A SHORT PERIOD OF TIME TO COUNT THE NUMBER OF A GIVEN LETTER THAT I STATE TO YOU LIKE A, B, C, OR D, COUNT AS FAST AND AS ACCURATELY AS YOU CAN."

PROJECT SLIDE 7 - TRAY B

State, "AS AN EXAMPLE LOOK AT THE FIRST SLIDE AND COUNT THE NUMBER OF SMALL LETTER F's THAT YOU SEE."
Pause for 15 seconds. State, "THE ANSWER IS TWO. YOU WILL USE THE SAME PROCEDURE FOR EACH OF THE NEXT SERIES OF SLIDES. DO YOU HAVE ANY QUESTIONS AS TO HOW YOU ARE TO DO THIS QUESTION?"

Subtest A. Scanning Abilities, Cont.

PROJECT SLIDE 8 - TRAY B <u>QUESTION</u> <u>48</u>.

Ask, "WHAT IS THE NUMBER OF SMALL LETTER C's THAT YOU SEE ON THIS SLIDE?"

Pause for 15 seconds. Answer: 3. If the subject correctly states the number of small letter c's, count the question correct.

PROJECT SLIDE 9 - TRAY B <u>QUESTION</u> <u>49</u>.

Ask, "WHAT IS THE NUMBER OF SMALL LETTER M's ON THIS SLIDE?"

Pause for 15 seconds. Answer: 13. If the subject correctly states the number of small letter m's, count the question correct.

PROJECT SLIDE 10 - TRAY B <u>QUESTION</u> <u>50</u>.

Ask, "WHAT IS THE NUMBER OF SMALL LETTER A's ON THIS SLIDE?"

Pause for 15 seconds. Answer: 10. If the subject correctly states the number of small letter a's, count the question correct.

PROJECT SLIDE 10 - TRAY B, SLIDE 7 - TRAY A.

State, "DURING THIS PART OF THE EXERCISE I AM GOING TO SHOW YOU TWO SLIDES AT THE SAME TIME. THE SLIDE ON THE RIGHT WILL BE OF A SINGLE DOT." Point out the dot. "THE SLIDE ON THE LEFT WILL CONTAIN MANY DOTS OF DIFFERENT SIZES. FOR EACH SLIDE ON THE LEFT I AM GOING TO GIVE YOU A SHORT PERIOD OF TIME TO COUNT THE NUMBER OF DOTS THAT SEEM TO BE THE SAME SIZE AS THE DOT ON THE RIGHT."

"AS AN EXAMPLE LOOK AT THE SLIDE ON THE LEFT AND COUNT THE NUMBER OF DOTS THAT SEEM TO BE THE SAME SIZE AS THE DOT ON THE RIGHT."

Pause for 15 seconds. Then state, "THE ANSWER IS ONE. YOU WILL USE THE SAME PROCEDURE TO DO THE NEXT SLIDE."

Subtest A. Scanning Abilities, Cont.

PROJECT SLIDE 10 - TRAY B, SLIDE 8 - TRAY A. QUESTION 51.

Ask, "HOW MANY DOTS ON THE LEFT SEEM TO BE THE SAME SIZE AS THE DOT ON THE RIGHT?"

Pause for 15 seconds. Answer: 5. If the subject correctly states the number of dots, count the question correct.

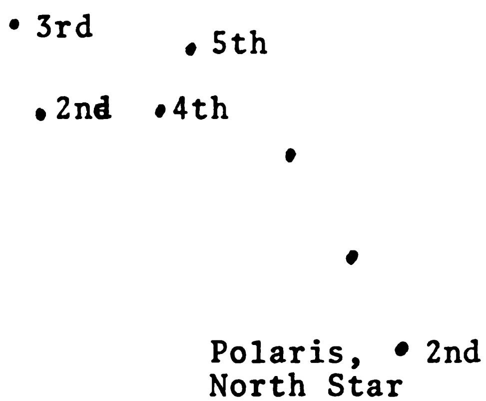
Subtest B. Orientation Skills

Set Up of Equipment	Questions & Comments
For this section of the test place large numbers around the dome of the planetarium going in a clockwise direction. Each number is printed on a white cardboard and the numbers are 6 inches tall. The numeral one should be opposite the point where the subject is participating in this section of the exam. The numbers 1-8 should be placed every 45° around the dome.	52. Examiner state to subject, "PRETEND NUMBER ONE ON THE PLANETARIUM DOME STANDS FOR THE DIRECTION NORTH, THEN WHAT DIRECTION DOES NUMBER 7 STAND FOR?" Answer: West
Questions 52, 53, and 54 should be administered with the straw colored lights turned on full intensity.	53. Examiner state to subject, "PRETEND NUMBER ONE STANDS FOR THE DIRECTION SOUTH, ASSUME YOU ARE WALKING TOWARDS THE NUMBER THREE AND TURN TO YOUR RIGHT, WHAT DIRECTION WOULD YOU THEN BE FACING?" Answer: North
Make sure the subject can see all of the numbers around the dome. The subject should stand near the center of the planetarium chamber. For a response of North mark Blank A, a response of South mark Blank B, a response of East mark Blank C, and a response of West mark Blank D.	54. Examiner state to subject, "PRETEND NUMBER ONE STANDS FOR WEST. ASSUME YOU ARE WALKING TOWARDS NUMBER 7, THEN YOU TURN TO YOUR LEFT, THEN TURN LEFT AGAIN, IN WHAT DIRECTION ARE YOU GOING NOW?" Answer: North

Subtest B. Orientation Skills, Cont.

Set Up of Equipment	Questions & Comments
Set planetarium projector for 40° N. Latitude. For questions 55 and 56 turn on blue colored cove lights. (60 rheo setting) Turn off bright lights. Place sun at position of near the Vernal Equinox (0h 20m RA) Turn the sun projector on and position the sun so that it is above the horizon in the East above number 7. Start the daily motion of the planetarium projector. Question 55. Drive by annual motion the sun to the position of the summer solstice. By daily motion drive the sun to a position where it appears to be 45° above the horizon in the Southwest. Stop the sun, then start daily motion (slow 1/4 turn to right) to move the sun until it reaches the horizon in the west. Question 56.	55. State to subject, "THE SUN IS RISING IN THE EAST. TELL ME TO STOP THE MOTION OF THE SUN WHEN THE SUN IS DIRECTLY IN THE SOUTH." Answer: To be correct the sun has to be within + or - one hour of number 1 (south). Check by turning on meridian and coordinates. 56. State to subject, "NUMBER ONE STANDS FOR THE DIRECTION SOUTH. WATCH THE SUN SET AND TELL ME THE DIRECTION THAT THE SUN SETS." Answer: West Northwest or Northwest are acceptable. On this question mark A if correct, B if incorrect.
Fade down blue colored lights to rheo 20 and turn on stars. Place the north section of the sky in front of the subject. Turn on daily motion so that stars will set in the west. Turn daily motion switch 1/4 turn to the right.	57. State to subject, "THE STAR THAT I AM NOW POINTING OUT IS THE NORTH STAR." Point out the North Star. State, "THE STARS SEEM TO BE GOING DOWN TO YOUR LEFT." Ask, "TOWARDS WHAT GENERAL DIRECTION - NORTH, SOUTH, EAST OR WEST DO THE STARS APPEAR TO BE SETTING?" Answer: West. For a response of North mark Blank A, a response of South mark Blank B, a response of East mark Blank C, and a response of West mark Blank D.

Subtest C. Brightness Discrimination

Set Up of Equipment	Questions & Comments
Place Ursa Minor in front of subject. The subject should be seated near the center of the planetarium chamber.  	58. State, "DURING THIS PART OF THE EXERCISE I WOULD LIKE YOU TO CONCENTRATE YOUR ATTENTION ON THE TOPIC OF THE BRIGHTNESS OF STARS. I AM NOW POINTING OUT THE BOWL OF THE LITTLE DIPPER. IT IS MADE UP OF FOUR STARS. WITH YOUR POINTER POINT OUT IN ORDER OF BRIGHTNESS THESE FOUR STARS. SHOW ME FIRST THE STAR WHICH IS THE HARDEST TO SEE, THAT IS THE FAINTEST. NEXT POINT OUT FOR ME THE NEXT EASIEST STAR TO SEE, THEN THE NEXT EASIEST, AND FINALLY THE BRIGHTEST OF THE FOUR STARS..." To be correct the subject must point out all four stars in proper sequence.
	59. State, "WHICH STAR IN THE BOWL OF THE LITTLE DIPPER (Point out four stars) SEEMS TO BE AS BRIGHT AS THIS STAR? (Point out the North Star) SHOW ME WITH YOUR POINTER." Answer: The brightest star in the bowl of the LITTLE DIPPER is a second magnitude star.

Subtest D. Measuring Skills

Set Up of Equipment	Questions & Comments
The subject should stand near the center of the planetarium chamber. Fade in the meridian. Have the stars turned on. Place the star Regulus 10° above the horizon in the South.	State to subject, "DURING THIS PART OF THE EXERCISES I WOULD LIKE YOU TO ESTIMATE OR GUESS DISTANCES BETWEEN STARS IN THE PLANETARIUM SKY." State, "THIS LINE WITH THE NUMBERS ON IT IS CALLED THE MERIDIAN. THE SPACES BETWEEN EACH OF THE LINES IS 10°." (Point out 10° on meridian.) "TRY AND REMEMBER THE SPACE WHICH IS 10° IN THE SKY. YOU CAN USE YOUR FINGERS TO HELP YOU REMEMBER THIS DISTANCE." Demonstrate how to use the hand sextant. State, "NOTICE THAT THE NUMBER OF DEGREES INCREASE AS YOU MOVE UP THE MERIDIAN FROM THE EDGE OF THE PLANETARIUM DOME. THIS IS 10°, THIS IS 20°, ETC." State, "AS AN EXAMPLE, WHAT IS THE DISTANCE THAT THIS STAR SEEMS TO BE ABOVE THE HORIZON?" Answer: 10°
Place North Star 20° above the horizon. Set the position with stars off by fading on the meridian and celestial equator and setting the celestial equator at a position of 70° above the horizon. Turn on stars. Leave blue colored lights turned on very faintly so that the subject can see the horizon. Use #40 on the rheostat of the blue lights.	60. State, "THIS IS THE NORTH STAR, HOW MANY DEGREES IS THE NORTH STAR ABOVE THE EDGE OF THE PLANETARIUM DOME?" Answer: 20° To be a correct response the answer has to be + or - 5° of 20°.

Subtest D. Measuring Skills, Cont.

Set Up of Equipment	Questions & Comments
Fade out stars. Turn on meridian. Turn on coordinates and switch latitude so that the North Star will be 40° above the horizon. The Celestial Equator is to be 50° above the horizon in the south. Use same light settings as described in question 60.	61. State, "THIS IS THE NORTH STAR, HOW MANY DEGREES DOES THE NORTH STAR APPEAR TO BE ABOVE THE EDGE OF THE PLANETARIUM DOME?" Answer: 40° To be a correct response the answer has to be + or - 5° of 20°.
Place North Star 60° above the horizon. Blue light rheostat set at 30. Place constellation Ursa Major below the North Star in the 6 o'clock position.	62. State, "WATCH AS I POINT OUT THE POINTER STARS OF THE BIG DIPPER. PLEASE POINT OUT THE POINTER STARS FOR ME WITH YOUR POINTER. PRETEND THAT YOU HAVE TO WALK BETWEEN THE POINTER STARS. NOTICE THIS DISTANCE VERY CAREFULLY. NOW SUPPOSE THAT YOU HAVE TO WALK FROM THIS STAR TO THE NORTH STAR." Point out the two stars for the subject - the upper pointer star and the North Star. "PLEASE POINT OUT THIS DISTANCE FOR ME. HOW MANY OF THESE SPACES, NOT COUNTING THIS ONE, (point out distance between pointer stars) COULD YOU FIT BETWEEN THIS STAR AND THE NORTH STAR?" Correct Answer: Either 5 or 6 times is acceptable.
Switch latitude so that south is now in front of subject and Taurus is located in the south, place RA 2h on meridian. Blue light rheostat set at 30.	63. State, "WATCH AS I POINT OUT ALDEBARAN AND THE PLEIADES. PLEASE POINT THESE OBJECTS OUT FOR ME WITH YOUR POINTER. IS THE SPACE (Do not point out space) BETWEEN THESE TWO SKY OBJECTS THE SAME DISTANCE, A FARTHER DISTANCE, OR A LESS DISTANCE AS BETWEEN THESE TWO STARS?"

Subtest D. Measuring Skills, Cont.

Set Up of Equipment	Questions & Comments
	63. (Continued) Just point out the Beta star in Taurus and Capella in Auriga. Answer: Less For a response of <u>Same</u> mark Blank A on the answer sheet; a response of <u>Farther</u> mark Blank B, a response of <u>Less</u> mark Blank C.
Place Winter section of sky in south so that the stars Sirius, Procyon, and Betelgeuse are visible, place RA 5h on meridian. Blue light rheostat set at 30.	64. State, "I AM NOW POINTING OUT A TRIANGLE IN THE SKY. (Point out triangle outlined by the three stars identified on the left.) PLEASE POINT THE TRIANGLE IN THE SKY FOR ME WITH YOUR POINTER. PRETEND THAT YOU WALK BETWEEN THESE TWO STARS (Sirius and Procyon.) HOW WOULD YOU COMPARE THE DISTANCES OF YOUR WALK. IS THE SPACE OR DISTANCE BETWEEN THESE TWO STARS (Sirius and Procyon) THE SAME DISTANCE, A FARTHER DISTANCE, OR A LESS DISTANCE AS BETWEEN THESE TWO STARS?" (Betelgeuse and Procyon) Answer: Same For a response of <u>Same</u> mark Blank A on the answer sheet; a response of <u>Farther</u> mark Blank B, a response of <u>Less</u> mark Blank C.

Subtest D. Measuring Skills, Cont.

Set Up of Equipment	Questions & Comments
Place Spring section of sky in South, so that the stars Spica, Denobola, and Arcturus are visible, place RA 11h on meridian. Blue light rheostat set at 30.	65. State, "I AM NOW POINTING OUT A TRIANGLE IN THE SKY. (Point out triangle outlined by the stars Spica, Arcturus, and Denebola.) PLEASE POINT THE TRIANGLE IN THE SKY FOR ME WITH YOUR POINTER. PRETEND THAT YOU WALK BETWEEN THESE TWO STARS (Spica and Denebola) AND BETWEEN THESE TWO (Denebola and Arcturus). HOW WOULD YOU COMPARE THE DISTANCES OF YOUR WALK. IS THE SPACE OR DISTANCE BETWEEN THESE TWO STARS (Spica and Denebola) THE SAME DISTANCE, A FARTHER DISTANCE, OR A LESS DISTANCE AS BETWEEN THESE TWO STARS. (Denebola and Arcturus)" Answer: Same For a response of <u>Same</u> mark Blank A on the answer sheet, a response of <u>Farther</u> mark Blank B, a response of <u>Less</u> mark Blank C.
Place the Summer Triangle in the sky in front of the subject. Place RA 19h on meridian. Point out the Summer Triangle.	66. State, "I AM NOW POINTING OUT THE SUMMER TRIANGLE. WATCH AS I OUTLINE IT WITH THE POINTER. YOU ARE TO SHOW ME THE SHORTEST SIDE WITH YOUR POINTER." Answer: Between Deneb and Vega
Place sun in position of south on the meridian. Locate sun at position of Vernal Equinox. Begin daily motion (turn daily motion switch 1/4 turn to right.) Drive sun to horizon.	67. State, "EVERYDAY THE SUN SEEMS TO MOVE IN A COMPLETE CIRCLE AROUND THE EARTH. WATCH THE SUN MOVE AND AFTER THE SUN SETS TELL ME WHAT PART OF A CIRCLE THE SUN HAS JUST MOVED THROUGH - 1/4, 1/2, 3/4 OR A WHOLE CIRCLE?" Answer: 1/4 or a quarter of a circle. For a response of 1/4 mark Blank A, 1/2 Blank B, 3/4 Blank C, and whole Blank D.

Subtest D. Measuring Skills, Cont.

Set Up of Equipment	Questions & Comments
Place sun on meridian in south. The sun should be located at the position of the Vernal Equinox.	68. State, "IN THE REAL SKY THE SUN MOVES ON TO THIS LINE FOR A SHORT TIME AND THEN MOVES OFF OF IT. PERSON's NAME , IN THE REAL SKY HOW MANY HOURS DO YOU THINK IT TAKES FOR THE SUN TO RETURN TO THE MERIDIAN, THIS LINE RIGHT IN FRONT OF YOU, (Point out the Meridian) ONCE MORE AFTER IT LEAVES IT?" Answer: 24 hours.

Subtest E. Spatial Abilities

Set Up of Equipment	Questions & Comments
Place Ursa Major above horizon in North. Place pointer stars on the meridian. The subject should be seated near the center of the chamber. Set blue rheostat at 40.	69. State, "THE CONSTELLATION I AM NOW SHOWING YOU IS THE BIG DIPPER. (Point out the Big Dipper) NOTICE ITS POSITION IN THE SKY. IT SEEMS TO BE RIGHT SIDE UP. I WANT YOU TO TELL ME WHEN THE BIG DIPPER IS EXACTLY UPSIDE DOWN FROM THE POSITION IT IS NOW IN. (Begin motion) "WATCH AS IT BEGINS TO MOVE. IF YOU LOSE IT, PLEASE LET ME KNOW AND I WILL POINT IT OUT FOR YOU ONCE MORE." Point out North Star. Answer: To be counted correct, the pointer stars of the Big Dipper must be + or - one hour of being on the meridian above the North Star.
Place Ursa Major so that the pointer stars are east of the North Star. (Place RA 5h on meridian in South.) Set sky for 50° North Latitude. Turn daily motion switch to right 1/4 turn. Set blue rheostat at 40.	70. State, "THE CONSTELLATION I AM NOW SHOWING YOU IS THE BIG DIPPER. NOTICE IT IS EXACTLY RIGHT OF THE NORTH STAR. IN JUST A MOMENT I AM GOING TO START THE MOTION OF THE PLANETARIUM MACHINE, AND I WANT YOU TO TELL ME TO STOP THE MACHINE WHEN THE BIG DIPPER IS EXACTLY LEFT OF ITS PRESENT LOCATION. IF YOU LOSE IT, PLEASE LET ME KNOW AND I WILL POINT IT OUT FOR YOU ONCE MORE." Answer: To be counted correct, RA of 17th + or - one hour must be on the meridian in the south.

Subtest E. Spatial Abilities, Cont.

Set Up of Equipment	Questions and Comments
Place sun on meridian in south. The sun should be located near the Vernal Equinox. (Oh 20m RA) Turn daily motion switch 1/4 turn to right. Set sky for 40° North Latitude. Set blue rheostat at 40.	71. (Turn on daily motion switch) State, "NOTICE THE SUN IS MOVING TOWARD THE HORIZON. WATCH THE SUN MOVE. (Move sun three hours to west and stop motion.) WITH YOUR POINTER PLEASE POINT OUT FOR ME WHERE YOU THINK THE SUN WOULD HAVE FIRST TOUCHED THE HORIZON IF I HAD LET THE SUN CONTINUE ITS MOTION ALL THE WAY DOWN TO THE HORIZON." Answer: To be counted correct the subject must point with his pointer + or - one hour of west point on horizon. Turn on coordinates to check.
Project slide of Aries. Slide 11 Tray B. Ident. Number 3-1 This slide is to remain illuminated for the total question. Project slides 9, 10, 11, and 12 Tray A. Ident. Numbers-- 3-2, 3-1B, 3-3, and 3-4. The slides in Tray A are to be projected one at a time and then repeated going through in the same order. Allow 5 seconds per slide.	72. (Show student a star chart shine pointer on front side of chart) State, "I AM SHINING MY LIGHT ON THE FRONT OF A STAR CHART. NOTICE YOU ARE LOOKING AT IT FROM THE FRONT SIDE. (Turn chart over) NOW YOU ARE LOOKING AT THE CHART FROM THE BACK SIDE. BEING SHOWN AT THIS TIME IS A PHOTOGRAPH OF THE CONSTELLATION ARIES. PRETEND THAT YOU COULD GET BEHIND THE PICTURE AND LOOK AT IT, LIKE WE DID FOR THE STAR CHART. HOW WOULD IT LOOK? LIKE THE FIRST, SECOND, THIRD, OR FOURTH SLIDE BEING SHOWN TO THE LEFT OF THE FIRST SLIDE?" Answer: Second. For a response of first mark Blank A, second Blank B, third Blank C, and fourth Blank D.

Subtest E. Spatial Abilities, Cont.

Set Up of Equipment	Questions & Comments
Project slide of Leo. Slide 12 Tray A. Slide Ident. Number 4-1. This slide is to remain illuminated for the total question. Project slides 13-16 Tray A. Ident. Numbers 4-2, 4-3, 4-4, and 4-1B. The slides in Tray A are to be projected one at a time and then repeated going through in the same order. Allow 5 seconds per slide.	73. State, "DISPLAYED ON THE DOME AT THIS TIME IS A PHOTOGRAPH OF THE CONSTELLATION LEO. PRETEND THAT YOU COULD GET BEHIND THE PICTURE AND LOOK AT IT. HOW WOULD IT LOOK? LIKE THE FIRST, SECOND, THIRD, OR FOURTH SLIDE BEING SHOWN TO THE LEFT OF THE FIRST SLIDE?" Answer: Fourth or last. For a response of first mark Blank A, second Blank B, third Blank C, and fourth Blank D.

Subtest E. Spatial Abilities, Cont.

Set Up of Equipment	Questions & Comments
Project standard and then ask question related to four projections-- Slide 13, Ident. Number 5-3, Tray B is the standard. This slide is to remain illuminated for the total question. Test slides are 17-20 in Tray A. Slide ident. numbers are 5-5, 5-1, 5-3, and 5-4. Project to the right of the standard one slide at a time - go through twice in same order. Allow 5 seconds per slide. Use same focal length lens and bulb wattage for projector.	74. State, "SHOWN ON THE DOME AT THIS TIME IS A SECTION OF THE SKY. WE WILL CALL IT OUR STANDARD WITH WHICH TO COMPARE. IMAGINE THAT YOU ARE IN A SPACE CRAFT FLYING AWAY FROM THIS CONSTELLATION GROUP. WHICH OF THE FOLLOWING PHOTOGRAPHS OF THIS SAME STAR GROUP ON THE RIGHT WOULD TELL YOU THAT YOU HAVE TRAVELED THE FARTHEST FROM THE STANDARD?" Answer: Second slide. For this and questions 75 and 76 for a response of first mark Blank A, second mark Blank B, third Blank C, and fourth mark Blank D.
	75. Repeat procedure of projecting slides for question 74. Ask, "WHICH SLIDE OF THE GROUP WOULD TELL YOU THAT YOU HAVE TRAVELED NEAREST TO THE STARS OF THE STANDARD?" Answer: First slide.
	76. Repeat procedure of projecting slides for question 74. Ask, "WHICH SLIDE OF THE GROUP WOULD TELL YOU THAT YOU HAVE NOT YET MOVED AND ARE IN THE SAME POSITION AS THE STARS OF THE STANDARD?" Answer: Third

Subtest E. Spatial Abilities, Cont.

Set Up of Equipment	Questions & Comments
Project slide 14 Tray B, Ident. Number 9-2A. Simultaneously project slide 21, Tray A. Ident. Number 9-23. ORIENTATION OF THE SLIDES SHOULD BE THE SAME.	77. State, "LOOK AT THE TWO SLIDES BEING SHOWN AT THIS TIME. WHICH STAR IN THE RIGHT HAND SLIDE SEEMS TO BE LARGER THAN THE ONE IN THE SAME PLACE IN THE LEFT HAND SLIDE? PLEASE POINT IT OUT FOR ME WITH YOUR POINTER." Answer: If subject correctly identifies the correct object in 5 seconds, count the question correct.
Project slide 15 Tray B, Ident. Number 9-1A. Simultaneously project slide 22, Tray A, Ident. Number 9-B. Rotate Slide 22 - 90° clockwise from the position of slide 15.	78. State, "LOOK AT THE TWO SLIDES OF THE SAME SECTION OF SKY BEING SHOWN AT THIS TIME. WHICH STAR IN THE RIGHT HAND SLIDE SEEMS TO BE LARGER THAN THE ONE IN THE SAME PLACE IN THE LEFT HAND SLIDE?" Answer: If the subject correctly identifies the correct object in 15 seconds, count the question correct.
Project slide 16 Tray B, Ident. Number 8 IV A. Simultaneously project slide 23, Tray A, Ident. Number 8 IV B. Rotate slide 23 - 90° clockwise from the position of slide 16.	79. State, "LOOK AT THE TWO SLIDES BEING SHOWN AT THIS TIME. THERE'S ONE MORE STAR IN THE RIGHT SLIDE NOT FOUND IN THE LEFT SLIDE, WHICH STAR IS IT? PLEASE POINT IT OUT FOR ME WITH YOUR POINTER." Answer: If subject correctly identifies the correct object in 15 seconds, count the question correct.

Subtest E. Spatial Abilities, Cont.

Set Up of Equipment	Questions & Comments
Project slide 17 Tray B, Ident. Number 8 V A. Simultaneously project slide 24 Tray A, Ident. Number 8 V B. Rotate slide 24 - 90° counter-clockwise from the position of the stars in slide 17.	80. State, "LOOK AT THE TWO SLIDES BEING PROJECTED AT THIS TIME. WHICH STAR IN THE RIGHT HAND SLIDE SEEMS TO BE EXTRA, THAT IS IT IS NOT FOUND IN THE LEFT HAND SLIDE? PLEASE POINT IT OUT TO ME WITH YOUR POINTER." Answer: If subject correctly identifies the correct object in 15 seconds, count the question correct.
Project slide 18 Tray B, Ident. Number 10 VII A. Simultaneously, project slide 25 Tray A, Ident. Number 10 VII B. Orientation of the slides should be the same.	81. State, "LOOK AT THE TWO SLIDES BEING SHOWN AT THIS TIME, WHICH STAR IN THE RIGHT HAND SLIDE SEEMS TO HAVE MOVED FROM ITS POSITION THAT IT HAD IN THE LEFT HAND SLIDE? PLEASE POINT IT OUT FOR ME WITH YOUR POINTER." Answer: If subject correctly identifies the correct object in 15 seconds, count the question correct.
Project slide 19 Tray B, Ident. Number 10 VIII A. Simultaneously project slide 26 Tray A, Ident. Number 10 VIII B Rotate slide 26 - 90° counter-clockwise from the position of the stars in slide 19.	82. State, "LOOK AT THE TWO SLIDES BEING SHOWN AT THIS TIME, WHICH STAR IN THE RIGHT HAND SLIDE SEEMS TO HAVE MOVED FROM ITS POSITION THAT IT HAD IN THE LEFT HAND SLIDE? PLEASE POINT IT OUT FOR ME WITH YOUR POINTER." Answer: If subject correctly identifies the correct object in 15 seconds, count the question correct.

Subtest E. Spatial Abilities, Cont.

Set Up of Equipment	Questions & Comments
Project slide 20 Tray B, Ident. Number 11 C B. Simultaneously project slide 27 Tray A, Ident. Number 11 C C. Have the subject take this portion of the exam at the planetarium console so that he can use the reading light. Show subject how to orientate chart for Questions 84 and 85. Turn off Tray B while doing Questions 84 and 85.	83. State, "LOOK AT THE PHOTOGRAPHS OF THE STARS BEING SHOWN AT THIS TIME ON THE PLANETARIUM DOME. NOTICE THE SLIDE ON THE LEFT SIDE HAS A LETTER NEXT TO ONE OF THE STARS WHILE THE SLIDE ON THE RIGHT OF THE SAME SECTION OF THE SKY HAS EACH STAR IDENTIFIED BY VARIOUS COLORS. PLEASE POINT OUT STAR C FOR ME ON THE RIGHT HAND SLIDE WITH YOUR POINTER." Answer: If the subject correctly identifies the star with the pointer within 15 seconds, count the question correct.
	84. State, "WHICH OF THE COLORED STARS BEING SHOWN ON THE DOME IS STAR D ON THIS STAR CHART OF THE SAME SECTION OF THE SKY. PLEASE POINT IT OUT FOR ME WITH YOUR POINTER." (Make sure star chart is correctly oriented.) Answer: If the subject correctly identifies the star with the pointer within 15 seconds, count the question correct.
	85. State, "WHICH OF THE COLORED STARS BEING SHOWN ON THE DOME IS STAR G ON THIS STAR CHART OF THE SAME SECTION OF THE SKY. PLEASE POINT IT OUT FOR ME WITH YOUR POINTER." (Make sure star chart is correctly oriented.) Answer: If the subject correctly identifies the star with the pointer within 15 seconds, count the question correct.

Subtest E. Spatial Abilities, Cont.

Set Up of Equipment	Questions & Comments
Project slide 28 Tray A, Ident. Number 11 A C while questions 86-91 are being asked. Have the subject take this part of the exam at the console so that he can use the reading light.	FOR QUESTION 86-91, IF THE SUBJECT CORRECTLY IDENTIFIES THE STAR WITH THE POINTER WITHIN 15 SECONDS, COUNT THE QUESTION CORRECT. State, "DURING THIS PART OF OUR EXERCISE I AM GOING TO GIVE YOU 6 SKY CHARTS - ONE AT A TIME - TO USE TO POINT OUT THE DIFFERENT STARS THAT ARE ASKED FOR. SOME OF THE CHARTS WILL HAVE MORE STARS ON THEM THAN ARE BEING SHOWN ON THE PLANETARIUM DOME, WHILE OTHERS WILL HAVE FEWER STARS ON THE CHART THAN YOU WILL BE ABLE TO SEE ON THE DOME.
	86. State, "HERE IS YOUR FIRST CHART TO USE, CHART A, POINT OUT FOR ME IN THE SKY WITH YOUR POINTER THE STAR NAMED K ON THE CHART."
	87. State, "HERE IS THE SECOND CHART TO USE, CHART B, POINT OUT THE STAR NAMED S ON THE CHART."
	88. State, "HERE IS THE NEXT CHART TO USE, CHART C, POINT OUT THE STAR NAMED G ON THE CHART."
	89. State, "HERE IS CHART D TO USE TO POINT OUT THE STAR NAMED A ON THE CHART."
	90. State, "HERE IS CHART E TO USE TO POINT OUT THE STAR NAMED M ON THE CHART."
	91. State, "HERE IS CHART F TO USE TO POINT OUT THE STAR NAMED H ON THE CHART."

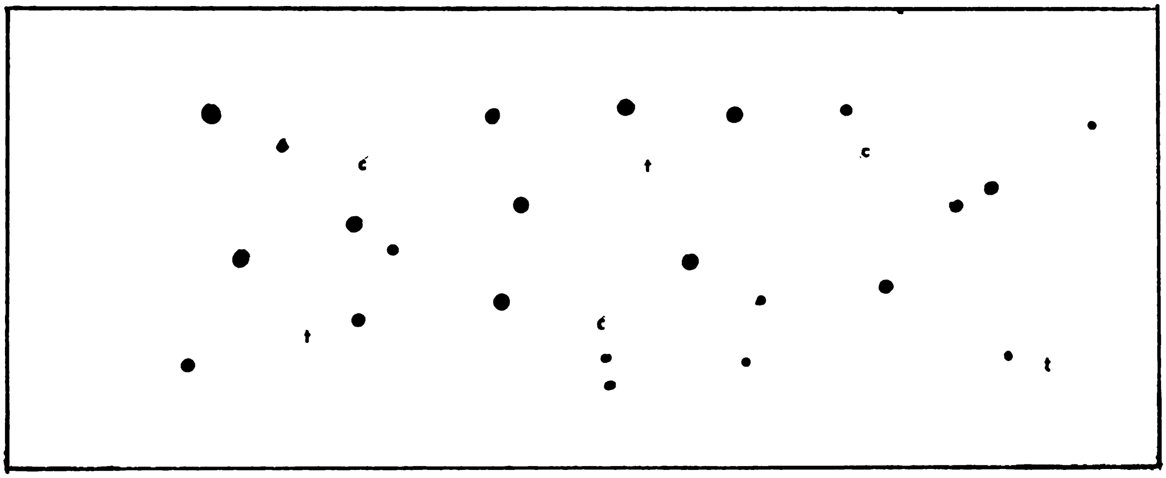
Subtest E. Spatial Abilities, Cont.

Set Up of Equipment	Questions & Comments
Turn Projectors off. Turn on stars (6h PA) on meridian in front of subject. Have the subject take this part of the exam at the console and use the reading light. Show subject how to orientate each of the charts as far as top and sides of the chart are concerned, and give the subject a reference point in the sky. Give subject chart of winter section of sky with constellations outlined on it.	92. State, "FOR THE NEXT FEW QUESTIONS YOU ARE GOING TO USE A LARGER STAR CHART TO IDENTIFY STARS OR STAR GROUPS IN THE PLANETARIUM SKY. ONE OF THE CHARTS WILL HAVE LINES ON IT WHILE THE OTHER WILL NOT. SEE THE THREE STARS IN A ROW ON YOUR CHART? HERE THEY ARE IN THE SKY. SEE THIS STAR (BETELGEUSE) HERE IT IS IN THE SKY. THIS GIVES YOU SOME IDEA OF THE SPACE ON THE STAR CHART AND THE SPACE IN THE SKY. WITH YOUR POINTER WOULD YOU POINT OUT FOR ME THE STAR NAMED CAPELLA AND IDENTIFIED BY LETTER A ON THE CHART?" Answer: If the subject correctly identifies the object within 15 seconds, count the question correct.
	93. State, "NOTICE ON YOUR STAR CHART THERE IS A CONSTELLATION NAMED TAURUS THE BULL. HERE SEE IT. (Point it out on the chart for the subject.) WOULD YOU PLEASE POINT IT OUT FOR ME IN THE SKY?" Answer: If the subject correctly identifies at least the Hyades within 15 seconds, count the question correct.

Subtest E. Spatial Abilities, Cont.

Set Up of Equipment	Questions & Comments
Use instructions found on page 188. Give subject the section of the winter sky chart without the lines on it.	94. State, "NOTICE THAT ON THE STAR CHART THAT YOU NOW HAVE THAT NONE OF THE STARS ARE CONNECTED BY LINES. THIS STAR CHART IS STILL OF THE WINTER SKY. WOULD YOU PLEASE POINT OUT FOR ME THE STAR IDENTIFIED BY LETTER L ON YOUR CHART IN THE PLANETARIUM SKY. HERE SEE THE STAR ON THE CHART." Answer: If the subject correctly identifies the star labeled Rigel, within 15 seconds, count the question correct.
	95. State, "THIS TIME I WOULD LIKE FOR YOU TO POINT OUT FOR ME THE STAR IDENTIFIED BY LETTER N." Answer: If subject correctly identifies the star labeled N, Pollux, within 15 seconds, count the question correct.

Drawings of the Slides For the Various Questions



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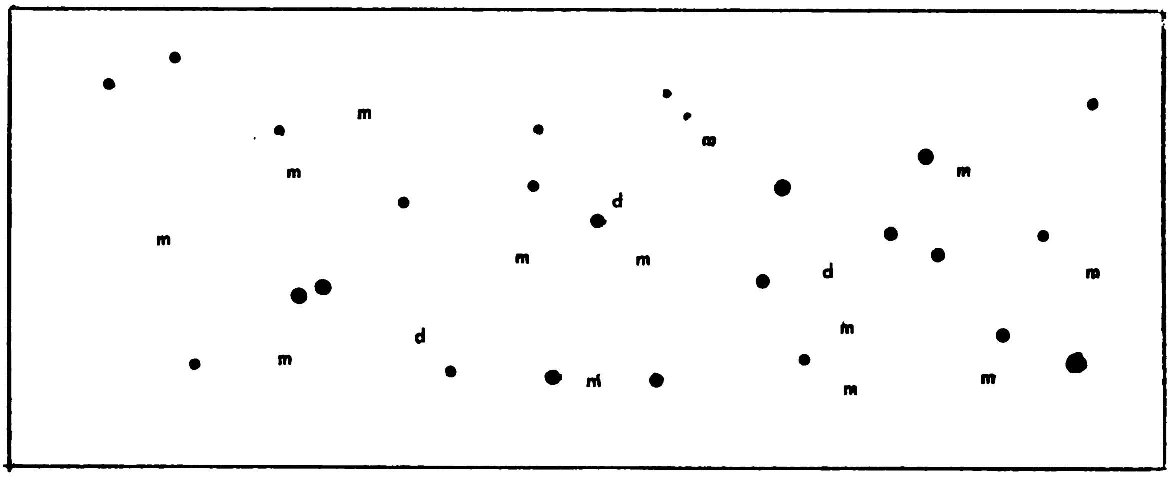

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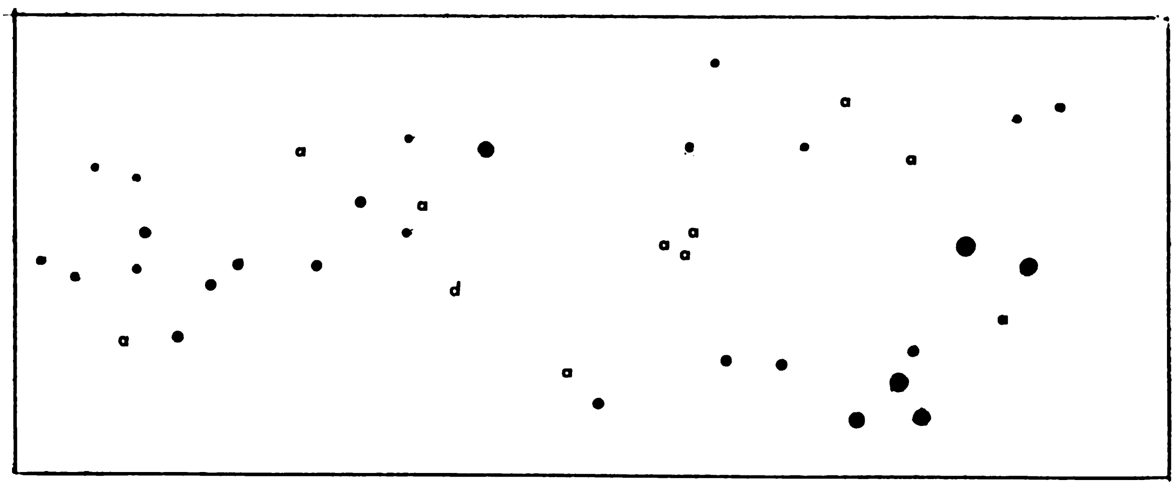

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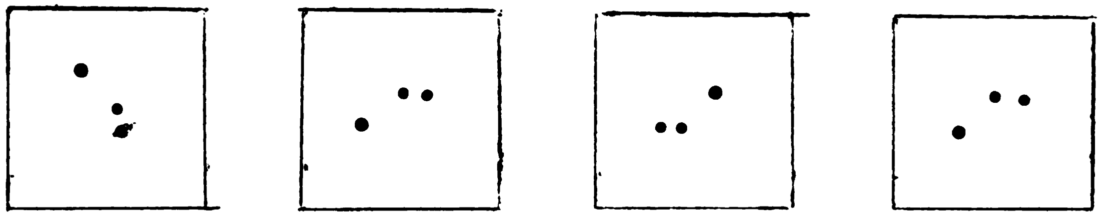

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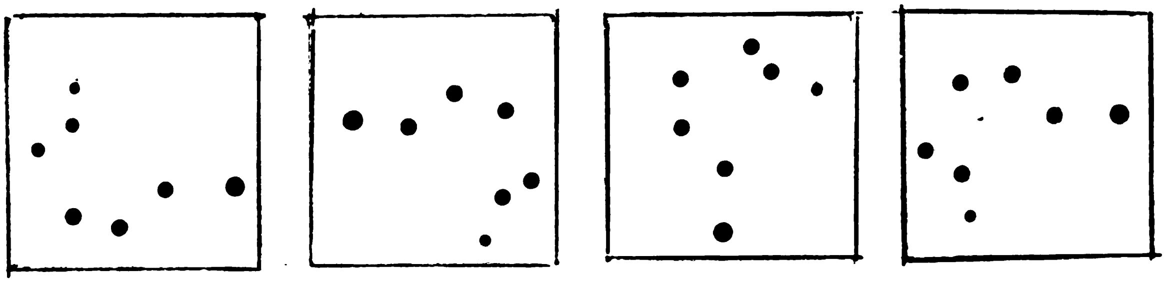
Slide 72



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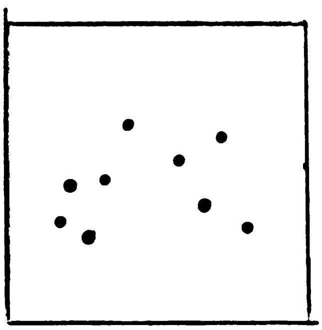

Standard
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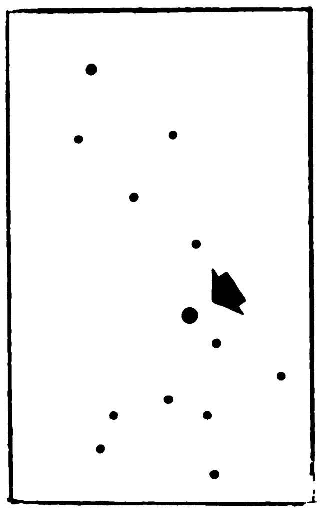

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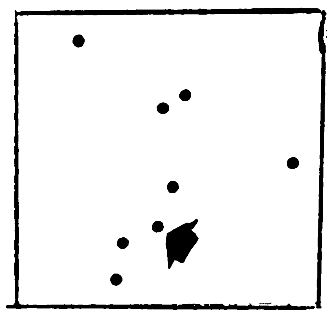
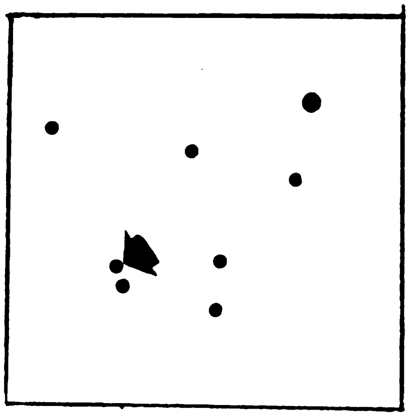


Slide 78

Drawings of the Slides for the Various Questions



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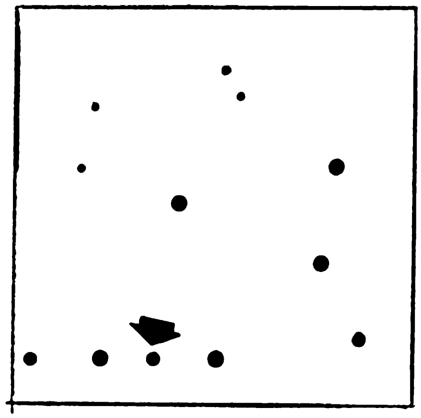

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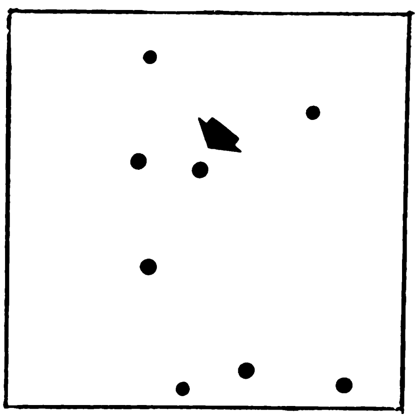

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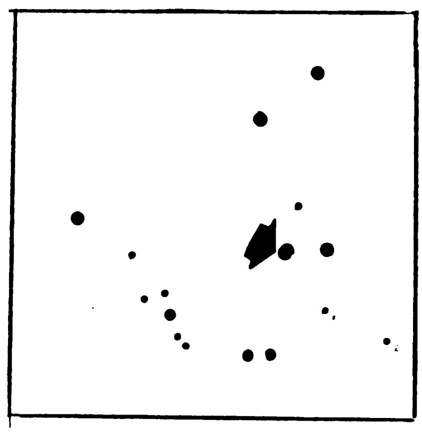

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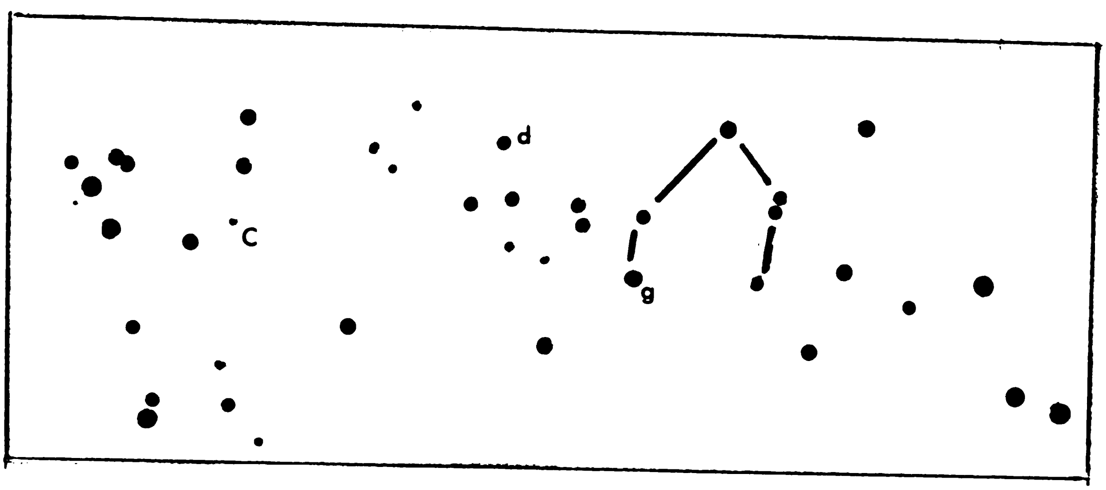

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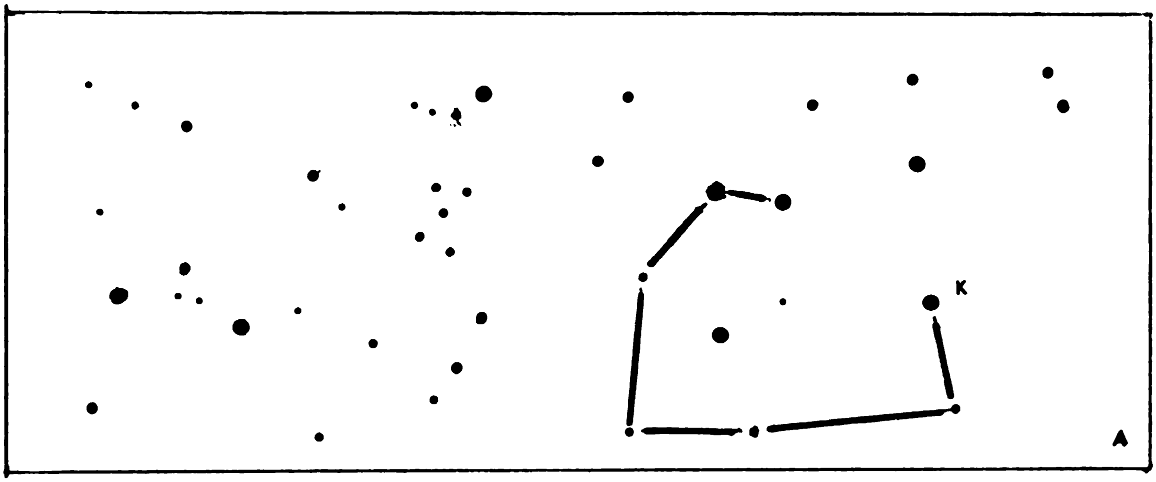
Drawings of the Slides for the Various Questions



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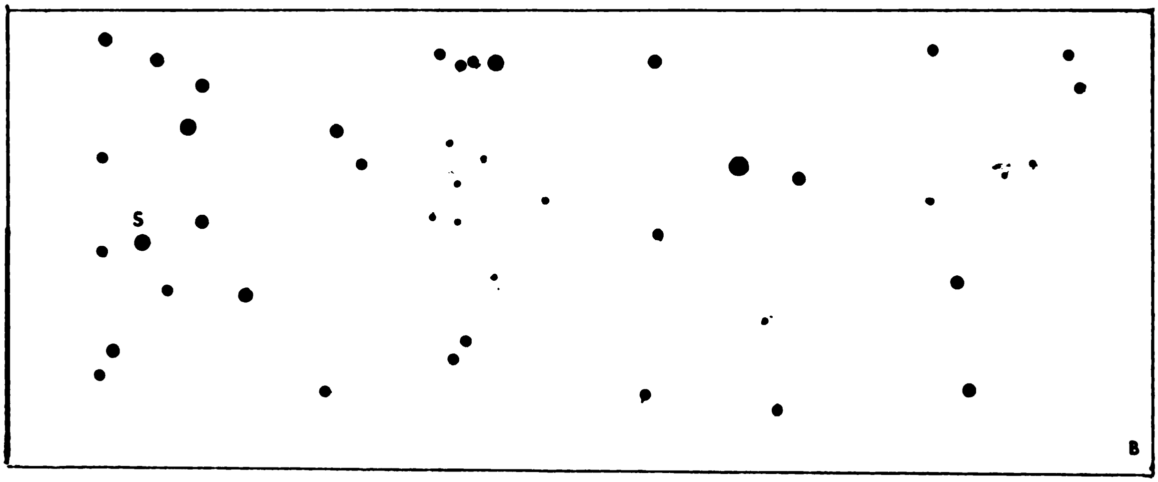

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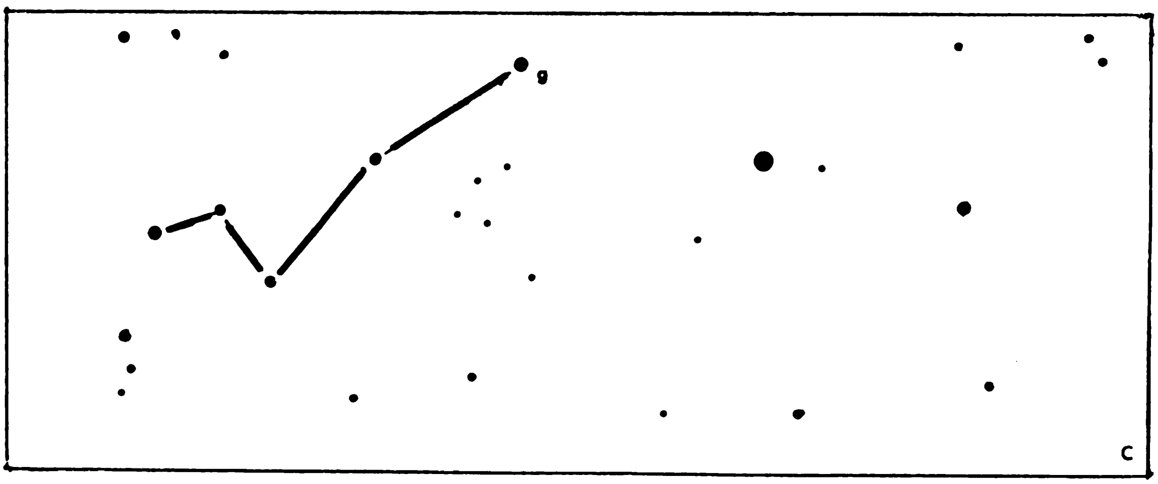

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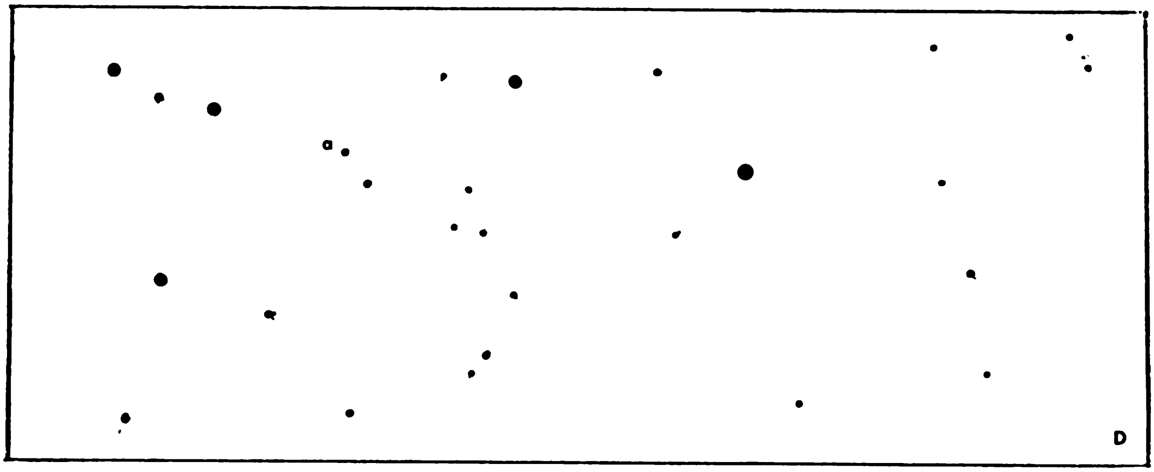
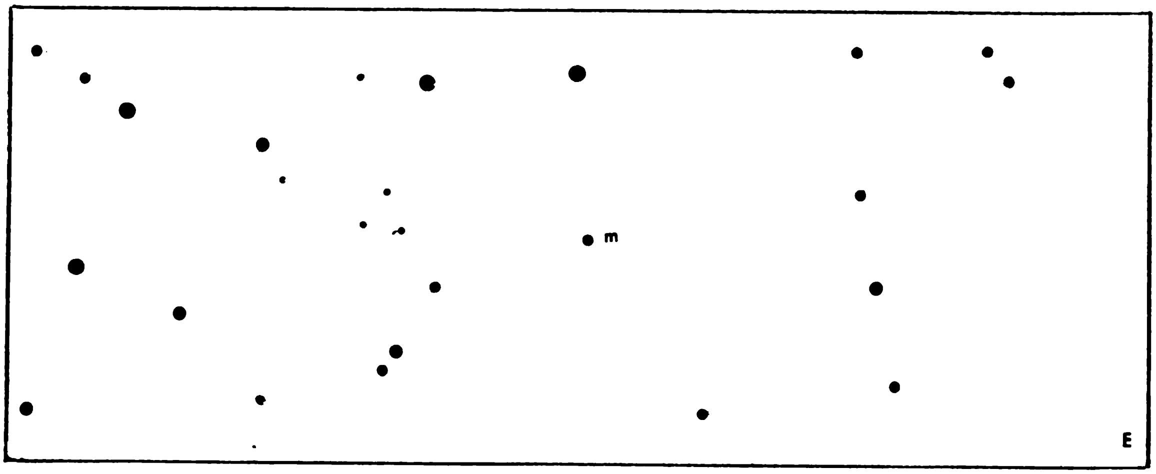
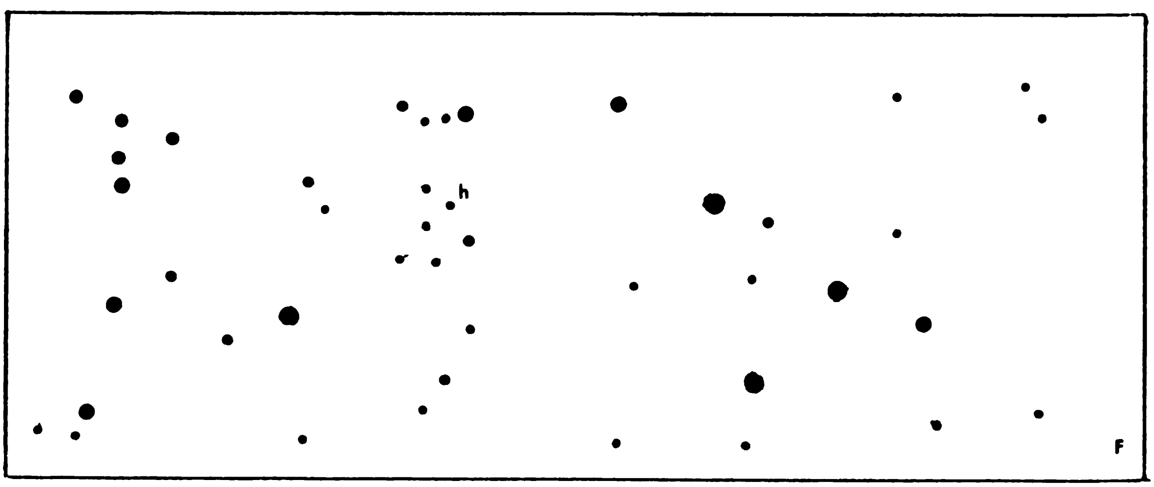
Drawings of the Slides for the Various Questions



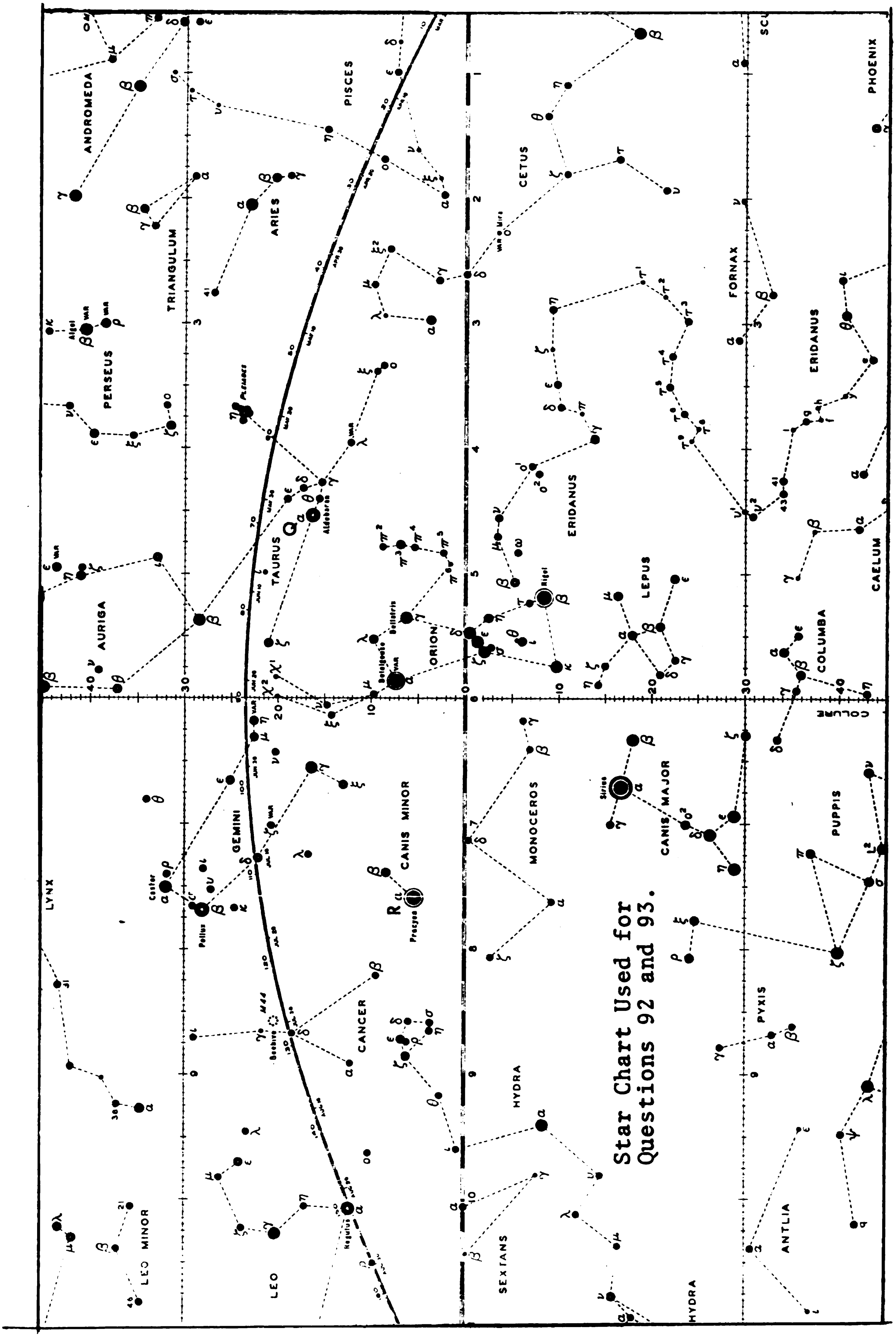
89



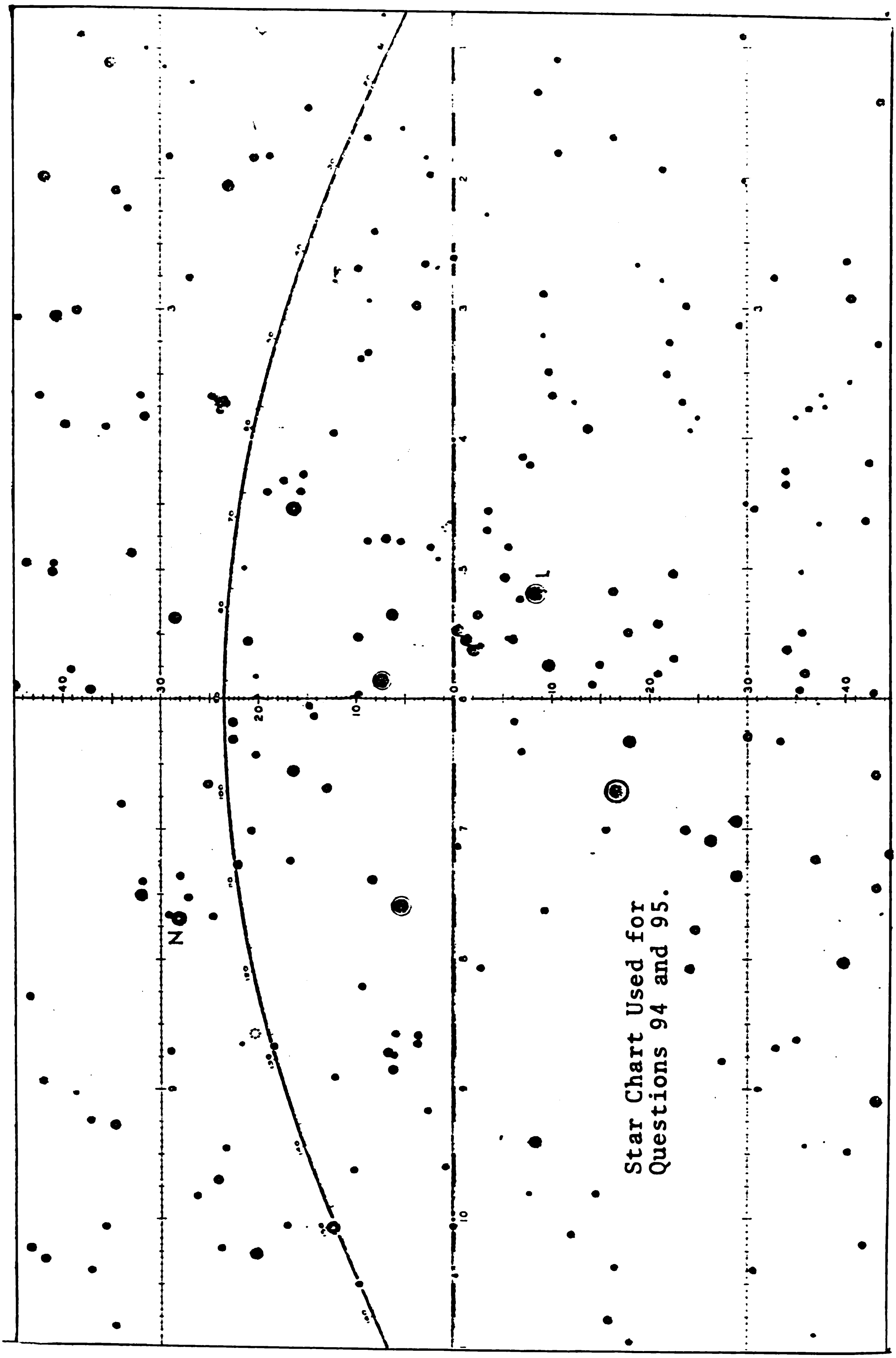
90



91



Star Chart Used for Questions 92 and 93.



Star Chart Used for Questions 94 and 95.

APPENDIX D

COMBINED TESTS FACTOR ANALYSIS

APPENDIX D

COMBINED TESTS FACTOR ANALYSIS

To follow are the twenty factors which resulted from the factor analysis of all of the items included in both the Classroom Indirect Measurement Instrument and Planetarium Skills Evaluation Tests. For each of the factors the items with high loadings on that factor are listed. In addition, the correlation of each of the items with the scale score of the factor is given. Then, too, the standard score coefficient alphas are listed. These coefficients are reliability coefficients for each of the scales.

It is expected that items from each of the Planetarium Skills Evaluation Test's subtest should have high loadings with their counterparts on the Classroom Instrument if indeed they are measuring the same thing. A factor analysis of both tests together permits a determination of this.

Factor 1

Table 21 shows seven items with high loadings on Factor 1. The range of the high loadings was from .65 to .25. The Reliability Coefficient for Scale 501 was .65. With the exceptions of items 53 and 87 all high loadings in Factor 1 were from the Classroom Indirect Measurement Instrument. All item correlations with the scale score were significant at the .05 level.

Item 53 was related to the determination of a cardinal point of direction while item 87 from the Planetarium Skills Evaluation Test required the subject ot use a star chart to locate a required star on a projected slide. Item 17 had a negative loading on Factor 1. This item required the subject to choose from four drawings which one was an ellipse. This negative loading suggests that this item is in some way contrasted to the other factors.

TABLE 21

Scale 501
Factor 1 of Combined Tests
(Scanning Abilities)

Test Item	High Loading	Correlation with Scale Score	Reliability Coefficient
3	.65	.68	.65
6	.58	.65	
4	.52	.55	
17	-.47	.41	
53	.44	.31	
87	.25	.20	
1	.25	.43	

The great majority of high loadings in this factor were associated with the ability to scan sentences for certain words. None of the high loadings included in Factor 1 required the use of the planetarium sky or items included in the scanning subtest of the planetarium test.

This suggests that the ability to successfully find words in a sentence (reading skills) does not involve the same abilities that are required to locate a star in the planetarium sky.

Factor 2

As Table 22 shows there were eight high loadings associated with Factor 2. Four of the items were from each test. Items 9, 10, and 11 were from the Orientation Skills Subtest of the Classroom Indirect Measurement Instrument while item 39 was from the Spatial Abilities Subtest. All four items were from instruments designed to measure intelligence.

TABLE 22

Scale 502
Factor 2 of Combined Tests
(Orientation Skills)

Test Item	High Loading	Correlation with Scale Score	Reliability Coefficient
9	.61	.68	.65
10	.52	.37	
11	.50	.60	
92	.35	.38	
39	.35	.40	
60	.34	.35	
57	.30	.32	
93	.28	.37	

All of the high loadings for items from the Planetarium Skills Evaluation Test required use of the planetarium sky. Items 92 and 93 required the subjects to locate stars in the planetarium sky that were identified on a star chart. Item 60 required the subject to determine the altitude of the north star above the horizon. Item 57 required the subjects to state the setting direction of the stars.

These high loadings tended to relate to the ability to state cardinal points of direction. The high loadings ranged from .61 to .28. The Reliability Coefficient of Scale 502 was .65. All of the correlations with the scale score were significant at the .05 level.

Factor 3

Table 23 shows the four items which had high loadings on Factor 3. The high loadings ranged from .85 to .64. The correlations of each item with the scale score were significant at the .05 level. The Reliability Coefficient for Scale 503 was .83. All of the items with high loadings on this factor were from the Spatial Abilities Subtest of the Classroom Indirect Measurement Instrument. Each of the items asked the subject to determine which star had risen, set, or was overhead for Mr. O who was standing on the side of the Earth. This factor is associated with spatial abilities especially related to visualizing the rising and setting of stars for a person located on a globe.

TABLE 23

Scale 503
Factor 3 of Combined Tests
(Spatial Abilities)

Test Item	High Loading	Correlation with Scale Score	Reliability Coefficient
34	.85	.84	.83
35	.85	.81	
36	.68	.69	
37	.64	.65	

Factor 4

Nine items, as shown in Table 24, had high loadings on Factor 4. The loadings ranged from .48 to .30. All of the items had correlations with the scale score significant at the .05 level. The Reliability Coefficient of Scale 504 was .67.

Items 47, 33, and 41 were from the Classroom Indirect Measurement Instrument, and were from the Spatial Abilities Subtest. Items 55 and 53 from the Planetarium Skills Evaluation Test were from the Orientation Skills Subtest, while items 77, 80, 78, and 72 were from the Spatial Abilities Subtest. Items 77 and 78 emphasized the concept of larger while 80 required the subject to find the extra star. Items 55, 53, 33, 77, 80, and 78 all required the subjects to know the direction of right in order to get the correct response. It seems that this factor is related to spatial abilities with an

TABLE 24

Scale 504
Factor 4 of Combined Tests
(Spatial Abilities)

Test Item	High Loading	Correlation with Scale Score	Reliability Coefficient
47	.48	.40	.67
55	.46	.54	
53	.46	.47	
33	.46	.31	
77	.46	.53	
80	.39	.35	
78	.36	.49	
41	.35	.44	
72	.30	.27	

emphasis on the direction of right. None of the items used the planetarium sky to determine the response.

Factor 5

Table 25 shows the nine items which had high loadings on Factor 5. The high loadings ranged from .52 to .24. Items 46, 48, and 12 had negative high loadings. This suggests that these items are in some way contrasted to the other factors. All item correlations with the scale score, except for items 46 and 48, were significant at the .05 level. The Reliability Coefficient for Scale 505 was .57.

TABLE 25

Scale 505
Factor 5 of Combined Tests

Test Item	High Loading	Correlation with Scale Score	Reliability Coefficient
26	.52	.54	.57
89	.49	.44	
94	.45	.54	
2	.41	.42	
12	-.39	.40	
48	-.33	.19	
68	.31	.34	
88	.24	.21	
46	-.23	.18	

Item 26 from the Classroom Indirect Measurement Instrument, which had the highest loading on the factor, required the subject to determine from four choices which drawing had a diameter. Items 12, 48, and 46 all had negative high loadings which suggests that these items are in some way contrasted to the other factors. Four of the items (26, 2, 12, and 46) were from the Classroom Indirect Measurement Instrument. All of the others were from the Planetarium Skills Evaluation Test. Only item 94 involved the use of the planetarium sky. The common ability represented by this factor is ambiguous. Items 2 and 48 were intended to measure scanning abilities, 12, brightness discrimination, items 26 and 68 measuring skills, while the remainder were used to evaluate spatial abilities.

Factor 6

Table 26 shows that Factor 6 was made up of six high loadings, one from the Classroom Indirect Measurement Instrument and five from the Planetarium Skills Evaluation Test. The high loadings ranged from .58 to -.32. All of the item correlations with the scale score were significant at the .05 level. The Reliability Coefficient for the scale was .56.

Items 58 and 59 were both included in the Brightness Discrimination Subtest of the Planetarium Skills Evaluation Test. Items 20 and 64 were from the Measuring Skills Subtest. Item 64 appears with a small negative loading which suggests that the item is in some way contrasted with the other factors. The high loadings of Factor 6 are primarily associated with comparison -- items 58 and 59 brightness, item 51 size of dots and 64 distances between stars. Three of the items 58, 59, and 64 used stars. There were no high loadings associated with star charts on this factor.

TABLE 26

Scale 506
Factor 6 of Combined Tests
(Comparison Abilities)

Test Item	High Loading	Correlation with Scale Score	Reliability Coefficient
58	.58	.50	.56
20	.48	.38	
59	.41	.41	
54	.37	.51	
51	.34	.36	
64	-.32	.37	

Factor 7

As shown in Table 27 five high loadings were made on Factor 7. The high loadings ranged from .64 to .32. All of the item correlations with the scale score were significant at the .05 level. The Reliability Coefficient of Scale 507 was .70.

All of the high loadings except for item 85 were from the Classroom Indirect Measurement Instrument. It is interesting to note that items 31, 32, and 28 referred to Mr. O, and in each item Mr. O was positioned on his back. Item 85 used a star chart and slide while for item 42 the subject was to determine where a piece of a jigsaw puzzle type drawing would fit--in four possible choices. This factor is associated with spatial abilities with emphasis on front-back relationships.

TABLE 27

Scale 507
Factor 7 of Combined Tests
(Spatial Abilities)

Test Item	High Loading	Correlation with Scale Score	Reliability Coefficient
31	.64	.59	.70
32	.61	.61	
28	.58	.64	
85	.54	.61	
42	.32	.39	

Factor 8

Table 28 shows that five items had high loadings on Factor 8. The high loadings ranged from .66 to .33. Item 66 had a negative high loading which suggests it is contrasted to the other factors. All of the item correlations with the scale score were significant at the .05 level of significance. The Reliability Coefficient for Scale 508 was .59.

All of the items with the exception of 40 were from the Planetarium Skills Evaluation Test. Item 40 was from the Spatial Abilities Subtest. All of the high loadings associated with this factor can be associated with comparison. For item 83 the comparison was made to locate a star identified in the left slide in the right slide. Item 81 used two slides projected side by side and the subject was to determine which star in the right slide had moved from its

TABLE 28

Scale 508
Factor 8 of Combined Tests
(Comparison Abilities)

Test Item	High Loading	Correlation with Scale Score	Reliability Coefficient
83	.66	.66	.59
40	.53	.53	
81	.45	.48	
66	-.38	.25	
62	.33	.47	

position in the left slide. Items 62 and 66 involved the students in using the stars in the planetarium sky. For item 62 the subjects were to compare the distance between the pointer stars to the distance from the pointer stars to the north star. Determining the shortest side of the summer triangle was the problem in item 66.

Factor 9

Four items had high loadings on Factor 9 as shown in Table 29. The loadings ranged from .56 to .29. All item correlations with the scale score were significant at the .05 level. The Reliability Coefficient for Scale 509 was .51. All items except 73 were from the Classroom Indirect Measurement Instrument.

Item 73 was from the Spatial Abilities Subtest of the Planetarium Skills Evaluation Test. This item involved the

TABLE 29

Scale 509
Factor 9 of Combined Tests
(Angular Measurement Abilities)

Test Item	High Loading	Correlation with Scale Score	Reliability Coefficient
23	.56	.71	.51
73	.49	.45	
7	.40	.37	
18	.29	.31	

subject in imagining what the constellations being projected would look like if he could get behind it and look at it. Items 23 and 18 both involved stating a number of degrees as required. Item 7 was related to the determination of directions. The high loadings associated with Factor 9 seemed to be associated with angular measurement: Item 23--the number of degrees around the Earth, Item 18--a ninety degree angle on the clock, Item 7--a quarter turn, Item 73--180° change in perspective.

Factor 10

As shown in Table 30 five items had high loadings on Factor 10. The range for the high loadings was from .61 to -.27. All item correlations with the scale score were significant at the .05 level. The Reliability Coefficient for Scale 510 was .53.

TABLE 30

Scale 510
Factor 10 of Combined Tests
(Spatial Abilities)

Test Item	High Loading	Correlation with Scale Score	Reliability Coefficient
30	.61	.65	.53
29	.56	.39	
90	.38	.47	
91	.27	.38	
63	-.27	.28	

Items 30 and 29 were from the Classroom Indirect Measurement Instrument. Both of the items involved had Mr. O positioned on his stomach. Items 90 and 91 were from the Planetarium Skills Evaluation Test. Both items involved the use of star charts. Item 63 had a negative high loading. This item required the subject to compare distances between stars in the planetarium sky. All items except 63 were included in the Spatial Abilities Subtest. Both of the star charts used in items 90 and 91 did not have lines. The high loadings in Factor 10 seem to be related to spatial abilities. There does seem to be some association in being able to determine right-left on Mr. O and being able to use a star chart to determine star locations in projected slide areas covering 300 square degrees.

Factor 11

Table 31 shows that five items had high loadings on Factor 11. The range of high loadings was from .54 to -.28. The correlations of the items with the scale score were all significant at the .05 level. The Reliability Coefficient of Scale 511 was .48.

TABLE 31

Scale 511
Factor 11 of Combined Tests
(Comparison Abilities)

Test Item	High Loading	Correlation with Scale Score	Reliability Coefficient
38	.54	.47	.48
14	.43	.49	
13	-.36	.38	
15	-.36	.38	
82	-.22	.27	

All of the items except 82 were from the Classroom Indirect Measurement Instrument. Items 13, 14, and 15 required the subject to compare the brightnesses of two dots of light projected simultaneously. Item 38 with the highest loading was from the Spatial Abilities Subtest. For this item, the subject had to determine in which of four choices the jigsaw piece drawing would fit. To get item 82 correct the subject had to determine which star in the right slide had moved from its position in the left slide. Items 13, 15, and 82 had negative high loadings, which suggest that these items are contrasted to the other factors. Again in each of the items some comparison is required -- brightness, movement, and shape, however, none of them involved the planetarium sky.

Factor 12

Table 32 shows four items which have high loadings on Factor 12. The range of the high loadings is from .48 to -.34. The correlations of the items with the scale score are all significant at the .05 level. The Reliability Coefficient of Scale 512 is .44. Items 65 and 76 have negative high loadings which suggest that they are contrasted to the other factors.

TABLE 32

Scale 512
Factor 12 of Combined Tests
(Measurement Abilities)

Test Item	High Loading	Correlation with Scale Score	Reliability Coefficient
21	.48	.54	.44
61	.46	.44	
65	-.37	.26	
76	-.34	.39	

All items except for 21 were from the Planetarium Skills Evaluation Test. Item 21 required the student to choose which of four drawings was an angle of 180°. Items 61 and 65 used the stars. For item 61 the subject had to determine how many degrees the north star was above the horizon, and for item 65 the subject was to compare the sides of the spring triangle in the planetarium sky. Item 76 involved the use of slides. The subject was to determine by comparison with a standard which of four choices indicated to him that he had not moved. These high loadings are associated with measurement skills.

Factor 13

Table 33 shows four items which had high loadings on Factor 13. The range in the high loadings was from .59 to .26. Except for item 67 all items had significant correlations at the .05 level. The Reliability Coefficient for Scale 513 was .53.

TABLE 33

Scale 513
Factor 13 of Combined Tests
(Measurement Abilities)

Test Item	High Loading	Correlations with Scale Score	Reliability Coefficient
27	.59	.39	.53
74	.43	.45	
22	.40	.47	
67	.26	.10	

Items 27 and 22 were from the Classroom Indirect Measurement Instrument. Both were from the Measuring Skills Subtest. Item 67 used the planetarium instrument. The subject was to describe what part of a circle the sun moved through. By comparing two slides, one of which was the standard, the subject had to state in item 74 which of four choices indicated to him that he had traveled farthest from the standard. These high loadings all seem to be associated with measurement, primarily in reference to what a given part is in relation to the whole.

Factor 14

Table 34 shows that only two items had high loadings on Factor 14. The range was between .56 to -.36. The Reliability Coefficient for Scale 514 was quite low being only .27. Both item correlations with the scale score were significant at the .05 level. Item 71 had a negative high loading.

TABLE 34

Scale 514
Factor 14 of Combined Tests
(Measurement Abilities)

Test Item	High Loading	Correlation with Scale Score	Reliability Coefficient
16	.56	.43	.27
71	-.36	.22	

Item 16 from the Classroom Indirect Measurement Instrument had drawings of several instruments used for measuring in science. The subject had to choose which of four choices was used to measure angles. For item 71 the subject had to predict the setting position of the sun. It seems that being able to predict the setting position of the sun besides requiring spatial abilities may also involve measurement abilities.

Factor 15

Table 35 shows four items which had high loadings on Factor 15. The range was from .59 to .32. All item correlations with the scale score except for item 95 were significant at the .05 level. The Reliability Coefficient for Scale 515 was .50.

TABLE 35

Scale 515
Factor 15 of Combined Tests
(Spatial Abilities)

Test Item	High Loading	Correlation with Scale Score	Reliability Coefficient
25	.59	.74	.50
44	.42	.32	
45	.44	.34	
95	.32	.07	

All items except for 95 were from the Classroom Indirect Measurement Instrument. Item 25 required the subject to determine from four choices which drawing had lines that were perpendicular. Items 44 and 45 were from the Spatial Abilities Subtest. Both of the items were from the _DAT Spatial Relations Test_. Item 95 involved the use of the star chart and the planetarium sky. The subjects were required to locate the star Castor. The items with high loadings on Factor 15 involved more complex spatial abilities. Knowing a perpendicular angle was important for the two DAT items, yet the distance from the known to Castor in the planetarium sky was not an angle of 90° but the distance was much greater than required for any of the other star chart test items. The high loadings seem to be related to spatial abilities.

Factor 16

Four items had high loadings on Factor 16 as shown in Table 36. The high loadings ranged from .57 to .34. The highest loading was on item 70 and the lowest on item 5. Except for item 69 all items had a significant correlation with the scale score at the .05 level of significance. The Reliability Coefficient for Scale 516 was .46.

Items 69 and 70 were from the Planetarium Skills Evaluation Test and items 5 and 43 from the Classroom Indirect Measurement Instrument. Items 69 and 70 used the stars in the planetarium sky. For these two items the Big Dipper was used.

TABLE 36

Scale 516
Factor 16 of Combined Tests
(Spatial Abilities)

Test Item	High Loading	Correlation with Scale Score	Reliability Coefficient
70	.57	.75	.46
43	.43	.70	
69	.39	.08	
5	.34	.26	

The subject had to tell when the Big Dipper was upside down of its right side up position, and exactly left of its given position. Item 43 was from the Spatial Abilities Subtest. The subject was to determine which boxes could be folded out of the given pattern. Item 5 was a sentence to scan. The high loadings associated with Factor 16 seem to be associated with right-left, right side up - upside down spatial abilities. The scanning sentence also emphasizes the left-right directions.

Factor 17

Table 37 shows that three items had high loadings on Factor 17. The range was from .50 to .33. All items had significant correlations with the scale score at the .05 level of significance. The Reliability Coefficient of Scale 517 was .37.

Items 77 and 85 were from the Planetarium Skills Evaluation Test. Both items involved the use of slides. Item 77

TABLE 37

Scale 517
Factor 17 of Combined Tests
(Spatial Abilities)

Test Item	High Loading	Correlation with Scale Score	Reliability Coefficient
77	.50	.43	.37
19	.43	.34	
85	.33	.47	

required the subject to determine which star in the right slide was larger than the one in the same location in the left slide. Item 85 involved the use of a star chart to point out a star. Item 19 was a measurement problem from the Classroom Indirect Measurement Instrument. The subjects had to express what part of a drawing was shaded. The three items with high loadings on Factor 17 seem to be related to spatial abilities.

Factor 18

Three items had high loadings on Factor 18, as shown in Table 38. The high loadings ranged from .58 to .38. All item correlations with the scale score were significant at the .05 level. The Reliability Coefficient of Scale 518 was .49.

All three items were from the Planetarium Skills Evaluation Test. Items 75 and 86 were from the Spatial Abilities Subtest while 56 was included in the Orientation Skills Subtest. Item 56 required the subject to determine

TABLE 38

Scale 518
Factor 18 of Combined Tests
(Spatial Abilities)

Test Item	High Loading	Correlation with Scale Score	Reliability Coefficient
86	.58	.57	.49
56	.38	.45	
75	.38	.47	

the direction of the setting sun. Item 86, which had the highest loading required the subjects to use a star chart to locate a star on the slide. Being able to determine from four choices which slide indicated that he had traveled nearest a standard, was required of the subject in item 75. The skills involved in this factor seem to be related to spatial abilities. For item 56 the sun set approximately one-half the distance between west and north. The subject had to recognize this spatial relationship before he could accurately state the direction.

Factor 19

As Table 39 shows three items had high loadings on Factor 19. The range was from .57 to -.37. All item correlations with the scale score were significant at the .05 level. The Reliability Coefficient for Scale 519 was .42.

TABLE 39

Scale 519
Factor 19 of Combined Tests

Test Item	High Loading	Correlation with Scale Score	Reliability Coefficient
24	.57	.60	.42
50	.38	.48	
8	-.37	.27	

Items 8 and 24 were from the Classroom Indirect Measurement Instrument. Item 8 was from the Orientation Skills Subtest. Item 24 was from the Measuring Skills Subtest, and it required the subject to decide which of four choices included horizontal lines. Item 50 from the Planetarium Skills Evaluation Test was included in the Scanning Skills Subtest. The item required the subject to scan a slide for letter a's. The relationships of the high loadings is ambiguous.

<u>Factor 20</u>

Table 40 shows that only one item had a high loading on Factor 20. It was item 49 from the Planetarium Skills Evaluation Test. The subjects were required to scan a slide for the number of letter m's. Since only one high loading for Factor 20 was included its exact relationship is uncertain.

TABLE 40

Scale 520
Factor 20 of Combined Tests

Test Item	High Loading	Correlation with Scale Score	Reliability Coefficient
49	.65	1.00	1.00

APPENDIX E

PLANETARIUM SKILLS EVALUATION TEST FACTOR ANALYSIS

APPENDIX E

PLANETARIUM SKILLS EVALUATION TEST FACTOR ANALYSIS

To follow are the factors which resulted from the factor analysis of all the items included in the Planetarium Skills Evaluation Test. For each of the factors the items with high loadings on that factor are listed. Then, too, the correlation of each of the items with the scale score of the factor is given. Also, the standard score coefficient alphas are listed. The coefficients are reliability coefficients for each of the scales.

A factor analysis of the Planetarium Skills Evaluation Test groups items which are measuring the same skills in the test.

Factor 1

As Table 41 shows nine items had high loadings on Factor 1. The high loadings ranged from .55 to .20. Item correlations with the scale score were all significant at the .05 level. The Reliability Coefficient for Scale 501 was .66.

The item with the highest loading in Factor 1 was number 78. This item required the subject to determine which star in the right slide was larger than the one in the same location in the left. The next three high loadings all related to items which required the subject to determine

TABLE 41

Scale 501
Factor 1 of Planetarium Skills Evaluation Test
(Orientation Skills)

Item	High Loading	Correlation with Scale Score	Reliability Coefficient
78	.55	.50	.66
53	.54	.60	
56	.51	.63	
55	.49	.49	
88	.46	.33	
86	.37	.35	
72	.33	.34	
75	.30	.33	
74	.20	.26	

directions. Items 88 and 86 with the next two high loadings on Factor 1 pertained to the use of star charts. Both star charts had the stars connected with lines. Item 72 with a high loading of only .33 required the student to choose which of four choices would be the correct view if the subject could get behind the projection and view it. Items 75 and 74 with small high loadings on Factor 1 pertained to recognizing if the subject had traveled nearer or farther from the projected standard.

Even though the subjects used a star chart and did several items related to direction none of the high loadings in Factor 1 used the planetarium sky. In the original test all items except for 53, 56, and 55 pertained to spatial abilities. These three items were related to orientation skills. Of the high loadings larger than .37 three of the five are related to orientation skills. Because of this it seems reasonable to assume that Factor 1 is related to orientation skills.

Factor 2

As shown in Table 42 Factor 2 had eight high loadings. The range of the high loadings was from .44 to .30. Item correlations with the scale score were all significant at the .05 level. The Reliability Coefficient for Scale 501 was .52.

The item with the highest loading on Factor 2 was number 60. Item 60 required the subject to determine the number of degrees that the north star was above the horizon. The item with the second highest loading on Factor 2 was item 91. This item involved the use of a star chart and a projected slide. Items 94, 93, and 92 also with high loadings on Factor 2 required the subject to use a star chart to locate objects in the planetarium sky. All of the high loadings with the exception of 91, 89, and 87, employed the planetarium sky. All high loadings in Factor 2 with the exception of 60 and 57 employed the use of a star chart. Yet both items required information related to the north star. The abilities associated with Factor 2 seem to be involved with measurement and the use of a star chart which is related to spatial abilities.

Table 42

Scale 502
Factor 2 of Planetarium Skills Evaluation Test
(Measurement and Spatial Abilities)

Item	High Loading	Correlation with Scale Score	Reliability Coefficient
60	.44	.49	.52
91	.42	.36	
94	.36	.38	
89	.34	.33	
87	.34	.29	
93	.31	.36	
92	.30	.34	
57	.30	.23	

Factor 3

As Table 43 shows five items had high loadings on Factor 3. The range of the high loadings was from .53 to .32. All of the items had significant correlations with the scale score at the .05 level of significance. The Reliability Coefficient for Scale 503 was .46.

In the original Planetarium Skills Evaluation Test items 51, 50, and 48 were included in the Scanning Abilities Subtest. Item 63 was included in the Measuring Skills Subtest while item 95 was included in the Spatial Abilities Subtest. Of these five high loadings only item 95 involved use of a star chart. Items 63 and 95 both involved use of the planetarium sky while items 51, 50, and 48 used slides. Item 63

TABLE 43

Scale 503
Factor 3 of Planetarium Skills Evaluation Test
(Comparison Skills)

Item	High Loading	Correlation with Scale Score	Reliability Coefficient
63	-.53	.46	.46
51	.41	.51	
95	.39	.41	
50	.32	.31	
48	.32	.24	

with the largest high loading (-.53) appears with a negative loading which suggests that this item is in some way contrasted to the other factors. The high loadings in Factor 3 did not involve any memory. Three of the high loadings--items 51, 50, and 48--did involve some speed in determining the answers. The highest loadings on Factor 3 seem to be related to comparison for item 63 distance and item 51 size of dots.

Factor 4

As Table 44 shows six items had high loadings on Factor 4. The high loadings ranged from .52 to .33. Item correlations with the scale score were all significant at the .05 level. The Reliability Coefficient for Scale 504 was .50.

In the original planetarium test four items -- 76, 69, 70, and 73 were included in the Spatial Abilities Subtest.

TABLE 44

Scale 504
Factor 4 of Planetarium Skills Evaluation Test
(Spatial Abilities)

Item	High Loading	Correlation with Scale Score	Reliability Coefficient
76	.52	.65	.50
49	.43	.40	
61	-.41	.24	
69	.38	.34	
70	.33	.35	
73	.33	.33	

Item 49 was included in the Scanning Skills Subtest while item 61 was included in the Measuring Skills Subtest. None of the high loadings in Factor 4 involved the use of a star chart; however, items 61, 69, and 70 did involve the use of the Big Dipper. Item 61 had a negative high loading. Four of the high loadings in Factor 4 called for the subjects to give responses in relation to position --up-down, right-left, same location, and behind the projection. Only item 49 was a timed item. Item 61 involved the use of the hands in determining altitude while the other items did not involve any interaction. Item 76 with the highest loading had the subject determine which of four projections indicated that he had not moved from the vicinity of the projected standard. This factor seems to be related to spatial abilities.

Factor 5

As shown in Table 45 four items had high loadings on Factor 5. The high loadings ranged from .52 to .30. All of the item correlations with the scale scores were significant at the .05 level. The Reliability Coefficient for Scale 505 was .49.

All of the high loadings in this factor with the exception of the one for item 67 were included in the Spatial Abilities Subtest. Item 67 was included in the Measuring Skills Subtest. For this item the subject was to state what part of a circle the sun had moved through. None of the items in Factor 5 required the use of a star chart or stars. Items 79 and 80 required the subjects to identify the extra star in the slide, while item 82 called for the subject to point out which star had moved from its original position. The first three items with high loadings on Factor 5 can be considered to involve comparison skills.

TABLE 45

Scale 505
Factor 5 of Planetarium Skills Evaluation Test
(Comparison Skills)

Item	High Loading	Correlation with Scale Score	Reliability Coefficient
79	.52	.59	.49
80	.50	.52	
82	.44	.42	
67	.30	.25	

Factor 6

As shown in Table 46 four items had high loadings on Factor 6. The high loadings ranged from .50 to .19. All of the item correlations with the exception of item 52 were significant at the .05 level. The Reliability Coefficient for Scale 506 was .40.

Two of the high loadings (items 84 and 85) involved the use of a star chart. Both items referred to the same projected slide. Item 77 required the subject to determine which star in the right slide seems larger than the one in the same place on the left slide. The orientation of the slides was the same. Item 52 had a very low loading on the factor. Item 52 was related to determination of one of the cardinal points of direction. Factor 6 may be related to items asked for the first time. Each of these items was the first to evaluate a specific skill. Items 84 and 85 were the first test items to use a star chart -- item 84 without lines, item 85 with lines.

TABLE 46

Scale 506
Factor 6 of Planetarium Skills Evaluation Test
(First Item Evaluation)

Item	High Loading	Correlation with Scale Score	Reliability Coefficient
84	.50	.56	.40
77	.47	.47	
85	.31	.34	
52	.19	.16	

Item 52 was the first item included in the Orientation Skills Subtest.

Factor 7

As Table 47 shows seven items had high loadings on Factor 7. The range of the high loadings was from .57 to .27. Except for item 66 all item correlations with the scale score were significant at the .05 level. The Reliability Coefficient for Scale 507 was .53.

TABLE 47

Scale 506
Factor 7 of Planetarium Skills Evaluation Test
(Comparison Skills)

Item	High Loading	Correlation with Scale Score	Reliability Coefficient
83	.57	.67	.53
81	.46	.53	
54	-.37	.31	
66	-.36	.19	
90	.33	.40	
68	.30	.27	
71	.27	.26	

Item 83 had the highest loading on Factor 7. This item required the subject to locate a star in two slides projected side by side. Item 81 required the subject to determine which star had moved from its position in the left slide. Item 54 with a negative high loading was from the Orientation Skills Subtest. Item 66 asked the subject to determine the shortest side of the Summer Triangle. This was the only item to use stars in Factor 7. Item 90 involved the use of a projected slide and star chart. Items 68 and 71 involved the subjects in predicting -- for item 68 time and for item 71 the setting location of the sun. The majority of the high loadings in Factor 7 involve comparisons.

Factor 8

As shown in Table 48 five items had high loadings on Factor 8. The range of the high loadings was from -.49 to -.28. All item correlations with the scale score were significant at the .05 level. The Reliability Coefficient for Scale 508 was .46.

All of the high loadings in Factor 8 used the planetarium sky. Item 65 with the highest and also negative high loading had the subject compare the sides of the Winter Triangle. Items 59 and 58 required the subjects to compare the brightnesses of stars. For item 62 the subject had to estimate the distance between the pointer stars and the north star. To perform on item 65 the subject had to compare the sides of the Spring Triangle. Factor 8 seems to be related to Comparison skills in this instance brightness and distance.

TABLE 48

Scale 508
Factor 8 of Planetarium Skills Evaluation Test
(Comparison Skills)

Item	High Loading	Correlation with Scale Score	Reliability Coefficient
64	-.49	.46	.46
59	.45	.51	
58	.44	.41	
62	.34	.31	
65	-.28	.24	

BIBLIOGRAPHY

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Books and Pamphlets

Adcock, C. J. Factor Analysis for Non-Mathematicians. Victoria, Australia: Melbourne University Press, 1954.

Anastasi, A. and Foley, J. P. Differential Psychology. New York: Macmillan Co., 1953.

Ary, Donald, Jacobs, Lucy and Razavich, Asghas. Introduction to Research in Education. New York: Holt, Rinehart and Winston, 1972.

Baker, Robert H. Introducing the Constellations. New York: Viking Press, 1966.

Baker, Robert H. When the Stars Come Out. New York: Viking Press, 1934.

Bennett, K., Seashore, H. G. and Wesman, A. C. Differential Aptitudes Tests. New York: The Psychological Corporation, 1959.

Berens, Conrad and Zuckerman, Joshua. Diagnostic Examination of the Eye Step by Step Procedure. New York: J. B. Lippincott Co., 1946.

Bernhard, Herbert J., Bennett, Dorothy A. and Rice, Hugh S. A New Handbook of the Heavens. New York: McGraw-Hill Book Co., 1948.

Buros, Oscar, Editor. The Fourth Mental Measurements Yearbook. Highland Park, New Jersey: Gryphon Press, 1953.

Burritt, A. M. The Geography of the Heavens. Hartford, Connecticut: F. J. Hunington, 1836.

Daniels, Dan. Photography from A to Z. New York: Chilton Book Co., 1968.

Earth-Space Science Education Center. Teacher's Guide to the Strassenburg Planetarium. Rochester, New York: Fairport Central School, 1968.

Gibson, James J. The Perception of the Visible Universe. New York: Houghton Mifflin Co., 1950.

Hurvich, Leo M. and Jameson, Dorothea. The Perception of Brightness and Darkness. Boston: Allyn & Bacon, 1966.

Joseph, Joseph Marion and Lippincott, Sarah Lee. Point to the Stars. New York: McGraw-Hill Book Co., 1963.

Kephart, Newell C. The Slow Learner in the Classroom. Columbus, Ohio: Charles E. Merrill Publishing Co., 1971.

Kodak, Eastman Co. Kodak Color Data Guide. Rochester, New York: Eastman Kodak Co., 1972.

Kuhlmann-Anderson Test, Booklet CD, Seventh Edition. Princeton, New Jersey: Personnel Press, Inc., 1964.

Kuhlmann-Anderson Test, Technical Manual, Seventh Edition. Princeton, New Jersey: Personnel Press, Inc., 1964.

Levitt, I. M. and Marshall, Roy K. Star Maps for Beginners. New York: Simon & Schuster, 1964.

Mayall, Newton, Mayall, Margaret, and Wyckoff, Jerome. The Sky Observer's Guide. New York: Golden Press, 1961.

Menzel, Donald H. A Field Guide to the Stars and Planets. Boston: Houghton Mifflin Co., 1964.

Nash, J. Developmental Psychology: A Psychobiological Approach. Englewoods Cliffs, New Jersey: Prentice-Hall, 1970.

National Academy of Science. Visual Search. Washington, D.C., 1973.

Neely, Henry M. The Stars by Clock and Fist. New York: Viking Press, 1966.

Olcott, William T., Revised by Mayall, R. Newton and Mayall, Margaret W. Field Book of the Skies. New York: G. P. Putnam's Sons, 1954.

Piaget, J. and Inhelder, B. The Child's Conception of Space. London: Routledge and Degan Paul, 1956.

Porter, Jermain G. The Stars in Song and Legend. Boston: Ginn & Co., 1901.

Reed, W. Maxwell. Patterns in the Sky the Story of the Constellations. New York: William Morrow & Co., 1951.

Rey, H. A. Find the Constellations. Boston: Houghton Mifflin Co., 1966.

Rey, H. A. The Stars a New Way to See Them. Boston: Houghton Mifflin Co., 1967.

Smith, Donald E. P., Editor. Word Tracking. Ann Arbor, Michigan: Ann Arbor Publishers, 1967.

Spitzer, H. F., Hoan, Ernest, McBroom, Maude, Greene, H. A. and Linquist, E. F. Iowa Every Pupil Tests of Basic Skills, Test D. Boston: Houghton Mifflin Co., 1947.

Staal, Julius D. Patterns in the Sky. Atlanta, Georgia: Econi-Co., 1972.

Terman, Lewis and Merrill, Maud A. Stanford-Binet Intelligence Scale, Manual for the Third Revision Form L-M. Boston: Houghton Mifflin Co., 1960.

Walker, Helen M. and Lev, Joseph. Statistical Inference. New York: Holt, Rinehart and Winston, 1953.

Williams, Lou. A Dipper Full of Stars, A Beginner's Guide to the Heavens. New York: Follett Publishing Co., 1956.

Wiseman, Stephen. Correlation Methods. Manchester, England: Manchester University Press, 1966.

Zaddle, Arthur and Smits, Theodore. Making Friends with the Stars. New York: Barnes & Noble, Inc., 1964.

Zimm, Herbert S. and Baker, Robert H. Stars a Guide to the Constellations, Sun, Moon, Planets, and Other Features of the Heavens. New York: Golden Press, 1966.

Articles and Periodicals

Ames, Louise and Learned, Janet. "The Development of Verbalized Space in the Young Child." The Journal of Genetic Psychology. LXXII (1948), 63-84.

Atkin, J. Myron. "Teaching Concepts of Modern Astronomy to Elementary Children." Science Education. XLV, No. 1 (February, 1961), 54-58.

Blitz, Theodore. "Let Stars Get in Their Eyes." Grade Teacher. LXXVI, No. 3 (November, 1958), 122-23.

Blough, G. O. "Studying the Heavens." Instructor. XLVII (January, 1938), 41-50.

Branley, Franklyn. "The Big Dipper." Grade Teacher. LXXIX (February, 1962), 46.

Brown, Robert and Strongman, Kenneth. "Visual Search and Stimulus Orientation." Perceptual and Motor Skills. XXIII (October, 1966), 539-542.

Burg, Albert. "Light Sensitivity as Related to Age and Sex." Perceptual and Motor Skills. XXIV (June, 1967), 1279-1288.

Clark, Brant and Malone, R. Daniel. "Topographic Orientation in Naval Aviation Cadets." Journal of Educational Psychology. XLV, No. 2 (February, 1954), 91-109.

Clifford, Thomas and Calvin, Allen. "Effect of Age on the Discriminative Learning of Color and Brightness." American Journal of Psychology. LXXI, No. 4, 766-767.

Coffin, Florence and Heisman, Richard. "Astronomy." Grade Teacher. LXXIII No. 5 (January, 1956), 49.

Coxford, Arthur, Jr. "Piaget Number and Measurement." The Arithmetic Teacher. X (November, 1963), 419-427.

Darnell, Lillian H. "Sky Above." Grade Teacher. LXXI No. 7 (March, 1954), 46-47.

Dean, Norman and Lauck, Gregory. "Planetarium Instruction Using an Open-Sky Test." Science Teacher. XXXIX No. 5 (May, 1972), 54-55.

Edwards, John. "How Well Are Intermediate Children Orientated in Space." Journal of Geography. LII No. 4 (April, 1953), 131-144.

Gingery, Walter G. "Astronomy for the Elementary Science Class." School Science and Mathematics. L No. 442 (November, 1950), 598-602.

Gregg, F. M. "An Important Principle in Teaching Primary-Grade Geography." Elementary School Journal. XLI No. 9 (May, 1941), 665-670.

Haines, Richard F. "Detection Time to a Point Source of Light Appearing on a Star Field Background with and without a Glare Source Present." Human Factors. X (October, 1968), 523-530.

Hainfield, Harold. "Seeing Stars." Journal of Education. CXXXVII No. 2 (November, 1954), 19.

Hansen, Violet. "Sky Study - A Unit of Activity Based on the Study of the Heavens." Grade Teacher. LV No. 5 (January, 1938), 12-13.

Howe, George F. "A Study of Children's Knowledge of Directions." Journal of Geography. XXX (October, 1931), 298-304.

Howe, George. "The Teaching of Directions." Journal of Geography. XXXI (May, 1932), 207-210.

Leslie, Ron and Calfee, Robert. "Visual Search Through Word Lists as a Function of Grade Level, Reading Ability, and Target Repetition." Perception and Psychophysics. X (September, 1971), 165-171.

Lord, F. E. "A Study of Spatial Orientation of Children." Journal of Educational Research. XXXIV 481-505.

Lovi, George. "Rambling Through March Skies." Sky and Telescope. XLV No. 3 (March, 1973), 170.

Lowey, Stan. "The Stars Overhead." Science Education. XLVI No. 2 (March, 1962), 145-148.

Marshall, Roy K. "Rambling Through July Skies." Sky and Telescope. XLII No. 1 (July, 1971), 30.

Neisser, U. and Beller, H. K. "Searching Through Word Lists." British Journal of Psychology. LVI (1965), 349-358.

Newport, John F. "A Look at the University of Illinois Astronomy Materials." School Science and Mathematics. LXV No. 2 (February, 1965), 145-147.

Pitluga, George E. "The Planetarium Visit...An Evaluation by Teachers." Science Activities. VI (1972), 15-18.

Posso, Mary Estelle. "Two Units on Astronomy for Upper Grades." Instructor. LXII No. 6 (February, 1953), 30.

Preston, Ralph C. "A Comparison of Knowledge of Directions in German and in American Children." The Elementary School Journal. LVII No. 3 (December, 1956), 158-160.

Sawada, Daiyo and Nelson, L. Doyal. "Conservation of Length and the Teaching of Linear Measurement: A Methodological Critique." The Arithmetic Teacher. XIV (May, 1967), 345-348.

Smith, Wiley F. "Direction Orientation in Children." Journal of Genetic Psychology. LII (1933), 154-165.

Songry, Clarisse. "Young Scientists See Stars." The Catholic School Journal. LIV No. 3 (March, 1954), 104.

Soroka, John J. "The Planetarium and Science Education." Projector I (1968), 18-20.

Spiero, Gwendolyn O'Hara. "Stargazing with a Purpose." Instructor. LXIV No. 7 (March, 1955), 49.

Stecher, Joann M. "Astronomy for Grades Five Through Eight." Science and Children. II No. 5 (February, 1965), 23-24.

"The Necessary Nine." Grade Teacher. LXXXV No. 5 (January, 1968), 87-90.

Tuttle, Donald. "Elgin's Research in Planetarium Curriculum." Projector. I (1968), 13-16.

Utley, Celia. "We Study the Skies." Grade Teacher. LXXI No. 4 (December, 1953), 45.

Williams, Bertha Mae. "Sky Gazing." Instructor. LX No. 6 (April, 1951), 26.

Unpublished Material

Battaglini, Dennis. "An Experimental Study of the Science Curriculum Improvement Study Involving Fourth Graders' Ability to Understand Concepts of Relative Position and Motion Using the Planetarium As a Testing Device." Unpublished PhD dissertation, Michigan State University, 1971.

Chamberlain, J. M. "The Administration of a Planetarium As An Educational Institution." Unpublished PhD dissertation, Columbia University, 1962.

Curtin, John. "An Analysis of Planetarium Program Content and the Classification of Demonstration Questions." Unpublished PhD dissertation, Wayne State University, 1967.

Hunter, John E. FACTRB. Computer Institute for Social Science Research Michigan State University, E. Lansing, Michigan, 1974.

Hunter, John E. Preliminary User's Manual. Computer Institute for Social Science Research, Michigan State University, E. Lansing, Michigan, 1974.

Korey, Ruth Anne. "Contributions of Planetariums to Elementary Education." Unpublished PhD dissertation, Fordham University, 1963.

Marie Drake Planetarium. <u>Planetarium Program K - 6</u>. Juneau, Alaska, 1966.

Mt. Clemens Community Schools. <u>1967-68 Planetarium Curriculum</u>. Mt. Clemens, Michigan: Mt. Clemens Community Schools, 1967.

Reed, George. "A Comparison of the Effectiveness of the Planetarium and the Classroom Chalkboard and Celestial Globe in the Teaching of Specific Astronomical Concepts." Unpublished PhD dissertation, University of Pennsylvania, 1970.

Ridky, Robert. "A Study of Planetarium Effectiveness on Student Achievement, Perceptions and Retention." Unpublished PhD dissertation, Syracuse University, 1973.

Rosemergy, John. "An Experimental Study of the Effectiveness of a Planetarium in Teaching Selected Astronomical Phenomena to Sixth-Grade Children." Unpublished PhD dissertation, University of Michigan, 1968.

Smith, Billy. "An Experimental Comparison of Two Techniques (Planetarium Lecture-Demonstration and Classroom Lecture-Demonstration) of Teaching Selected Astronomical Concepts to Sixth-Grade Students." Unpublished EdD dissertation, Arizona State University, 1966.

Sunal, Dennis. "The Planetarium in Education: An Experimental Study of the Attainment of Perceived Goals." Unpublished PhD dissertation, University of Michigan, 1973.

Wright, D. L. C. "Effectiveness of the Planetarium and Different Methods of Its Utilization in Teaching Astronomy." Unpublished PhD dissertation, University of Nebraska, 1968.