INFORMATION TO USERS

This was produced from a copy of a document sent to us for microfilming. While the most advanced technological means to photograph and reproduce this document have been used, the quality is heavily dependent upon the quality of the material submitted.

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

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

2. When an image on the film is obliterated with a round black mark it is an indication that the film inspector noticed either blurred copy because of movement during exposure, or duplicate copy. Unless we meant to delete copyrighted materials that should not have been filmed, you will find a good image of the page in the adjacent frame.

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

4. For any illustrations that cannot be reproduced satisfactorily by xerography, photographic prints can be purchased at additional cost and tipped into your xerographic copy. Requests can be made to our Dissertations Customer Services Department.

5. Some pages in any document may have indistinct print. In all cases we have filmed the best available copy.

University of Microfilms International
300 N ZEEB ROAD, ANN ARBOR, MI 48106
18 BEDFORD ROW, LONDON WC1R 4EJ, ENGLAND
STUDENT ACHIEVEMENT AND ATTITUDES IN ASTRONOMY: AN EXPERIMENTAL STUDY OF THE EFFECTIVENESS OF A TRADITIONAL "STAR SHOW" PLANETARIUM PROGRAM AND A "PARTICIPATORY ORIENTED PLANETARIUM" PROGRAM

Temple University ED.D. 1980

University Microfilms International

Copyright 1980 by

MALLON, GERALD L.

All Rights Reserved
PLEASE NOTE:

In all cases this material has been filmed in the best possible way from the available copy. Problems encountered with this document have been identified here with a check mark □.

1. Glossy photographs □
2. Colored illustrations □
3. Photographs with dark background □
4. Illustrations are poor copy □
5. Print shows through as there is text on both sides of page □
6. Indistinct, broken or small print on several pages □ throughout □
7. Tightly bound copy with print lost in spine □
8. Computer printout pages with indistinct print □
9. Page(s) □ lacking when material received, and not available from school or author □
10. Page(s) □ seem to be missing in numbering only as text follows □
11. Poor carbon copy □
12. Not original copy, several pages with blurred type □
13. Appendix pages are poor copy □
14. Original copy with light type □
15. Curling and wrinkled pages □
16. Other □
STUDENT ACHIEVEMENT AND ATTITUDES IN ASTRONOMY: 
AN EXPERIMENTAL STUDY OF THE EFFECTIVENESS OF A 
TRADITIONAL "STAR SHOW" PLANETARIUM PROGRAM AND 
A "PARTICIPATORY ORIENTED PLANETARIUM" PROGRAM

By

Gerald L. Mallon

Submitted to the Temple University Graduate Board
in partial fulfillment of the requirements
for the degree of

DOCTOR OF EDUCATION

January 1980
Title of Dissertation:

Student Achievement and Attitudes in Astronomy: An Experimental Study of the Effectiveness of a Traditional "Star Show" Planetarium Program and a "Participatory Oriented Planetarium" Program

Author:

Gerald L. Mallon

Read and Approved by:

[Signatures]

Date submitted to the Graduate Board: 11-30-79

Accepted by the Graduate Board of Temple University in partial fulfillment of the requirements for the degree of Doctor of Education.

Date: 1/25/80

Gabrielle Bernard Jackson
(Dean of Graduate School)
ACKNOWLEDGEMENTS

I wish to express my sincere appreciation to the members of my committee, Matthew Bruce, Daniel Rosenthal, Joseph Schmuckler, and Hubert Harber, for their advice and guidance throughout the development and implementation of this study.

In particular, I would like to thank Dr. Bruce, my major adviser, for his constant support and understanding during this difficult process.

To Hu Harber, I owe a particular debt of gratitude for his unfailing encouragement and counsel. Hu has served as an excellent role model for me over the last ten years, providing me with an example of a superior teacher and friend.

I would like to thank the Methacton School District for allowing me to conduct the study within the district and also each of the participating planetarium directors, and their respective educational institutions, for their help in the development or replication of this study. These include:

Jeanne E. Bishop        Dave Hostetter
Dennis V. Brinkman       Eloise W. Koonce
Alan J. Friedman         George F. Reed
George Hamilton          Cary I. Sneider
To my dear friend, Stephen C. Pelz, I wish to express my deepest gratitude for his loyal friendship and love. When times seemed the bleakest, Stephen always managed to help me muddle through.

To my parents, Gerald and Laura Mallon, I wish to dedicate this dissertation in appreciation for their love and guidance all the days of my life.

Finally, in closing, allow me to thank God Almighty for all of His good gifts to me, the successful completion of this program being one for which I am indeed most thankful.
# TABLE OF CONTENTS

<table>
<thead>
<tr>
<th>Chapter</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>I. INTRODUCTION</td>
<td>1</td>
</tr>
<tr>
<td>Introduction</td>
<td>1</td>
</tr>
<tr>
<td>Statement of Problem</td>
<td>5</td>
</tr>
<tr>
<td>General Design</td>
<td>10</td>
</tr>
<tr>
<td>Assumptions</td>
<td>13</td>
</tr>
<tr>
<td>Limitations</td>
<td>13</td>
</tr>
<tr>
<td>Definition of Terms</td>
<td>14</td>
</tr>
<tr>
<td>II. RELATED LITERATURE</td>
<td>16</td>
</tr>
<tr>
<td>Introduction</td>
<td>16</td>
</tr>
<tr>
<td>Planetarium Research</td>
<td>16</td>
</tr>
<tr>
<td>Studies Concerned With the Effectiveness of the Planetarium</td>
<td>18</td>
</tr>
<tr>
<td>Studies Comparing the Effectiveness of the Planetarium vs. the Classroom</td>
<td>20</td>
</tr>
<tr>
<td>Studies Comparing the Effectiveness of Different Styles of Planetarium Presentations</td>
<td>28</td>
</tr>
<tr>
<td>III. PROCEDURES</td>
<td>32</td>
</tr>
<tr>
<td>Introduction</td>
<td>32</td>
</tr>
<tr>
<td>Description and Selection of Participants in Main Study</td>
<td>32</td>
</tr>
<tr>
<td>Description and Selection of Participants in Replications of Study</td>
<td>34</td>
</tr>
<tr>
<td>The Instructional Programs</td>
<td>38</td>
</tr>
<tr>
<td>Instrumentation</td>
<td>40</td>
</tr>
<tr>
<td>The Experimental Procedures</td>
<td>44</td>
</tr>
<tr>
<td>Analysis of Data</td>
<td>45</td>
</tr>
<tr>
<td>IV. ANALYSIS OF DATA</td>
<td>48</td>
</tr>
<tr>
<td>Introduction</td>
<td>48</td>
</tr>
<tr>
<td>Measurement of Change in Astronomy Knowledge</td>
<td>49</td>
</tr>
<tr>
<td>Chapter</td>
<td>Page</td>
</tr>
<tr>
<td>---------</td>
<td>------</td>
</tr>
<tr>
<td>Measurement of Change in Astronomy Attitudes</td>
<td>58</td>
</tr>
<tr>
<td>Summary of Findings</td>
<td>67</td>
</tr>
<tr>
<td>V. SUMMARY, CONCLUSIONS, AND RECOMMENDATIONS</td>
<td>70</td>
</tr>
<tr>
<td>Synopsis of Research</td>
<td>70</td>
</tr>
<tr>
<td>Conclusions</td>
<td>76</td>
</tr>
<tr>
<td>Discussion and Educational Implications</td>
<td>78</td>
</tr>
<tr>
<td>Recommendations</td>
<td>80</td>
</tr>
<tr>
<td>BIBLIOGRAPHY</td>
<td>82</td>
</tr>
<tr>
<td>APPENDICES</td>
<td>90</td>
</tr>
<tr>
<td>Appendix A: Correspondence</td>
<td>90</td>
</tr>
<tr>
<td>Appendix B: Testing Instruments</td>
<td>99</td>
</tr>
<tr>
<td>Appendix C: Treatment Scripts</td>
<td>119</td>
</tr>
</tbody>
</table>
## LIST OF TABLES

<table>
<thead>
<tr>
<th>Table</th>
<th>Summary of the Results of a Correlated t Test on Pre-test and Post-test Content Scores for the P.O.P. Groups in All Five Studies.....</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>I.</td>
<td>Summary of the Results of a Correlated t Test on Pre-test and Post-test Content Scores for the Star Show Groups in All Five Studies..</td>
<td>51</td>
</tr>
<tr>
<td>III.</td>
<td>Summary of the Results of a 2 X 2 Factorial Analysis of Variance of the Pennsylvania Star Show and P.O.P. Groups on the Content Test........</td>
<td>53</td>
</tr>
<tr>
<td>IV.</td>
<td>Summary of the Results of a 2 X 2 Factorial Analysis of Variance of the Texas Star Show and P.O.P. Groups on the Content Test...............</td>
<td>54</td>
</tr>
<tr>
<td>V.</td>
<td>Summary of the Results of a 2 X 2 Factorial Analysis of Variance of the California Star Show and P.O.P. Groups on the Content Test................</td>
<td>55</td>
</tr>
<tr>
<td>VI.</td>
<td>Summary of the Results of a 2 X 2 Factorial Analysis of Variance of the Minnesota Star Show and P.O.P. Groups on the Content Test................</td>
<td>56</td>
</tr>
<tr>
<td>VII.</td>
<td>Summary of the Results of a 2 X 2 Factorial Analysis of Variance of the Nevada Star Show and P.O.P. Groups on the Content Test................</td>
<td>57</td>
</tr>
<tr>
<td>VIII.</td>
<td>Summary of the Results of a Correlated t Test on Pre-test and Post-test Attitude Scores for the P.O.P Groups in All Five Studies.....</td>
<td>60</td>
</tr>
<tr>
<td>Table</td>
<td>Page</td>
<td></td>
</tr>
<tr>
<td>-------</td>
<td>------</td>
<td></td>
</tr>
<tr>
<td>IX.</td>
<td>Summary of the Results of a Correlated $t$ Test on Pre-test and Post-test Attitude Scores for the Star Show Groups in All Five Studies. 60</td>
<td></td>
</tr>
<tr>
<td>X.</td>
<td>Summary of the Results of a 2 X 2 Factorial Analysis of Variance of the Pennsylvania Star Show and P.O.P. Groups on the Attitude Test. 62</td>
<td></td>
</tr>
<tr>
<td>XI.</td>
<td>Summary of the Results of a 2 X 2 Factorial Analysis of Variance of the Texas Star Show and P.O.P. Groups on the Attitude Test. 63</td>
<td></td>
</tr>
<tr>
<td>XII.</td>
<td>Summary of the Results of a 2 X 2 Factorial Analysis of Variance of the California Star Show and P.O.P. Groups on the Attitude Test. 64</td>
<td></td>
</tr>
<tr>
<td>XIII.</td>
<td>Summary of the Results of a 2 X 2 Factorial Analysis of Variance of the Minnesota Star Show and P.O.P. Groups on the Attitude Test. 65</td>
<td></td>
</tr>
<tr>
<td>XIV.</td>
<td>Summary of the Results of a 2 X 2 Factorial Analysis of Variance of the Nevada Star Show and P.O.P. Groups on the Attitude Test. 66</td>
<td></td>
</tr>
<tr>
<td>XV.</td>
<td>Summary of Post-test Means for Content Test. 69</td>
<td></td>
</tr>
<tr>
<td>XVI.</td>
<td>Summary of Post-test Means for Attitude Test. 69</td>
<td></td>
</tr>
</tbody>
</table>
CHAPTER I

INTRODUCTION

American Astronomy Education has gone through many changes during the last two-hundred years. It has vasculated from periods of importance to unimportance as documented by Jeanne E. Bishop in her article, "United States Astronomy Education: Past, Present, and Future."¹ Today, one of the most widely used forums for astronomy education is the planetarium. It has been estimated that 12 million people visit U.S. planetariums each year.²

The planetarium permits visitors to experience an intensive educational session under the direction of a professional knowledgeable in the field of astronomy or space science. At present, no other science area exhibits a parallel facility for the regular education of the public. The planetarium thus fulfills the vital role in science education of providing scientific information about an important and


constantly changing field, as well as answering visitors' personal questions about the universe.

The most widely used planetarium experience among the 1100 planetariums in the United States is the "Star Show." This is usually a lecture format presentation, often recorded, illustrated with special effects, and accompanied by musical selections. This method is used both in the large installations (domes 41-75 feet in diameter) of which there are about fifty in the United States, and the smaller installations (domes 10-40 feet in diameter) making up the remainder.

These "Star Show" programs have been in use now for many years, but very little has been done to evaluate their effectiveness as educational techniques. Glenn Warneking in his article "Planetarium Education in the 70's: Time for Assessment," stressed the need for planetarium evaluation. At the time of publication of that article (1970) Warneking estimated that there were 600 planetariums in the nation's schools. Today the figure is much higher, and yet the evidence on the effectiveness of these programs remains inadequate.

---

3Alan J. Friedman, Associate Research Editor, Director of Astronomy and Physics Education, Lawrence Hall of Science to Doctoral Committee for Gerald Mallon, Temple University, October 23, 1978.

Some studies have been done comparing the planetarium programs with classroom instruction and these studies have produced confusing results. Dean and Lauck, and Wright found the planetarium to be superior to the classroom in increasing students' knowledge of astronomy, while Reed and Rosemergy found the classroom to be superior. Considering the large number of planetariums in the U.S. and their expense, if the planetarium is indeed inferior to the classroom as an instructional device, then the planetarium may be one of the most expensive failures in recent U.S. educational history.

However, perhaps the problem lies not in the planetarium facility but rather in its use. Much recent work has been done in the area of educational theory. Among these efforts, the work of Jean Piaget and David Ausubel offer particular promise for approaching this problem. Piaget's work implies that people go through various levels of thinking ability from sensory motor to formal operations. Depending on the level of intellectual development, different instructional techniques may be more effectively used to teach particular concepts. For example, those on

---

the concrete level of cognitive structure may best be able to learn new material by active manipulation of appropriate materials.

Ausubel's theory of meaningful learning is based on the crucial assumption that a person's ability to learn new material is dependent upon the knowledge that he/she already possesses. For those people approaching a topic for which they have little or no previous knowledge (subsuming concepts), an activity based lesson would be most appropriate to allow them to interact with the subject and form the necessary subsuming concepts for further study.

Because of the high reliance on passive absorption of audio-visual material, many traditional "Star Shows" may not offer the student enough concrete experiences in the study of astronomy to be effective in instruction. At present however, no research has been done to either support or dispute this premise.

Within the last few years, a small group of planetarium educators has begun to advocate a different type of planetarium technique. This technique referred to as a "Participatory Oriented Planetarium" program (P.O.P.) relies on a discovery-inquiry approach to the planetarium session. The "P.O.P." program uses

---

extensive verbal interaction between members of the audience and the planetarium instructor. Although this technique has been supported by the National Science Foundation through a series of planetarium workshops conducted across the United States, no relevant research has been done to verify its value over the "Star Show" format. Indeed the only study directly applicable to this problem seems to indicate that instructor personality is more important than planetarium techniques.⁷

**Statement of Problem**

"In a smaller educational planetarium, with a capacity of between 15-75 people, is the traditional 'Star Show' planetarium program or the 'Participatory Oriented Planetarium' program the most effective for instruction and attitude change?"

The following statement by Alan J. Friedman, Associate Research Editor and Director of Astronomy and Physics Education for the Lawrence Hall of Science, made specifically in support of this study, succinctly states this problem of planetarium education:

> Much general theory of learning, including especially the work of Jean Piaget, supports

⁷Jack Fletcher, "An Experimental Comparison of the Effectiveness of a Traditional Type Planetarium Program and a Participatory Type Planetarium Program," (Ph.D. dissertation, University of Virginia, 1977).
the concept of 'hands-on' activity-based learning strategies. In practice however, most instruction at all levels is still based on some variant of the lecture format. This extends to planetariums. Our national survey of all North American planetariums (to be published soon) indicates that the great majority of planetarium programs are of the illustrated lecture format. If a more effective mode of learning were available, using it would enrich educational experiences for an estimated 11 million planetarium goers, including school children and adults. To date, there is not a single study that compares a conventional passive planetarium program with an activity-based program. 8 (For further information, please see Dr. Friedman's letter included in the appendix.)

Dr. George F. Reed, Science Educator and Chairperson of the Research Committee for the Middle Atlantic Planetarium Society, also added his support for this research. In his letter, Dr. Reed states:

I am particularly interested in Mr. Mallon's dissertation proposal. I believe that his results would be of significance because of his use of a large sample with one instructor. The one instructor is necessary to provide a competent familiarity of the program and approaches that are being tested. The planetarium field needs this type of information if it is to provide the maximum educational service to its students. Without good educational research of this type, planetarium educators are subject to the passing whims and fads of time. 9 (For further information, please see Dr. Reed's letter included in the appendix.)

In their letters of support, Dr. Friedman and Dr. Reed spoke of the national implications of this

---

8 Friedman, "Letter to Doctoral Committee."

9 George F. Reed, Professor of Astronomy and Science Education, West Chester State College, West Chester, Pa. to Gerald L. Mallon Doctoral Committee, October 31, 1978.
study. On a more local level, this study is of particular importance to the Commonwealth of Pennsylvania because of the large number of planetariums located within the state. Pennsylvania has the highest density of planetariums in the country. Of the 190 now in existence in Pennsylvania, over 140 of these are in public schools. William H. Bolles, Science Education Adviser, Bureau of Curriculum Services for the Pennsylvania Department of Education has expressed his support for this study and has indicated that the results "would be of great value to the Department," and that "this is something that has been needed for many years." 10 (For further information, please see Dr. Bolles's letter included in the appendix.)

This research study was executed then in order to examine the following questions.

1. Is either treatment, Participatory Oriented Planetarium program or Star Show program, effective in increasing student understanding of selected astronomical concepts?

2. Are there any differences in the achievement level of students who receive the Participatory Oriented Planetarium program and the students who receive the Star Show treatment?

3. Is either treatment, Participatory Oriented Planetarium or Star Show, effective in changing student attitudes towards astronomy?

4. Are there any differences in the composite

---

mean attitudinal test scores of the students in the Participatory Oriented Planetarium treatment and the Star Show treatment in their attitudes towards astronomy?

From these four questions, the following null hypotheses were derived:

\( H_0.1 \). There is no difference in student pre-treatment and post-treatment understanding of selected astronomical concepts, whether they experience a traditional Star Show planetarium program or a Participatory Oriented Planetarium program.

\( H_0.2 \). There is no difference in the achievement level of students who receive a Participatory Oriented Planetarium treatment and the achievement level of students who receive a traditional Star Show treatment.

\( H_0.3 \). There is no difference in the students' pre-treatment and post-treatment attitudes towards astronomy, whether they receive a Participatory Oriented Planetarium program or a traditional Star Show planetarium program.

\( H_0.4 \). There is no difference in the composite mean attitudinal test scores of the students who experience a Participatory Oriented Planetarium treatment and the students who experience a Star Show treatment in their attitudes towards astronomy.

Since there is no standardized test in existence for the measurement of student's knowledge of selected astronomical concepts, it was necessary to construct an evaluation instrument for this study. This test was designed to measure student understanding of the concepts addressed by the objectives of the two treatments. It was a paper-and-pencil test, rather than an open-sky test, since this format of test
has been shown to be an effective means of evaluating constellation study. This test was reviewed by a panel of prominent planetarium educators, considered to be expert in the field of planetarium education, in order to establish content validity. Further, this instrument was tested in order to determine the reliability of the test and further tested to examine its correlation to individual testing sessions under the planetarium sky.

The attitudinal survey was one of the most difficult aspects of this study. Attitude measurement is an area of science education that still requires much research. Richard E. Pearl dramatically addresses this problem in his statement, "A survey of the literature reveals one consistent theme - the total inadequacy of science attitude measurement." Therefore, rather than attempt to construct and validate a new instrument specifically for this study, an accepted science opinionnaire was selected from the few in existence and used in this study.

To use this science opinionnaire to test astronomy attitudes, the test was made more specific by

---


making the following adaptations:

1. The word 'astronomy' was inserted wherever the word 'science' appeared.

2. The word 'planetarium' replaced the words 'science classroom.'

3. The word 'astronomer' replaced the word 'scientist.'

No other changes were made in the body of the survey instrument.

When this attitude test was administered to the students, it was read aloud by the researcher, rather than privately read by the students. This format was used in order to diminish the effects of different reading levels within the population. To respond to the survey, students simply marked an optical scanning sheet according to their preference (i.e. strongly agree, agree, undecided, disagree, strongly disagree).

General Design

In order to address the four hypotheses of this study, the following research format was devised. This study used a modified "Solomon Four Group" design. First a population of eight-to-ten year old students was identified and randomly assigned to four groups. It should be noted that eight-to-ten year old students were selected for this study for the following reasons:
1. This age group makes up a large percentage of many school district planetarium populations.

2. At this age the participants in the study should not have formed a pre-disposition (expectancy) towards the type of planetarium treatment.

3. Research indicates that students at this age are capable of understanding the concepts of constellation study chosen for this investigation.13

From these four groups, two were pre-tested in order to determine the entry level knowledge and attitudes of the population. However, because of the possibility of sensitization to the treatments by the pre-test, two groups were not pre-tested. These four groups then received one of the two treatments, as explained in the following outline, and then received a post-test.

**General Design for Study**

**Population**

**Random Assignment**

<table>
<thead>
<tr>
<th>Group 1</th>
<th>Group 2</th>
<th>Group 3</th>
<th>Group 4</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pre-test</td>
<td>Pre-test</td>
<td>Treatment 1</td>
<td>Treatment 2</td>
</tr>
<tr>
<td>Treatment 1</td>
<td>Treatment 1</td>
<td>Treatment 2</td>
<td>Treatment 2</td>
</tr>
<tr>
<td>Post-test</td>
<td>Post-test</td>
<td>Post-test</td>
<td>Post-test</td>
</tr>
</tbody>
</table>

_Treatment 1 was an adapted version of the Fels_13

Planetarium's (Philadelphia, Pa.) production of "Leo and His Friends." This script appeared to be representative of the better "Star Show" programs and was used to invalidate any accusations that the investigator purposely created an inferior script. The treatment was tape recorded and used narrative as well as musical selections in its presentation. Various slides and special effects were created to make this production a typical "Star Show."

Treatment 2 was an adapted version of the Holt Planetarium's (Berkeley, Ca.) production of "Finding Your Star." This program appeared to be representative of a Participatory Oriented Planetarium program on constellation study. It was adapted to address the same concepts and objectives of the "Star Show" program. This treatment was presented live and although it used some music and special effects, the distinguishing point was that it stressed active participation by the participants.

This study was conducted at the Methacton School District Planetarium, Fairview Village, Pa., using the entire third grade population (approximately 340 students). The study was also repeated at similar grade levels in four selected planetariums across the United States (Texas, California, Minnesota, and Nevada). These educational planetariums were selected
from the list of people who attended the 1978 NSF funded workshops on Planetarium Techniques. These three day workshops were offered at five locations across the United States and offered the participants training in the methods of Participatory Oriented Planetarium programming.

This selection process was used in order to assure the researcher that the Participatory Oriented Planetarium treatment would be as similar as possible in all participating planetariums. It should be noted that the "Star Show" treatment was close to identical in all involved planetariums since they all used copies of the same slides and pre-recorded tapes.

Assumptions

It was assumed that Piaget's and Ausubel's work, as well as others important in the field of educational theory and development, had bearing on the planetarium facility. It was assumed that the tested population was as representative as possible of the educational planetarium population at large in the United States. It was also assumed that the treatments under study were the major factors in any differences found, and not the personalities of the instructors involved in the study.

Limitations

Since this study used eight-to-ten year old
students as the population for examination (for the specific reasons stated earlier), there are some difficulties generalizing the outcomes of this study to other age groups. However, since eight-to-ten year old students are usually on the "concrete" level of intellectual development and therefore strongly benefit from concrete experiences when approaching new problems and subject matter, and since many people of other ages benefit from "concrete" operations when approaching new problems and subject matter for which they have no subsuming concepts, it may be argued that the outcomes of this study are applicable to all those requiring (or benefiting) from concrete operations in the planetarium facility, whether young or old. This statement would seem to be supported by a review of both Piaget's theory of cognitive structure and Ausubel's theory of meaningful learning.

Definition of Terms

PLANETARIUM The planetarium is a simulation mechanism that shows the movements of the celestial bodies as they appear to an observer on earth. The planetarium consists of one half of a great sphere which is fixed and referred to as the planetarium dome. The inner white surface serves as a projection surface for many small projectors that are placed at the center of the sphere. The positions and motions of the little projectors are inter-connected by driving gears in such a manner that the images of the celestial bodies, thrown upon the fixed hemisphere, represents the celestial positions and motions of those bodies, just as they are seen in the natural clear sky. The instrument can be
manipulated to show the appearance of the sky at any time in the past or future at any place on earth.14

STAR SHOW A "Star Show" is a planetarium program of about 40-60 minutes in length relying on a didactic (lecture) format to dispense information. The program is usually tape recorded and uses various projected visuals to illustrate its points. Musical accompaniment is often included in the production. No lecturer/audience interaction takes place during the main program, although questions may be answered at the end.

PARTICIPATORY ORIENTED PLANETARIUM PROGRAM (P.O.P.) A Participatory Oriented Planetarium program is one that is about 40-60 minutes in length using discovery-inquiry approach activities and extensive verbal interaction with audience members and the planetarium instructor. These activities are specifically designed to match the student's general cognitive level and the chosen objectives. The program is presented live and may use various audio-visual materials to actively involve the audience in thinking about the subject matter.

CHAPTER II

RELATED LITERATURE

Introduction

Projection planetariums have existed for over fifty-five years and have been used extensively in education for at least the last twenty years. In the United States alone there are over one thousand planetarium installations, with many of them being directly associated with educational institutions. The question may be asked, why should a school build such a complex. The answer most frequently given would probably be that it can offer the student a concrete experience in the science of astronomy, similar to a biology or chemistry laboratory experience. But is the planetarium effective in teaching astronomy and enhancing positive attitudes, and are planetariums utilizing the most effective instructional techniques? This literature review has been conducted in an attempt to address these questions.

Planetarium Research

The effectiveness of the planetarium as a learning device has been discussed in varying ways.
Morris and Peterson stated that:

Planetariums take science out of the realm of the abstract, bringing it clearly and enjoyably to life. Astronomy and space science become relevant especially with the planetarium's ability to simulate most celestial phenomena...the planetarium is a powerful motivator. 14

Whitman Cross in an article in the Science Teacher, made the claim that an advantage of the planetarium is the "ease with which more subject matter can be assimilated in less time with far greater understanding and retention than is possible in a standard classroom situation." 15

These statements make a very strong claim for the value to education of the planetarium facility, but it is unclear whether they can be supported by the planetarium research conducted to date.

Through an intensive literature search, twenty-four research studies involving the planetarium have been uncovered. From a review of these studies, only fourteen were found to deal with student achievement and attitudes. The other ten studies were concerned mostly with managerial aspects of the planetarium, such as selection of projector instruments,


planetarium design, etc.

The fourteen studies concerned with the educational aspects of the planetarium have some overlap, but can be roughly divided into three general categories. These are: Studies Concerned With the Effectiveness of the Planetarium, Studies Comparing the Effectiveness of the Planetarium vs. the Classroom, and Studies Comparing the Effectiveness of Different Styles of Planetarium Presentations.

**Studies Concerned With the Effectiveness of the Planetarium**

Three studies were found which attempted to determine if the planetarium can effectively teach astronomical concepts. In overview, these studies all indicated that the planetarium was effective in instruction. These studies were conducted with school children in grades two and eight.

In a study with 101 eighth grade students, John J. Soroka compared the effects of attending a planetarium lesson, designed to summarize a six week unit on space science, with a supervised study period. Soroka concluded that "the planetarium is an effective educational device and makes a positive contribution to the understanding and comprehension of basic astronomical and geographic concepts."\(^1^6\)

John Miles Akey, and Dennis Wayne Sunal both conducted studies with second grade students. Akey in a study with six classes of elementary students, attempted to evaluate the effectiveness of a planetarium curriculum. It was found that the planetarium experience resulted in a significant increase in the level of student understanding of the selected topics. After a two week lapse, these concepts were significantly retained. Also, there was a positive correlation between the student's retention after two weeks and the time spent post-teaching by the classroom teacher.\(^\text{17}\)

Sunal working with 986 students from two suburban Detroit school districts, endeavored to investigate the relative effectiveness of the planetarium in attaining the perceived goals of planetarium educators. Students were assigned to one of three groups. One group received a two week astronomy unit. Another group received a two week astronomy unit supplemented by one 55 minute planetarium lesson. The third group received no astronomy or planetarium experiences. Sunal concluded, through an analysis of pre and post test scores, that the astronomy-planetarium unit

experience and the astronomy unit experience were effective in producing positive change in the goal areas. However, the addition of one planetarium lesson did not produce results significantly greater than the astronomy unit.18

Studies Comparing the Effectiveness of the Planetarium vs. the Classroom

The bulk of planetarium research on student achievement has fallen into a comparison of the planetarium vs. the classroom. Nine studies were reviewed that attempted to determine the more effective of the two situations. A review of these studies produces a very clouded picture. Three studies found the planetarium to be more effective; two studies found the classroom to be more effective; and four studies found neither situation to be more effective than the other. It is very difficult to compare these studies because of the great differences between them. In overview, a few general statements can be made but a brief description of each of the studies should be examined first.

Studies Favoring the Planetarium

Delivee L. Wright working with eighth grade

students from the Lincoln Nebraska public schools compared the effectiveness of teaching an astronomy unit when it was supplemented by: a) a planetarium program, b) a planetarium program, preparation by the teacher and a follow-up exercise, and c) a planetarium program, preparation by the planetarium lecturer, and a follow-up exercise. All students had completed an astronomy unit prior to treatments. Wright concluded that:

Students who attended a planetarium program made significantly larger gains on an Astronomy achievement test than did those who had not attended the program.19

Dean and Lauck tested a total of forty-eight sixth grade students to determine the effectiveness of the planetarium and the classroom. Twenty-four students received three planetarium lessons on observational astronomy and twenty-four other students received three classroom lessons on observational astronomy. The students were then individually tested under the real sky with a seven element oral test, rather than with a paper-and-pencil test. They concluded that:

For the teaching of selected aspects of observational astronomy, the planetarium was statistically, clearly, and significantly

superior to the classroom, chalkboard, and celestial globe.20

One major problem with this study was the small number of subjects involved, but it is important to note that this was the first published study that used a real sky test rather than a paper-and-pencil test.

Robert Ross Hayward in 1975 produced an evaluation instrument designed to measure student attainment of the concept of annual motion. After carefully confirming its validity and reliability, he used this test with 471 sixth grade students from DeKalb County Georgia to determine if the planetarium or classroom was more effective. One third of the students received a planetarium lesson; one third received a similar classroom lesson; and one third received no instruction. A comparison of the scores indicated that although both the planetarium and classroom groups advanced, the planetarium group was significantly superior.21

Studies Favoring the Classroom

Billy A. Smith conducted the earliest recorded


21 Robert Ross Hayward, "The Developing and Field Testing of An Instrument Using the Planetarium to Evaluate the Attainment of the Concept of Annual Motion," (Ph.D. dissertation, Georgia State University, 1975).
planetarium research study concerned with student achievement. Working with 339 elementary students, Smith compared the post-test scores of the students on teacher made tests and concluded that the classroom lecture-demonstration was significantly more effective than the 40 minute planetarium lecture-demonstration. It is important to note that the planetarium lecture-demonstration method used in this study would be classified as a "Star Show" format.

George Reed tested 758 college students over a two semester period to determine if the attainment and retention of selected astronomical concepts differed from a classroom situation with a chalkboard and celestial globe to a planetarium situation using the "lecture under the stars method." Reed concluded that:

1) The chalkboard-globe teaching situation is significantly superior to the planetarium situation with respect to the immediate attainment and retention of specific cognitive behavioral objectives and
2) There is no difference in the affective domain between the chalkboard-globe teaching situation and the planetarium teaching situation.23


Studies Favoring Neither Planetarium or Classroom

Four studies were conducted which found the planetarium and the classroom to be approximately equal in their ability to teach astronomical concepts or change student attitudes. These studies involved students from elementary, secondary, and college levels. It is interesting to note that one of these studies (by George Reed, 1973) grew out of an earlier investigation by the researcher which found the classroom not to be equal, but to be superior to the planetarium situation.

John C. Rosemergy compared three teaching arrangements using a planetarium. In one group, students received four classroom lessons followed by one 45 minute planetarium lesson. Another group received one planetarium lesson, three classroom lessons, and then one final planetarium lesson. The third group received all five lessons in the classroom. It was concluded that sixth grade children do not achieve a greater understanding of selected astronomical topics from instruction utilizing a planetarium than from instruction which does not.

Theodore Smith investigated three methods of

---

teaching constellation study with 103 children, teenagers, and adults. One of these methods used 35 mm slides in a classroom; another used 35 mm slides in the planetarium; and the third used the planetarium sky. Smith concluded that regardless of treatment type, all subjects performed equally well when tested under the real sky, but that on a paper and pencil instrument, the planetarium group scored lower. Also, the group which used slides in the planetarium reported more positive responses to the study of constellations.25

George Reed conducted a study in the Fall of 1970 in an attempt to research some of the implications of his earlier investigation. The earlier study indicated that the classroom was superior to the planetarium. In this new study, he compared the standard classroom situation with a planetarium situation in which a different style of instruction was utilized than in the original study. A total of 159 college students were involved. One half were taught concepts on the celestial sphere and precession in a classroom using a chalkboard and celestial globe. The other half were taught these concepts in the planetarium, also using a chalkboard and celestial globe.

---

globe in addition to the projection equipment. This style required that the lights be raised and lowered several times in contrast to most lecture under the stars (Star Show) type lessons. The results indicated that the planetarium method used in this study was as effective as the classroom in teaching the selected concepts. Reed concluded that the planetarium is most effective when it is used as a classroom learning situation rather than as a celestial demonstration chamber.26

Robert William Ridky conducted a study which produced some important but unusual results. One hundred eighth grade students were assigned to one of three groups. Group I received one orientation session to the planetarium followed by five taped planetarium lessons on celestial motion and non-celestial motion. Group II received five sessions of instruction in the classroom using activity inquiries drawn from prominent curriculum projects. Group III received a combination of planetarium and classroom lessons. This study was repeated on the college level. Also, a pilot study was conducted to determine if an orientation session to the planetarium affected results.

It was concluded that:

1) An orientation session does positively effect scores.
2) For the junior high level, a combined planetarium/classroom teaching approach was most effective.
3) On the college level, no treatment type was more effective.
4) The planetarium group in both the junior high and college level tests had the greatest positive perception change of the three groups.27

In reviewing these nine studies, the differences between them make comparisons very difficult, and yet a few general statements can be made.

1) Only three studies indicated that the planetarium method used was other than a "Star Show" format. (Reed 1973, Dean and Lauck 1972, Rosemergy 1967)

2) Seven studies used a paper-and-pencil test which was not compared to a planetarium or real sky test situation. (all studies but Dean and Lauck 1972, and Smith 1974)

3) One study did use a real sky test and noted a difference in favor of the planetarium students. (Dean and Lauck 1972)

4) One study used a real sky test which found the planetarium students to be equal to the others and a paper-and-pencil test which found the same students to be inferior to the others. (Smith 1974)

5) Only three studies indicated that students were randomly assigned to groups. The other six studies randomly assigned pre-existing groups to treatments. (Reed 1970, Reed 1973, and Ridky 1974)

6) Only four studies attempted to measure attitudes. (Reed 1970, Reed 1973, Smith 1974, Ridky 1974)

7) Only three studies attempted to assess retention of students over any interval of time. (Reed 1970, Reed 1973, Ridky 1974)

8) The conclusions varied from the planetarium being superior, to the classroom being superior, to neither being superior in the cognitive domain; and from the planetarium being superior to neither being superior in the affective domain.

Considering these points and the nine research studies from which they were drawn, it is difficult to determine whether these studies have helped the planetarium educators in determining a direction in education or not. They have however, raised the very valuable question of just what is the most effective way to use a planetarium facility. To date, just two studies have been conducted to examine this question, a question which may be the very crux of the problem.

**Studies Comparing the Effectiveness of Different Styles of Planetarium Presentation**

Only two studies have been completed which have specifically attempted to compare different styles of planetarium teaching methods for effectiveness. One of these studies was conducted by this researcher in 1973 with second grade students, while the other tested eighth and ninth grade students in 1977.

Gerald L. Mallon in the Spring of 1973, tested 103 second grade students. These students were
pre-tested and randomly assigned to one of two groups. Group I received a taped planetarium program on constellation study while Group II received an identical but "live" version of the program. Both groups were post-tested in the planetarium immediately following their treatment and before any interaction could take place. Questions were not permitted in either situation. A t test was used on the post-test scores and the results indicated a significant difference between the groups. The "live" treatment group advanced five times more than the students who received the identical but taped program. 28

Jack Fletcher's study conducted in 1977 is the most relevant planetarium research project to this present study, and therefore deserves special examination. Fletcher attempted to compare a traditional type planetarium program with a participatory type planetarium program. In this study, eight planetarium directors from the southeast United States were involved. Each director submitted a list of existing eighth and ninth grade Earth science classes and from these lists two were chosen to receive the P.O.P. program and two the traditional program for each planetarium. Students were tested immediately

after the presentations and then four weeks later. In all, 686 students were tested. The results of the study indicated that no significant difference, in the cognitive domain, occurred between students who received a participatory program and students who received a traditional program. Fletcher concluded that the important factor is the instructor who presents the program and not the treatment type.29

Although Fletcher's study appears to have been carefully planned and executed, there are certain problems within it which raise serious doubts about his conclusions. None of the eight planetarium directors involved in the study had ever attended a workshop on P.O.P. and only three directors indicated that they had any previous experience with using participatory programs. The most significant problem however, concerns the structure of his treatments. Fletcher began with a P.O.P. program on Stonehenge from the Holt Planetarium in Berkeley, California. In this program, students marked the rising and setting points of the sun on the planetarium dome during the different seasons. This script was the basis for the P.O.P. treatment in this study. To develop a non-participatory

29Jack Fletcher, "An Experimental Comparison of the Effectiveness of a Traditional Type Planetarium Program and a Participatory Type Planetarium Program," (Ph.D. dissertation, University of Virginia, 1977).
treatment, he removed the student's physical activities from the P.O.P. program and demonstrated the rising and setting points for them. Aside from this, he left the questions and structure of the lessons the same. Students were permitted to question and discuss during the traditional program as well as during the P.O.P. program.

In considering these problems and the definitions of the terms P.O.P. and Star Show, this researcher finds that Fletcher did not examine a traditional "Star Show" planetarium program and a "Participatory Oriented Planetarium" program, but rather two versions of a P.O.P. program, one requiring physical activities and one requiring cerebral activities. Neither program truly fits the definition of "Star Show."

Therefore to date, there still has not been a single study conducted which has examined the effectiveness of a traditional "Star Show" planetarium program and a "Participatory Oriented Planetarium" program. It is for this purpose that this study has been undertaken. The following chapter will discuss the procedures followed to implement this investigation.
CHAPTER III

PROCEDURES

Introduction

The major purpose of this study was to investigate the relative effectiveness of a Participatory Oriented Planetarium program and a traditional Star Show planetarium program in increasing student understanding of selected elements of constellation study. Also, this investigation attempted to assess and compare the attitudes towards astronomy and the planetarium that were exhibited by the participants both prior to, and after the two planetarium treatments. The investigation consisted of a main research study and four smaller replications. This chapter discusses in detail the procedures in implementing this investigation.

Description and Selection of Participants

In Main Study

The population of the main research study consisted of all third grade students in the Methacton School District, a suburban Philadelphia educational system serving the Lower Providence and Worcester Townships of Pennsylvania. This community,
although consisting of many sections of large single homes, also includes areas of farm land, a few large apartment complexes, some townhouses, and two trailer park sections. Economically, the area is mostly middle class but does cover a wide range of incomes. In summary, the Methacton community can be considered to be a fairly typical example of a suburb of a large metropolitan area.

In the Fall of 1974, the Methacton School District instituted a K-12 planetarium program for the district. The program was designed to offer the students a unique learning experience in astronomy and interdisciplinary studies. However, although the planetarium program had been in operation for five years at the time of this study, the students involved in this investigation had not had any lessons scheduled in the planetarium for a period of eighteen months prior to the experiment. This plan was devised by the researcher, who is the planetarium director, so that the students would enter the experiment without being biased towards either treatment type.

Approximately 340 students were involved in grade three at the time of this study but due to attrition, absenteeism, and the desire of the researcher to equalize groups, only 324 students were actually tested. Included in this study were all ranges of
children from those in special education classes, to those classified as academically gifted.

To meet the needs of the research design chosen for this study, the students in each of the five elementary buildings in the district were randomly assigned to one of four groups within each building. This assignment process utilized the table of random numbers as found in Runyon and Haber's book, *Fundamentals of Behavioral Statistics*.30

Description and Selection of Participants

In Replications of Study

As well as the main research study conducted in the Methacton School District, four smaller replications were also completed. These replications were carried out in an attempt to investigate the generalizability of the study to other geographic locations. A detailed procedure was followed in selecting these four planetariums for involvement in the study.

First, the list of all people who attended any one of the five three day National Science Foundation funded workshops on Planetarium Techniques was obtained. As mentioned in Chapter I, this population was chosen in order to insure the investigator that each of the participating planetarium teachers would

have at least a three day minimum exposure to P.O.P. techniques and the rationale behind it. Next, letters were sent to twenty-three of the one hundred workshop attendees explaining the study and asking them to participate. These people were selected based on the recommendations of the NSF workshop director as to their competency and possible interest in studying P.O.P. techniques. A second letter was sent out four weeks later with additional information and again a request for their participation. Copies of these letters are included in the appendix.

In review, seven people did not respond at all; eight responded no, and gave as reasons: time restraints, the complexity of design, fire at planetarium, etc.; eight planetariums originally indicated a willingness to participate but only four were actually able to complete the study. Those other four planetariums, which were not able to carry through with their plans, cited scheduling as the biggest problem. Each planetarium that did agree to participate received a complete research kit which included: all slides (113), scripts, audio tapes, tests, and instruction booklets, necessary to perform the study with their students.

A description of the subjects in each of the four replications is offered below:
Texas Study

The Richardson Independent School District Planetarium, serving the Dallas area of Texas, agreed to perform the research study with their students. This replication involved 76 third grade pupils, which was the entire third grade enrollment from one elementary building in the district. These students came from a totally urban environment and included both special education as well as regular education children. The students came from an area that was described by the planetarium director as upper middle class and were described as average to high average in intelligence. Most of these students had visited the planetarium earlier in the Fall for a lesson on the solar system.

California Study

The Holt planetarium from the Lawrence Hall of Science in Berkeley California is a museum planetarium associated with the University of California. The Holt planetarium repeated this study with students from a local private school. Fifty-two students in grades three and five participated (approximately twenty-six from grade three and twenty-six from grade five). These students attended the Madelaine School in Berkeley, California, which is a Catholic parochial school. The children were
described as average to above average in intelligence and from an urban area.

Minnesota Study

The Como Planetarium serving the St. Paul, Minnesota School District repeated the study with fifty-two fourth grade students. These students attended a learning center school that drew students from throughout the city of 300,000. They represented a cross section of the city and came from a wide range of incomes and ethnic backgrounds. In general, they were described as being of average intelligence.

Nevada Study

The Fleischman Atmospherium/Planetarium from the University of Nevada in Reno, Nevada, repeated this study with students from the local school district. Fifty-two students in grade four from the Anderson Elementary School in southwest Reno, Nevada were tested. These students came from an area that has been described as middle to upper middle class and were of average to above average in intelligence. Although no figures were available, many of the students had visited a planetarium at least once before and some were there earlier in the year for a program on weather.
The Instructional Programs

The topic chosen for instruction in both treatments was constellation study, specifically, Spring Constellations. Constellation study is an important part of most basic astronomy programs and is probably one of the most common topics presented in planetariums. It offers the students a visual awareness of the sky and allows them to concretely identify with some of the abstractions of the science of astronomy.

Considering the grade level of the students and the chosen area of study, five behavioral objectives were constructed to serve as the basis for both programs. These objectives are listed below:

Objectives

By the end of the planetarium session, the participants should be able to:

1. Define the term "Constellation" as a group of stars connected together to form a shape in the sky.

2. State that constellations can be used as "Skymarks" or signposts to locate other objects in the sky. (e.g. nebulae, planets).

3. Recognize a given set of constellations as represented on a "Star Map."

4. Demonstrate the use of a "Star Map" in locating an object or constellation in the sky.

5. Relate various pieces of factual information about the sky. (e.g. if a star is seen next to one star on one night, it will be next to that star on other nights.)
For the Star Show planetarium program, a script entitled "Leo and His Friends" was obtained from the Fels Planetarium in Philadelphia, Pennsylvania and modified for use. Modifications were kept to a minimum and consisted mostly of deletions of material that might have been considered by some to have been too difficult for the students or too tangential to the main topic of constellation study. Examples of material deleted include sections on: stellar magnitude scale, speed of light, definition of light year, eclipsing binary stars, and globular clusters. Also, a section on star map usage was added to insure that both programs would equally address the chosen objectives. A copy of the script appears in the appendix.

This program was pre-recorded and included musical passages and special sound effects as well as the spoken narrative. The narration was done by Mr. Donald Todd of Philadelphia, Pennsylvania. A skilled narrator, other than the researcher, was chosen to record the script in order to insure good vocal quality and to remove any possibility of bias. The program was exactly forty minutes in length.

The Participatory Oriented Planetarium program was developed from a script titled, "Finding Your Star" from the Holt Planetarium, Lawrence Hall of
Science, University of California, Berkeley, California. This script was slightly modified to more closely match the Star Show program and to directly address the chosen objectives for instruction. A copy of the script appears in the appendix.

The program was presented live and relied on active audience participation throughout the lesson. The instructors were directed not to merely memorize the script but to use it as a guide for presentation. Thus, although the content and order of presentation remained the same, the actual programs varied slightly in each replication due to the various audience responses. The length of the program was kept to forty minutes in all cases.

**Instrumentation**

Astronomy Cognitive Test

Since no standard astronomy test exists for the chosen grade level and objectives of the programs, it was necessary to construct an appropriate testing device. A panel of five planetarium directors was chosen for this task. The panel included the past secretary of the International Planetarium Society, the chairperson of the Research Committee of the Middle Atlantic Planetarium Society, the planetarium education editor for the Planetarium Reference Handbook,
and the two directors for the N.S.F. workshops on Planetarium Techniques.

After careful review, a twenty-two point paper-and-pencil test was produced. This test required no written responses from the students and included questions on basic sky information, star map usage, and constellation identification. The test was judged by two reading specialists to be at the 2.5 grade level. However, to insure an even greater level of understanding, the test was read aloud in each testing session. A copy of the test and instruction manual appears in the appendix.

Some investigators have questioned the validity of a paper-and-pencil test to measure a person's ability to identify constellations. Therefore, to address this criticism, a special testing situation was devised to judge the validity of the constellation identification questions. Eighteen students were randomly chosen from the grade four population of two of the elementary buildings in the Methacton School District. These students had received instruction on constellation study during the Spring of 1978 and again in the Fall of 1978. These students were administered the Astronomy

Cognitive Test in a group session in May of 1979 and then were individually tested using the planetarium sky. The planetarium session took place within one week of the paper and pencil test. In the planetarium, the students were asked to identify the same constellations that were used on the paper-and-pencil test. A Pearson r correlation was obtained on the two sets of scores and produced a correlation figure of .86.

As a test for reliability, forty-two students were randomly chosen from two other buildings in the Methacton School District and involved in a test, retest situation. First, the students were administered the Astronomy Cognitive Test and then without any instruction, were retested approximately one week later. These scores were compared using a Pearson r and produced a correlation figure of .88. Also, the test scores of eighty-one students from the Methacton School District's main research study were analyzed using the Kuder-Richardson Formula 20 statistical test. This split half test produced a correlation figure of .745.

When the test was administered, a transparency of each page was projected using an overhead projector while the students worked on their own copy. This projected image allowed the investigator to easily explain the questions and procedures for completing the test.
Astronomy Attitude Test

In order to assess the attitudes of the students both prior to and after the experimental treatments, some type of opinionnaire was necessary. Rather than attempt to construct and validate such an instrument, specifically for this investigation, it was decided to choose an already existing instrument and modify it for use in this study. After reviewing the literature, a Likert style opinionnaire was chosen which had been presented and discussed in the November 1973 issue of School Science and Mathematics by Thomas H. Fisher from the Michigan Department of Education. The article reported a test-retest reliability score for the opinionnaire of .793 and a split half correlation figure of .833. These tests were performed on a group of junior high school students.

For the purpose of this study, this test was made more specific by changing the following words:

1. The word 'astronomy' was inserted wherever the word 'science' appeared.

2. The word 'planetarium' replaced the words 'science classroom.'

3. The word 'astronomer' replaced the word 'scientist.'

When the test was administered, it was not distributed to the students but rather read aloud to them while they marked their responses on an answer sheet. This procedure was chosen to eliminate the effect of varying reading levels within the groups.

To aid them in remembering the five possible choices for each statement, an overhead transparency was projected showing three cartoon faces representing the range of possible responses. This transparency was projected throughout the duration of the test for easy referral. A copy of the attitude survey and the cartoon referral sheet is included in the appendix.

The Experimental Procedure

Since this experiment was intended to investigate the increase in students' scores related to the treatments, it was necessary to assess the students' knowledge and attitudes prior to the treatments. However, testing sessions held before treatments can produce a pre-test sensitization to the treatments. Therefore it was decided not to pre-test all students but rather to employ a research design where half of the students from each treatment would be pre-tested but the other half would not be. This would enable the researcher to determine if indeed the taking of a pre-test affected the scores of either treatment group.
In the main research study, because of the large number of students, it was necessary to conduct the planetarium sessions over a five day period. All students from any one building were treated during the same day. To nullify the possible effect of the time of day of presentation, the order of treatments for each day was randomly decided.

Immediately following each of the planetarium programs and before the subjects could possibly interact with each other, the students were administered the Astronomy Cognitive Test and the Astronomy Attitude Test.

**Analysis of Data**

In order to address the four null hypotheses of this investigation, and to determine the possible effects of pre-test sensitization, various statistical tests were employed. These tests were performed on the data by the West Chester State College Computer Center, West Chester, Pennsylvania. The program STATISTICAL PACKAGE FOR THE SOCIAL SCIENCES (S.P.S.S.) was used in the analysis.

Specifically, in order to address null hypothesis Number One,

There is no difference in student pre-treatment and post-treatment understanding of selected astronomical concepts, whether they experience a traditional Star Show planetarium program or a Participatory Oriented Planetarium program.
a correlated t test was performed on Group 1's pre-test scores and post-test scores, and on Group 3's pre-test and post-test scores on the Astronomy Cognitive Test.

To address null hypothesis Number Two,

There is no difference in the achievement level of students who receive a Participatory Oriented Planetarium treatment and the achievement level of students who receive a traditional Star Show treatment.

a 2 X 2 factorial analysis of variance was employed comparing the scores on the Astronomy Cognitive Test for each of the four groups.

To address null hypothesis Number Three,

There is no difference in the students' pre-treatment and post-treatment attitudes towards astronomy, whether they receive a Participatory Oriented Planetarium program or a traditional Star Show planetarium program.

a correlated t test was used on Group 1's pre-test scores and post-test scores, and Group 3's pre-test scores and post-test scores on the Astronomy Attitude Test.

To address null hypothesis Number Four,

There is no difference in the composite mean attitudinal test scores of the students who experience a Participatory Oriented Planetarium treatment and the students who experience a Star Show treatment in their attitudes towards astronomy.

a 2 X 2 factorial analysis of variance was used comparing the post-test scores obtained on the Astronomy Attitude Test for each of the four groups.
In order to determine if the pre-test sensitized the students and thus affected either their cognitive or attitude scores, an examination of the 2 X 2 factorial analyses of variance was conducted both for main effects and interactions.

This chapter has discussed the procedures used in this experiment to investigate the effects of a Participatory Oriented Planetarium program and a traditional Star Show planetarium program on student achievement and attitudes. The populations of the main study and the four replications were described and the details of the testing instruments and experimental procedures were presented. Chapter IV will present the results obtained from following the procedures discussed in this chapter.
CHAPTER IV

ANALYSIS OF DATA

Introduction

The purpose of this investigation was to determine if a Participatory Oriented Planetarium program or a traditional Star Show planetarium program was more effective in increasing student achievement on selected elements of astronomy and in changing student attitudes towards astronomy and the planetarium. Specifically, the study was designed to address the following four hypotheses:

$H_01$. There is no difference in student pre-treatment and post-treatment understanding of selected astronomical concepts, whether they experience a traditional Star Show planetarium program or a Participatory Oriented Planetarium program.

$H_02$. There is no difference in the achievement level of students who receive a Participatory Oriented Planetarium treatment and the achievement level of students who receive a traditional Star Show treatment.

$H_03$. There is no difference in the students' pre-treatment and post-treatment attitudes towards astronomy whether they receive a Participatory Oriented Planetarium program or a traditional Star Show planetarium program.

$H_04$. There is no difference in the composite mean attitudinal test scores of the
students who experience a Participatory Oriented Planetarium treatment and the students who experience a Star Show treatment in their attitudes towards astronomy.

In addition, this inquiry also attempted to determine the effects of taking a pre-test or not taking a pre-test, prior to treatment, on students' post-test scores. This study included a large scale experiment conducted in Pennsylvania (Methacton School District) and four smaller scale replications conducted in Texas, California, Minnesota, and Nevada. The results from each of these studies will be presented and compared for each of the four hypotheses.

**Measurement of Change in Astronomy Knowledge**

The major thrust of this investigation was an attempt to evaluate two methods of planetarium instruction and their effectiveness in teaching selected elements of astronomy. Null Hypotheses 1 and 2 were concerned with the aspect of knowledge in this study.

To test Null Hypothesis #1 and thus determine if either program was effective in increasing student scores on the Astronomy Content Test, a correlated t-test was performed on the appropriate pre-test and post-test scores of the students. A summary of the results for the students in the Participatory Oriented Planetarium treatments for the Pennsylvania (Methacton)
study and each of the four replications is given in Table I.

A summary of the results for the students in the Star Show treatment for the Pennsylvania (Methacton) group and each of the four replications is given in Table II.

In comparing the results for the students listed in Table I, the t value was found to be significant at the .01 level in all cases for the Participatory Oriented Planetarium treatment. Thus it can be stated that the Participatory Oriented Planetarium program was significantly effective in increasing students' scores.

When comparing the results listed in Table II, only the Pennsylvania and the Nevada studies indicated a significant difference. However, since the difference between the means from pre-test to post-test was approximately the same or greater in all but one of the other studies, it may be suggested that the t value would have been significant if the numbers in the other studies had been larger.

Considering the results of the above tests, it can be stated that a difference does exist between student pre-treatment and post-treatment scores.
TABLE I

SUMMARY OF THE RESULTS OF A CORRELATED t TEST ON PRE-TEST AND POST-TEST CONTENT SCORES FOR THE P.O.P. GROUPS IN ALL FIVE STUDIES

<table>
<thead>
<tr>
<th>Study</th>
<th>N</th>
<th>Pre Mean</th>
<th>SD</th>
<th>Post Mean</th>
<th>SD</th>
<th>t</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pa.</td>
<td>81</td>
<td>9.88</td>
<td>2.89</td>
<td>16.37</td>
<td>3.47</td>
<td>12.39*</td>
</tr>
<tr>
<td>Tx.</td>
<td>19</td>
<td>12.74</td>
<td>2.35</td>
<td>17.37</td>
<td>2.40</td>
<td>5.93*</td>
</tr>
<tr>
<td>Ca.</td>
<td>13</td>
<td>11.38</td>
<td>3.40</td>
<td>15.54</td>
<td>2.25</td>
<td>4.24*</td>
</tr>
<tr>
<td>Mn.</td>
<td>13</td>
<td>10.77</td>
<td>3.06</td>
<td>17.31</td>
<td>2.29</td>
<td>5.54*</td>
</tr>
<tr>
<td>Nv.</td>
<td>13</td>
<td>10.77</td>
<td>2.38</td>
<td>17.92</td>
<td>1.38</td>
<td>11.38*</td>
</tr>
</tbody>
</table>

*p < .01

TABLE II

SUMMARY OF THE RESULTS OF A CORRELATED t TEST ON PRE-TEST AND POST-TEST CONTENT SCORES FOR THE STAR SHOW GROUPS IN ALL FIVE STUDIES

<table>
<thead>
<tr>
<th>Study</th>
<th>N</th>
<th>Pre Mean</th>
<th>SD</th>
<th>Post Mean</th>
<th>SD</th>
<th>t</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pa.</td>
<td>81</td>
<td>9.75</td>
<td>2.61</td>
<td>11.65</td>
<td>3.25</td>
<td>3.84*</td>
</tr>
<tr>
<td>Tx.</td>
<td>19</td>
<td>12.89</td>
<td>2.35</td>
<td>12.31</td>
<td>2.21</td>
<td>.71</td>
</tr>
<tr>
<td>Ca.</td>
<td>13</td>
<td>11.08</td>
<td>2.39</td>
<td>12.46</td>
<td>3.57</td>
<td>1.45</td>
</tr>
<tr>
<td>Mn.</td>
<td>13</td>
<td>10.00</td>
<td>3.89</td>
<td>12.38</td>
<td>3.47</td>
<td>1.25</td>
</tr>
<tr>
<td>Nv.</td>
<td>13</td>
<td>11.62</td>
<td>2.29</td>
<td>14.46</td>
<td>2.93</td>
<td>3.17*</td>
</tr>
</tbody>
</table>

*p < .01
To test the second Null Hypothesis, concerning the comparative effectiveness of the two programs in increasing student achievement and also the effect of a pre-test on the students' results, a two-way factorial analysis of variance was performed on the students' post-test scores on the Astronomy Content Test. It should be noted that this test was performed without first performing a statistical check for the homogeneity of variance. After review, it was decided that this homogeneity of variance test would not be necessary, since the numbers in each group, within each study, were the same. This point was addressed by Huck, Cormier, and Bounds as follows:

Previous experiments have shown that the F test (Analysis of Variance) is valid when group variances are dissimilar, as long as the sample sizes are constant, that is, the F test is robust to violations of the homogeneity of variance assumption provided that the number of scores in the groups is the same.33

Tables III, IV, V, VI, and VII present summaries of the results of the two-way analysis of variance for the group scores in each of the five studies, respectively, Pennsylvania, Texas, California, Minnesota, and Nevada.

TABLE III

SUMMARY OF THE RESULTS OF A 2 X 2 FACTORIAL ANALYSIS OF VARIANCE OF THE PENNSYLVANIA STAR SHOW AND P.O.P. GROUPS ON THE CONTENT TEST

<table>
<thead>
<tr>
<th>Source of Variation</th>
<th>d.f.</th>
<th>Sum of Squares</th>
<th>Mean Squares</th>
<th>F</th>
</tr>
</thead>
<tbody>
<tr>
<td>Treatment</td>
<td>1</td>
<td>1858.57</td>
<td>1858.57</td>
<td>192.19 *</td>
</tr>
<tr>
<td>Pre-test</td>
<td>1</td>
<td>.49</td>
<td>.49</td>
<td>.01</td>
</tr>
<tr>
<td>Interaction</td>
<td>1</td>
<td>.44</td>
<td>.44</td>
<td>.05</td>
</tr>
<tr>
<td>Within</td>
<td>320</td>
<td>3094.59</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>323</td>
<td>4954.09</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

* Significant F at the .001 level.
### TABLE IV

SUMMARY OF THE RESULTS OF A 2 X 2 FACTORIAL ANALYSIS OF VARIANCE OF THE TEXAS STAR SHOW AND P.O.P. GROUPS ON THE CONTENT TEST

<table>
<thead>
<tr>
<th>Source of Variation</th>
<th>d.f.</th>
<th>Sum of Squares</th>
<th>Mean Square</th>
<th>F</th>
</tr>
</thead>
<tbody>
<tr>
<td>Treatment</td>
<td>1</td>
<td>371.37</td>
<td>371.37</td>
<td>39.87 *</td>
</tr>
<tr>
<td>Pre-test</td>
<td>1</td>
<td>1.32</td>
<td>1.32</td>
<td>.14</td>
</tr>
<tr>
<td>Interaction</td>
<td>1</td>
<td>11.84</td>
<td>11.84</td>
<td>1.27</td>
</tr>
<tr>
<td>Within</td>
<td>72</td>
<td>670.63</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>75</strong></td>
<td><strong>1055.16</strong></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

* Significant F at .001 level.
## TABLE V

### SUMMARY OF THE RESULTS OF A 2 X 2 FACTORIAL ANALYSIS OF VARIANCE OF THE CALIFORNIA STAR SHOW AND P.O.P. GROUPS ON THE CONTENT TEST

<table>
<thead>
<tr>
<th>Source of Variation</th>
<th>d.f.</th>
<th>Sum of Squares</th>
<th>Mean Squares</th>
<th>F</th>
</tr>
</thead>
<tbody>
<tr>
<td>Treatment</td>
<td>1</td>
<td>86.33</td>
<td>86.33</td>
<td>12.91 *</td>
</tr>
<tr>
<td>Pre-test</td>
<td>1</td>
<td>.48</td>
<td>.48</td>
<td>.07</td>
</tr>
<tr>
<td>Interaction</td>
<td>1</td>
<td>1.56</td>
<td>1.56</td>
<td>.23</td>
</tr>
<tr>
<td>Within</td>
<td>48</td>
<td>321.08</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>51</td>
<td><strong>409.45</strong></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

* Significant F at the .001 level.
TABLE VI

SUMMARY OF THE RESULTS OF A 2 X 2 FACTORIAL ANALYSIS OF VARIANCE OF THE MINNESOTA STAR SHOW AND P.O.P. GROUPS ON THE CONTENT TEST

<table>
<thead>
<tr>
<th>Source of Variation</th>
<th>d.f.</th>
<th>Sum of Squares</th>
<th>Mean Squares</th>
<th>F</th>
</tr>
</thead>
<tbody>
<tr>
<td>Treatment</td>
<td>1</td>
<td>188.48</td>
<td>188.48</td>
<td>15.79 *</td>
</tr>
<tr>
<td>Pre-test</td>
<td>1</td>
<td>3.25</td>
<td>3.25</td>
<td>.27</td>
</tr>
<tr>
<td>Interaction</td>
<td>1</td>
<td>5.56</td>
<td>5.56</td>
<td>.47</td>
</tr>
<tr>
<td>Within</td>
<td>48</td>
<td>572.76</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>51</td>
<td>770.05</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

* Significant F at the .001 level.
### TABLE VII

**SUMMARY OF THE RESULTS OF A 2 X 2 FACTORIAL ANALYSIS OF VARIANCE OF THE NEVADA STAR SHOW AND P.O.P. GROUPS ON THE CONTENT TEST**

<table>
<thead>
<tr>
<th>Source of Variation</th>
<th>d.f.</th>
<th>Sum of Squares</th>
<th>Mean Squares</th>
<th>F</th>
</tr>
</thead>
<tbody>
<tr>
<td>Treatment</td>
<td>1</td>
<td>105.31</td>
<td>105.31</td>
<td>16.42 *</td>
</tr>
<tr>
<td>Pre-test</td>
<td>1</td>
<td>13.00</td>
<td>13.00</td>
<td>2.03</td>
</tr>
<tr>
<td>Interaction</td>
<td>1</td>
<td>4.92</td>
<td>4.92</td>
<td>.77</td>
</tr>
<tr>
<td>Within</td>
<td>48</td>
<td>307.84</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>51</td>
<td><strong>431.07</strong></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

* Significant F at the .001 level.
In reviewing these five tests, the respective F values for Treatment was found to be significant in all cases. However, the F value for Pre-test or Interaction was not found to be significant in any case. These tests indicate that a difference does indeed exist between the groups, in favor of the Participatory Oriented Planetarium program. Also, since the respective F values for Pre-test and Interaction were not significant, it can be concluded that no pre-test sensitization took place for the subjects taking the Astronomy Content Test.

Measurement of Change In Astronomy Attitudes

This study also attempted to evaluate the effectiveness of the two treatment types in changing students' attitudes towards astronomy and the planetarium. Hypotheses 3 and 4 addressed this area.

Null Hypothesis #3 was developed to determine if either program was effective in changing student attitudes towards astronomy. This was tested by using a correlated t test to compare the mean responses from the pre-test and post-test scores for each of the treatment types. The scores reflect a five point Likert scale with one being low and five being high. Table VIII summarizes the results from the P.O.P. group in each of the five studies. Table IX
summarizes the results from the Star Show groups in each of the five studies.

The results indicate that for the P.O.P. groups, only the Pennsylvania students significantly increased their scores. For the Star Show groups, only the Texas study indicated a significant difference from pre-test to post-test.
### TABLE VIII
SUMMARY OF THE RESULTS OF A CORRELATED t TEST ON PRE-TEST AND POST-TEST ATTITUDE SCORES FOR THE P.O.P. GROUPS IN ALL FIVE STUDIES

<table>
<thead>
<tr>
<th>Study</th>
<th>N</th>
<th>Pre Mean</th>
<th>SD</th>
<th>Post Mean</th>
<th>SD</th>
<th>t</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pa.</td>
<td>81</td>
<td>3.53</td>
<td>.47</td>
<td>3.80</td>
<td>.46</td>
<td>4.18 *</td>
</tr>
<tr>
<td>Tx.</td>
<td>19</td>
<td>3.95</td>
<td>.29</td>
<td>3.92</td>
<td>.35</td>
<td>.19</td>
</tr>
<tr>
<td>Ca.</td>
<td>13</td>
<td>3.28</td>
<td>.66</td>
<td>3.61</td>
<td>.99</td>
<td>.99</td>
</tr>
<tr>
<td>Mn.</td>
<td>13</td>
<td>3.11</td>
<td>.25</td>
<td>3.24</td>
<td>.52</td>
<td>.83</td>
</tr>
<tr>
<td>Nv.</td>
<td>13</td>
<td>3.40</td>
<td>.34</td>
<td>3.60</td>
<td>.66</td>
<td>1.13</td>
</tr>
</tbody>
</table>

*p < .01

### TABLE IX
SUMMARY OF THE RESULTS OF A CORRELATED t TEST ON PRE-TEST AND POST-TEST ATTITUDE SCORES FOR THE STAR SHOW GROUPS IN ALL FIVE STUDIES

<table>
<thead>
<tr>
<th>Study</th>
<th>N</th>
<th>Pre Mean</th>
<th>SD</th>
<th>Post Mean</th>
<th>SD</th>
<th>t</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pa.</td>
<td>81</td>
<td>3.48</td>
<td>.56</td>
<td>3.61</td>
<td>.49</td>
<td>.11</td>
</tr>
<tr>
<td>Tx.</td>
<td>19</td>
<td>3.73</td>
<td>.28</td>
<td>4.02</td>
<td>.35</td>
<td>2.29 *</td>
</tr>
<tr>
<td>Ca.</td>
<td>13</td>
<td>3.45</td>
<td>.61</td>
<td>3.10</td>
<td>.45</td>
<td>1.44</td>
</tr>
<tr>
<td>Mn.</td>
<td>13</td>
<td>3.10</td>
<td>.52</td>
<td>3.24</td>
<td>.52</td>
<td>.81</td>
</tr>
<tr>
<td>Nv.</td>
<td>13</td>
<td>3.48</td>
<td>.39</td>
<td>3.46</td>
<td>.69</td>
<td>.07</td>
</tr>
</tbody>
</table>

*p < .05
To test Null Hypothesis # 4, concerning the comparative effectiveness of the Participatory Oriented Planetarium program and the Star Show program on students' composite mean attitudinal test scores, and the possible effects of taking a pre-test, a two-by-two factorial analysis of variance was conducted on the appropriate groups in each of the five studies. Tables X, XI, XII, XIII, and XIV present summaries of the results of the analysis of variance for the five studies, respectively, Pennsylvania, Texas, California, Minnesota, and Nevada.

In reviewing each of these five tests, the Pennsylvania and Minnesota studies indicated a significant difference at the .05 level for Treatment, with the P.O.P. treatment being the superior one. The F value for Pre-test and Interaction effects were each less than the critical value of F at the five per cent level of significance. Thus the application of a pre-test did not affect the students' scores but the type of treatment they received did.
TABLE X

SUMMARY OF THE RESULTS OF A 2 X 2 FACTORIAL ANALYSIS OF VARIANCE OF THE PENNSYLVANIA STAR SHOW AND P.O.P. GROUPS ON THE ATTITUDE TEST

<table>
<thead>
<tr>
<th>Source of Variation</th>
<th>d.f.</th>
<th>Sum of Squares</th>
<th>Mean Squares</th>
<th>F</th>
</tr>
</thead>
<tbody>
<tr>
<td>Treatment</td>
<td>1</td>
<td>1.53</td>
<td>1.53</td>
<td>6.50 *</td>
</tr>
<tr>
<td>Pre-test</td>
<td>1</td>
<td>.61</td>
<td>.61</td>
<td>2.58</td>
</tr>
<tr>
<td>Interaction</td>
<td>1</td>
<td>.21</td>
<td>.21</td>
<td>.90</td>
</tr>
<tr>
<td>Within</td>
<td>320</td>
<td>75.72</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>323</td>
<td>78.07</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

* p < .05 level.
<table>
<thead>
<tr>
<th>Source of Variation</th>
<th>d.f.</th>
<th>Sum of Squares</th>
<th>Mean Squares</th>
<th>F</th>
</tr>
</thead>
<tbody>
<tr>
<td>Treatment</td>
<td>1</td>
<td>.38</td>
<td>.38</td>
<td>.28</td>
</tr>
<tr>
<td>Pre-test</td>
<td>1</td>
<td>.30</td>
<td>.30</td>
<td>2.20</td>
</tr>
<tr>
<td>Interaction</td>
<td>1</td>
<td>.82</td>
<td>.82</td>
<td>.60</td>
</tr>
<tr>
<td>Within</td>
<td>72</td>
<td>9.94</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>75</td>
<td>11.44</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

all p > .05 level.
TABLE XII

SUMMARY OF THE RESULTS OF A 2 X 2 FACTORIAL ANALYSIS OF VARIANCE OF THE CALIFORNIA STAR SHOW AND P.O.P. GROUPS ON THE ATTITUDE TEST

<table>
<thead>
<tr>
<th>Source of Variation</th>
<th>d.f.</th>
<th>Sum of Squares</th>
<th>Mean Squares</th>
<th>F</th>
</tr>
</thead>
<tbody>
<tr>
<td>Treatment</td>
<td>1</td>
<td>1.28</td>
<td>1.28</td>
<td>2.96</td>
</tr>
<tr>
<td>Pre-test</td>
<td>1</td>
<td>.30</td>
<td>.30</td>
<td>.07</td>
</tr>
<tr>
<td>Interaction</td>
<td>1</td>
<td>.59</td>
<td>.59</td>
<td>1.38</td>
</tr>
<tr>
<td>Within</td>
<td>48</td>
<td>20.68</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>51</td>
<td>22.85</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

all p > .05 level.
### TABLE XIII

**SUMMARY OF THE RESULTS OF A 2 X 2 FACTORIAL ANALYSIS OF VARIANCE OF THE MINNESOTA STAR SHOW AND P.O.P. GROUPS ON THE ATTITUDE TEST**

<table>
<thead>
<tr>
<th>Source of Variation</th>
<th>d.f.</th>
<th>Sum of Squares</th>
<th>Mean Squares</th>
<th>F</th>
</tr>
</thead>
<tbody>
<tr>
<td>Treatment</td>
<td>1</td>
<td>1.49</td>
<td>1.49</td>
<td>5.53 *</td>
</tr>
<tr>
<td>Pre-test</td>
<td>1</td>
<td>.28</td>
<td>.28</td>
<td>1.03</td>
</tr>
<tr>
<td>Interaction</td>
<td>1</td>
<td>.43</td>
<td>.43</td>
<td>.16</td>
</tr>
<tr>
<td>Within</td>
<td>48</td>
<td>12.93</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>51</td>
<td>14.13</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

* p < .05 level.
TABLE XIV

SUMMARY OF THE RESULTS OF A 2 x 2 FACTORIAL ANALYSIS OF VARIANCE OF THE NEVADA STAR SHOW AND P.O.P. GROUPS ON THE ATTITUDE TEST

<table>
<thead>
<tr>
<th>Source of Variation</th>
<th>d.f.</th>
<th>Sum of Squares</th>
<th>Mean Squares</th>
<th>F</th>
</tr>
</thead>
<tbody>
<tr>
<td>Treatment</td>
<td>1</td>
<td>.20</td>
<td>.20</td>
<td>.54</td>
</tr>
<tr>
<td>Pre-test</td>
<td>1</td>
<td>.55</td>
<td>.55</td>
<td>1.45</td>
</tr>
<tr>
<td>Interaction</td>
<td>1</td>
<td>.24</td>
<td>.24</td>
<td>.01</td>
</tr>
<tr>
<td>Within</td>
<td>48</td>
<td>18.22</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>51</td>
<td><strong>19.21</strong></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

all p > .05 level.
Summary of Findings

The Participatory Oriented Planetarium groups and the traditional Star Show planetarium groups were compared with regard to achievement in astronomy and attitudes towards astronomy and the planetarium. The instruments used were the Astronomy Content Test and the Astronomy Attitude Test. The method used to compare change from pre-test to post-test was the correlated t test. To compare the groups' post-test scores on content and attitude, two 2 X 2 analyses of variances were employed.

The results of the correlated t tests for the P.O.P. groups' content scores indicated a significant difference from pre-test to post-test. This was significant at the .01 level. The correlated t tests for the Star Show groups' content scores indicated that only the Pennsylvania and the Nevada studies demonstrated a significant change. This may have been because of the small numbers in the other studies.

The results of the two-way analysis of variance on the students' content scores indicated a significant difference for Treatment type in all five studies. The Participatory Oriented Planetarium program was the superior treatment in all cases. The actual significance levels ranged from .001 to .0001.
In considering the correlated t tests for the pre-test to post-test attitude scores, a significant difference was found for the Pennsylvania P.O.P. group scores and for the Texas Star Show group scores. No other groups indicated a significant difference.

The two-way analysis of variance on the students' attitude scores showed a significant difference at the .05 level for Treatment in the Pennsylvania and Minnesota studies. The superior treatment in these cases was the P.O.P. program. No other study indicated a significant difference for treatment.

Also, since the respective F values for Pre-test and Interaction were not significant in any case, it was found that the pre-tests did not affect student post-test scores on either the Astronomy Content Test or the Astronomy Attitude Test.

Table XV presents a summary of post-test mean scores for the Content test for all groups in each of the five studies. Table XVI presents a summary of post-test mean scores for the Attitude test for all groups in each of the five studies.
### TABLE XV

**SUMMARY OF POST-TEST MEANS FOR CONTENT TEST**

<table>
<thead>
<tr>
<th></th>
<th>Total</th>
<th>Group 1</th>
<th>S.D.</th>
<th>Group 2</th>
<th>S.D.</th>
<th>Total of POP Groups</th>
<th>Group 3</th>
<th>S.D.</th>
<th>Group 4</th>
<th>S.D.</th>
<th>Total of S.S. Groups</th>
</tr>
</thead>
<tbody>
<tr>
<td>PA</td>
<td>324</td>
<td>16.4</td>
<td>3.47</td>
<td>16.5</td>
<td>2.86</td>
<td>16.5</td>
<td>11.5</td>
<td>3.26</td>
<td>11.6</td>
<td>2.80</td>
<td>11.6</td>
</tr>
<tr>
<td>TX</td>
<td>76</td>
<td>17.4</td>
<td>2.41</td>
<td>16.8</td>
<td>2.77</td>
<td>17.1</td>
<td>12.3</td>
<td>2.21</td>
<td>13.3</td>
<td>3.39</td>
<td>12.8</td>
</tr>
<tr>
<td>CA</td>
<td>52</td>
<td>15.5</td>
<td>2.26</td>
<td>15.4</td>
<td>2.67</td>
<td>15.5</td>
<td>12.4</td>
<td>3.57</td>
<td>13.2</td>
<td>2.14</td>
<td>12.8</td>
</tr>
<tr>
<td>MN</td>
<td>52</td>
<td>17.3</td>
<td>2.29</td>
<td>15.0</td>
<td>3.26</td>
<td>16.2</td>
<td>12.4</td>
<td>3.47</td>
<td>12.4</td>
<td>4.78</td>
<td>12.4</td>
</tr>
<tr>
<td>NV</td>
<td>52</td>
<td>17.9</td>
<td>1.38</td>
<td>16.3</td>
<td>3.11</td>
<td>17.1</td>
<td>14.5</td>
<td>2.93</td>
<td>14.0</td>
<td>2.40</td>
<td>14.3</td>
</tr>
</tbody>
</table>

### TABLE XVI

**SUMMARY OF POST-TEST MEANS FOR ATTITUDE TEST**

<table>
<thead>
<tr>
<th></th>
<th>Total</th>
<th>Group 1</th>
<th>S.D.</th>
<th>Group 2</th>
<th>S.D.</th>
<th>Total of POP Groups</th>
<th>Group 3</th>
<th>S.D.</th>
<th>Group 4</th>
<th>S.D.</th>
<th>Total of S.S. Groups</th>
</tr>
</thead>
<tbody>
<tr>
<td>PA</td>
<td>324</td>
<td>3.80</td>
<td>.46</td>
<td>3.66</td>
<td>.44</td>
<td>3.73</td>
<td>3.61</td>
<td>.49</td>
<td>3.58</td>
<td>.54</td>
<td>3.60</td>
</tr>
<tr>
<td>TX</td>
<td>76</td>
<td>3.92</td>
<td>.35</td>
<td>3.85</td>
<td>.41</td>
<td>3.89</td>
<td>4.03</td>
<td>.35</td>
<td>3.88</td>
<td>.32</td>
<td>3.94</td>
</tr>
<tr>
<td>CA</td>
<td>52</td>
<td>3.62</td>
<td>.99</td>
<td>3.32</td>
<td>.51</td>
<td>3.47</td>
<td>3.10</td>
<td>.45</td>
<td>3.17</td>
<td>.46</td>
<td>3.14</td>
</tr>
<tr>
<td>MN</td>
<td>52</td>
<td>3.24</td>
<td>.52</td>
<td>3.40</td>
<td>.55</td>
<td>3.32</td>
<td>3.24</td>
<td>.52</td>
<td>3.04</td>
<td>.53</td>
<td>3.14</td>
</tr>
<tr>
<td>NV</td>
<td>52</td>
<td>3.59</td>
<td>.66</td>
<td>3.38</td>
<td>.56</td>
<td>3.49</td>
<td>3.46</td>
<td>.69</td>
<td>3.27</td>
<td>.52</td>
<td>3.37</td>
</tr>
</tbody>
</table>
CHAPTER V

SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

Synopsis of Research

At present in the United States, there are approximately 1,100 planetariums in existence. These installations, both large (dome diameters 41-75 feet) and small (dome diameters 9-40 feet) offer the field of science education a unique tool for the dissemination of information to the public about the constantly changing field of astronomy. It has been estimated that 12 million people visit U.S. planetariums each year.\footnote{Friedman, Schatz, and Sneider, "Audience Participation and the Future of the Small Planetarium," p. 3.}

Among these 1,100 planetariums in the U.S., the most widely used planetarium experience is the "Star Show." This is usually a lecture format presentation, often recorded, illustrated with special effects, and accompanied by musical selections. These Star Show programs have been in use now for many years, but very little has been done to evaluate their effectiveness as a teaching method. Recently, a small
group of planetarium educators have begun to advocate a different form of planetarium experience called the Participatory Oriented Planetarium program (i.e., P.O.P.). This program relies on a discovery-inquiry approach and uses extensive verbal interaction between members of the audience and the planetarium director as its mode of instruction.

This dichotomy of methods has raised the following general question for consideration:

In a smaller educational planetarium, with a capacity of between 15-75 people, is the traditional 'Star Show' planetarium program or the 'Participatory Oriented Planetarium' program the most effective for instruction and attitude change?

This research study was conducted to explore the above question. In the present study, the following four hypotheses were made:

H₀₁. There is no difference in student pre-treatment and post-treatment understanding of selected astronomical concepts, whether they experience a traditional Star Show planetarium program or a Participatory Oriented Planetarium program.

H₀₂. There is no difference in the achievement level of students who receive a Participatory Oriented Planetarium treatment and the achievement level of students who receive a traditional Star Show treatment.

H₀₃. There is no difference in the students' pre-treatment and post-treatment attitudes towards astronomy, whether they receive a Participatory Oriented Planetarium program or a traditional Star Show planetarium program.

H₀₄. There is no difference in the composite
mean attitudinal test scores of the students who experience a Participatory Oriented Planetarium treatment and the students who experience a Star Show treatment in their attitudes towards astronomy.

In addition to testing the above four hypotheses, the investigation also examined the effects of taking a pre-test on students' content and attitude scores.

The study was conducted at five locations across the United States; i.e., Pennsylvania, Texas, California, Minnesota, and Nevada. In Pennsylvania, the Methacton School District Planetarium used the entire third grade population of the school district. Three hundred and twenty-four third grade students were tested during the Spring of 1979. During the same time period, four other planetariums conducted smaller versions of the study. In Texas, the Richardson School District Planetarium tested seventy-six third grade students. In California, the Holt Planetarium of the Lawrence Hall of Science, University of California at Berkeley, used fifty-two third and fifth grade students from the Madelaine Parochial school in Berkeley. In Minnesota, the Como Planetarium of the St. Paul School District tested fifty-two fourth grade students. In Nevada, the Fleischman Atmospherium/Planetarium of the University of Nevada tested fifty-two fourth grade students from the local Reno School
District. In all, five hundred and fifty-six students were tested.

The study used a traditional Star Show planetarium program from the Fels Planetarium in Philadelphia, Pennsylvania and a Participatory Oriented Planetarium program from the Holt Planetarium in Berkeley, California. These two programs were slightly modified from the original scripts in order to make them match the chosen topic of constellation study more closely, and the five behavioral objectives for instruction. These alterations were kept to a minimum and consisted mostly of deletions of materials that were either too potentially difficult for the students or too tangential to the main topic of constellation study.

The Star Show program was presented via a tape recorded format using a skilled narrator, other than the researcher, and musical accompaniment. The Participatory Oriented Planetarium program was presented live by the planetarium instructors, who were selected from the list of participants in the NSF workshops on P.O.P. techniques. Both programs were for forty-minute durations and used slides as well as the planetarium projector.

To test the students' understanding of selected elements of astronomy, a twenty-two point paper-and-
pencil test was constructed. This test was validated by a panel of five prominent planetarium educators and was further tested for validity by comparing the scores of eighteen students who were group tested using the instrument and individually tested using the planetarium sky. The Pearson r produced a correlation figure of .86. This instrument was tested for reliability by the test-retest method and the split half method. The Pearson r and Kuder Richardson formula 20 tests produced correlation figures of .88 and .745 respectively. The test required no written responses and was read aloud to the subjects to insure as wide a level of understanding as possible.

To assess students' attitudes, a Likert style science opinionnaire was selected from the few published tests. This test had a reported split half correlation figure of .833 and a test-retest figure of .793. To address the specific areas of astronomy and the planetarium, this test was changed in the following way:

The word 'Astronomy' was substituted for 'Science.'
The word 'Astronomer' was substituted for 'Scientist.'
The word 'Planetarium' was substituted for 'Science Classroom.'

When the test was administered, each statement was read aloud by the researcher while the students
marked their preference on an answer sheet. To help the students remember the choices, an overhead transparency with three cartoon faces was projected showing the range of possible choices.

In all five of the studies, students were randomly assigned to one of four groups. After assignment, the students in Groups 1 and 3 were pre-tested with the Astronomy Content Test and the Astronomy Attitude Test. After a one week interval, with no intervening instruction, Groups 1 and 2 visited the planetarium together for one of the treatments and Groups 3 and 4 visited for the other. Immediately following each of the planetarium programs, the students were administered the post-test, which consisted of the Astronomy Content Test and the Astronomy Attitude Test.

The scores achieved by the groups were analyzed by a correlated t test for pre-test to post-test scores and a two-way analysis of variance was used to compare the four groups' post-test scores. The alpha level selected for rejection of the null hypotheses of no significant difference among the means of the groups involved was that corresponding to at least the five percent level of significance.
Conclusions

For this particular investigation, the research findings seem to warrant the following conclusions:

1. Null Hypothesis # 1 must be rejected. As measured by the Astronomy Content Test, the Participatory Oriented Planetarium program was a significantly effective method of instruction for all five studies. The Star Show was less effective in increasing students' scores and not always significantly effective.

2. Null Hypothesis # 2 must be rejected. As indicated by an analysis of the Astronomy Content Test scores, the Participatory Oriented Planetarium program was significantly superior to the Star Show program as a method of instruction in all five studies.

3. Null Hypothesis # 3 must be rejected. As determined by the Astronomy Attitude Test, the P.O.P. program significantly changed attitudes in the major study (Pennsylvania) but not in the replications. The Star Show program significantly changed attitude...
scores in the Texas study but not in the others. In general, all students entered with positive attitudes about astronomy and the planetarium and they left with the same or greater.

4. Null Hypothesis # 4 must be rejected. As determined by an analysis of the post-test scores from the Astronomy Attitude Test, the Participatory Oriented Planetarium program was significantly superior to the Star Show program as a method of changing attitudes in the Pennsylvania and Minnesota studies. Both the P.O.P. groups and the Star Show groups had relatively high attitudes.

5. Pre-test sensitization did not occur. As measured by both the Astronomy Content Test and the Astronomy Attitude Test, the absence or presence of the pre-test, prior to treatment, did not affect the students' post-test scores.

Considering the findings and the above conclusions, a final general conclusion can be made:

6. The Participatory Oriented Planetarium program, utilizing an activity based format and extensive verbal interaction, is
clearly the more effective utilization of a small planetarium facility for teaching constellation study and improving students' attitudes about astronomy.

Discussion and Educational Implications

The objection raised by Friedman, et al. regarding the use of Star Show planetarium programs and the possible effects of Participatory Oriented Planetarium programming, seems to have been quite valid. The present study definitely indicates that a Participatory Oriented Planetarium program should prove to be the most effective of the two program types for constellation study, if used with other students in other, similar planetarium settings. In all five studies conducted as part of this experiment, sampling populations in major regions of the United States, the Participatory Oriented Planetarium program was statistically superior to the Star Show program. This is not to say that the Star Show program was an inferior program, rather that for the teaching of observational astronomy, an activity based program is the more effective method. This conclusion is consistent with current educational theories and

---

35 Friedman, Schatz, and Sneider, "Audience Participation and the Future of the Small planetarium."
should offer important implications to the planetarium profession, especially since 96% of the U.S. planetariums are smaller installations, readily capable of P.O.P. programming.

Concerning attitudes, the inconsistency among the five studies makes it difficult to emphatically make a statement about the treatments. However, based on the major study, which indicated a significant growth from pre-test to post-test for the P.O.P. group (but not for the Star Show group), and which also indicated a significant difference in post-test scores for the treatments, with the P.O.P. treatment being superior, it would appear that the Participatory Oriented Planetarium program is the more effective method of changing attitudes. It is suggested that this same finding may have occurred in the replication studies if their numbers had been larger.

As a general statement about attitudes, all of the students involved had very positive attitudes towards astronomy and the planetarium when they began and they were maintained or increased throughout the programs. Indeed, in responding to question number six of the post-test opinionnaire (referring to whether they liked going to the planetarium) the average response for all 556 students was 4.24 out of 5, an extremely positive response.
In light of the results of this research study, planetariums appear to be clearly in an excellent position to attempt to teach astronomy to students. Since positive attitudes towards the learning environment and the subject matter are very important elements of the instructional process, and since Participatory Oriented Planetarium programming has proven to be a very effective method of instruction, these conclusions would support the role of the planetarium in education. The properly used planetarium is an excellent vehicle for the teaching of astronomy (an important but sometimes neglected discipline) and thus a worthwhile investment for education.

**Recommendations**

The results of this study strongly support the premise that smaller educational planetariums should utilize the Participatory Oriented Planetarium technique when attempting to teach elements of observational astronomy to students. However, because of the limitations of this study and the questions that were raised during its implementation, the following recommendations are proposed for future research:

1. Studies of this type should be repeated using other instructional topics from
the science of astronomy. This would help establish the applicability of the Participatory Oriented Planetarium program to the various topics taught in the planetarium.

2. Similar studies should be repeated using different grade levels and ages to determine the effectiveness of Participatory Oriented Planetarium programming and Star Show programming with students of varying ages.

3. Studies of this type should be repeated using a different form of attitude assessment. This study indicated no change in attitudes, using the Astronomy Attitude Test, for three of the five studies, but there is some question as to the validity of paper-and-pencil attitude surveys for correctly gauging personal attitudes. A study performed with individual interviews, for example, might produce different results.

In conclusion, it is hoped that this study will offer the field of planetarium education a clearer direction for educational programming and for possible future research in the profession.
BIBLIOGRAPHY


Fletcher, Jack. "An Experimental Comparison of the Effectiveness of a Traditional Type Planetarium Program and a Participatory Type Planetarium Program." Ph.D. dissertation, University of Virginia, 1977.

Fraser, Barry J. "Development of a Test of Science Related Attitudes." Science Education. 62 (October-December 1978): 509-515.


Wright, Delivee L. "Effectiveness of the Planetarium and Different Methods of its Utilization in Teaching Astronomy." Ph.D. dissertation, University of Nebraska, 1968.
To: Doctoral Committee for Gerald Mallon.

Dear Committee:

I would like to very strongly support the need for Mr. Mallon's proposed dissertation. I see an immediate and very significant application for his study which I will describe briefly here. Mr. Mallon can also show you copies of our "Techniques for Developing Planetarium Programs" which describes existing theory and practice in planetariums and which supports my comments below.

Much general theory of learning, including especially the work of Jean Piaget, supports the concept of "hands-on" activity-based learning strategies. In practice, however, most instruction at all levels is still based on some variant of the lecture format. This extends to planetariums. Our national survey of all North American planetariums (to be published soon) indicates that the great majority of planetarium programs are of the illustrated lecture format. If a more effective mode of learning were available, using it would enrich educational experiences for an estimated 11 million planetarium goers, including school children and adults. To date, there is not a single study that compares a conventional passive planetarium program with an activity-based program. Two studies have been done, each comparing a non-traditional but passive program with activity programs, and these studies have shown the active method to be equally effective but not significantly more effective.

As I understand it, Mr. Mallon's proposed study would compare a traditional planetarium program with an activity-based version of that same program. This would be a very influential study in helping planetariums decide whether to embark on activity-based development. In our work over the past several years, we have been in contact with literally hundreds of planetariums around the world. Most of them are interested in activity-based learning, but are not convinced that it is worth the additional effort. Mr. Mallon's study could answer this question one way or the other, and if his findings are in favor of the activity-based approach, I believe that hundreds of additional planetariums reaching millions of people would encourage this mode of operations by adding activities
To: Doctoral Committee for Gerald Mallon.
October 23, 1978
Page 2

to their programs. If his findings are not in favor of this approach, it might save a lot of futile effort. In either event, I believe this study will be of great interest in the planetarium field and may serve as a model for applied education research beyond the planetarium domain.

Sincerely,

[Signature]

Alan J. Friedman
Associate Research Educator
Director of Astronomy and Physics Education
Lawrence Hall of Science

AJF:db
October 31, 1978

Gerald L. Mallon Doctoral Committee
c/o Gerald L. Mallon
Methacton School District Planetarium
Arcola Junior High School
Eagleville Road
Norristown, PA 19401

Dear Committee Member,

In 1977 the National Science Foundation provided funds for a project by the Lawrence Hall of Science Research Center in Science Education. The project called for the development of several "participatory oriented planetarium" programs. The programs that were developed were intuitively excellent and firmly based in Piagetian psychology. Further funding was provided in 1978 to sponsor participatory oriented planetarium workshops in several parts of the United States.

The funding was done prior to any evaluative studies that tested the basic premise of the project. The project assumed that students who actively participate in a planetarium lesson will perform significantly better in both the cognitive and affective domains in comparison to students who participate in a passive planetarium lesson.

A recent doctoral dissertation from the University of Virginia does not support the above premise. This study showed that the different instructors that participated in the program were a more important factor than the type of planetarium presentation. While this conclusion is significant, I still think that the two planetarium approaches need to be further evaluated. I am particularly interested in Mr. Mallon's dissertation proposal. I believe that his results would be of significance because of his use of a large sample with one instructor. The one instructor is necessary to provide a competent familiarly of the program and approaches that are being tested. The planetarium field needs this type of information if it is to provide the maximum educational service to its students. Without good educational research of this type planetarium educators are subject to the passing whims and fads of time.
As chairman of the Middle Atlantic Planetarium Society Research Committee, and as one who has published in this area, I would like to support Mr. Mallon's endeavors in behalf of a research-based approach to Planetarium Education.

Sincerely,

George Reed
Professor of Astronomy
and Science Education

GR/lt
October 17, 1978

Mr. Gerald L. Mallon, Director
Methacton School District Planetarium
Arcola Junior High School
Eagleville Road,
Norristown, PA 19401

Dear Mr. Mallon;

In reference to your letter of October 12, 1978 I have argued for years that the value of a school planetarium lies in the fact that they do not simply present "star shows" as one would find in public planetaria. I am aware that this claim is not valid in many of the public school planetaria, however, there are a significant number who do offer students the opportunity to participate in laboratory type experiences.

My last computer list, 1973-74, indicates 140 planetaria in public schools. This does not include colleges and public installations. I will request a copy of the report from the 1977-78 school year to update the list.

I would be very much interested in seeing a study done which would attempt to document the fact that student participation in planetarium programs results in increased learning. I would also hope that there would be an increased interest in learning on the part of the student. Such a study, should it prove to be significant, would be of great value to the Department.

If I can be of any help to you during your study please let me know. I hope you can convince your doctoral committee that this is something that has been needed for many years.

Sincerely,

William H. Bolles
Science Education Adviser
Bureau of Curriculum Services
Dear Colleague:

I am the Planetarium Director for the Methacton School District Planetarium. I am also a doctoral student at Temple University, Philadelphia, Pa., in the midst of performing a research study which will be the basis for my dissertation. This study will compare the effectiveness of a traditional "Star Show" planetarium program with a "Participatory Oriented Planetarium" program.

Since you participated in the three day P.O.P. workshop held earlier this year, you are now one of a select group of planetarium directors with training in this methodology. Further, you have been rated very highly by your colleagues on your understanding of the intricacies of this area. Therefore, I am going to ask a favor of you which I hope that you will be able to grant. This spring, (1979) I will perform the bulk of my research study in my planetarium but it is extremely important that this study be replicated in other educational planetariums. Because of your expertise, I would very much like you to help replicate it. I realize that it will take some of your time and energy and I can not offer you any monetary rewards, but your help may assist the planetarium field to grow and develop and, depending on the results of the study, add valuable information to our profession about the effectiveness of the P.O.P. method. Of course you will be formally thanked in my dissertation as well as in any other way that I can to show you my gratitude for your assistance.

If you agree to help, I will send you a complete package of items necessary for you to conduct the study (e.g. tapes, slides, overhead transparencies, ditto masters, scripts, etc.). The study should not take more than two weeks of your time and it may prove quite valuable to other planetariums interested in P.O.P. An important consideration is that the study must be conducted during this spring, since I will be using a spring "Star Show" from the Fels Planetarium, Philadelphia, Pennsylvania.

Following, is a step by step description of what you would...
have to do to replicate the study in your planetarium:

1. Choose one of the elementary schools in your area. From this building, choose either the third, fourth or fifth grade students as your population. For your ease, the building chosen should have no more than 3 or 4 classes per grade level.

2. Meeting with the teachers involved, explain that you would appreciate their help in a research study. Inform them that you would like to randomly assign their students to four groups. (An example of this would be as follows: Mrs. S's class consists of thirty students. Mr. X's class also consists of thirty students. These sixty total students are randomly assigned to four groups numbered I, II, III, IV with each group having fifteen students.)

3. Next, two of these groups (that is, Groups I & III) would be pretested one week before the scheduled planetarium lessons. Groups II, & IV would not be pretested. The pretest would include both a cognitive and an attitude instrument and should not take much more than twenty minutes.

4. Groups I & II would go together to the planetarium for Treatment 1 (either the "Star Show" or the P.O.P. program) and Groups III, & IV would go together to the planetarium for Treatment 2 (the opposite of the one used in Treatment 1).

5. After each treatment, of approximately forty minutes duration, the groups would then be post-tested in the planetarium. This will be the same test that was used for the pre-test. Total time in the planetarium should not be much more than sixty minutes.

6. The completed forms and materials would then be sent to me for analysis. In this regard, it is very important that students ALWAYS mark their group number (I, II, III, IV) on their answer sheets both pre and post-test.

I hope that you will consider my request and if possible, please agree to help. If you desire any additional information about my dissertation proposal, please do not hesitate to contact me. If you do agree to help, please return the enclosed information sheet as soon as possible. In closing, thank you very much for your kind attention to this matter.

Sincerely,

Gerald L. Mallon
INFORMATION SHEET FOR PARTICIPATION IN RESEARCH STUDY

DIRECTOR NAME: ________________________________

NAME OF PLANETARIUM: __________________________

ADDRESS: _______________________________________

_____________________________________________________________________

_____________________________________________________________________

_____________________________________________________________________

SIZE OF PLANETARIUM DOME: ________________

SEATING CAPACITY: _____________________________

TAPE SYSTEM AVAILABLE: Cassette (yes or no) Reel-to-reel (yes or no)

SLIDE PROJECTORS AVAILABLE (circle) 1 2 3

OVERHEAD PROJECTOR AVAILABLE yes no

NUMBER OF STUDENTS THAT YOU WILL INVOLVE ______________

GRADE LEVEL OF STUDENTS INVOLVED _________________________

SPECIAL CONSIDERATIONS FOR YOUR PLANETARIUM (e.g. letter to your School Board is necessary, etc.)

_____________________________________________________________________

_____________________________________________________________________

DATE WHEN MATERIALS WILL BE NEEDED __________________________

SIGNATURE OF DIRECTOR ____________________________

(On a separate piece of paper, please confidentially describe the population of students that you have chosen, e.g. rural, lower middle class, average intelligence, etc. Thank you)
January 17, 1979

Dear Colleague:

A few weeks ago, I wrote to you asking for your help in a planetarium research study. Since then, a few people have written asking for additional information on various aspects of the study. In review, some of this information may be worthwhile for you to have in making your decision whether to participate or not. Therefore, I will attempt to briefly detail some of these points in this letter.

Concerning the content of the two programs, they both deal with the general topic of "Constellation Study" but approach it in different ways. The "POP" program is an adaptation of "Finding Your Star" from the Holt Planetarium, Berkeley, California, and the "Star Show" is an adaptation of "Leo and His Friends" from the Fels Planetarium, Philadelphia, Pennsylvania. The treatments and tests are designed for 8-10 year old students, so please feel free to consider either third, fourth or fifth grade students, at your convenience. If possible, it would be important to consider a grade which has not had previous instruction in constellation study.

One restriction on the treatment groups is that they must be similar. One question asked if third and fourth grade students could be mixed together. If this situation applies to you, this mix would be all right if the mix is randomly the same for all groups and does not turn out to be mostly third grade students for the one treatment and mostly fourth for the other.

If you have any questions or other concerns, please do not hesitate to contact me. The materials will be ready for use in April, May, or June of this year, and I would be elated if you found that you would be able to help. Thank you again.

Sincerely,

Gerald L. Mallon
Planetarium Director
(215) 489-1900 x283
APPENDIX B

TESTING INSTRUMENTS
INSTRUCTIONS FOR ADMINISTERING ASTRONOMY CONTENT TEST
INSTRUCTIONS FOR ADMINISTERING
ASTRONOMY CONTENT TEST

(Important, this test should be administered before the attitude test.)

A) Requirements
   1) Pencils
   2) Test Booklets
   3) Instruction Booklet
   4) Transparencies
   5) Clock with second hand

B) Prior to distributing the test booklets, perform the following tasks:
   1) Introduce the test session by quieting the group and gaining their attention.
   2) Explain that they are now going to take a short test just to check their knowledge about the sky. They will not be graded and they will not even have to put their names on the paper but they will have to put their "Group Number" on it, so that the group level can be determined.
   3) Read the following aloud to the group:
      "You are to answer all questions that you know, or are pretty sure about, but do not guess at questions that you don't know at all. You will only have a certain amount of time to
work, not all day, so you must work quickly.

I will read each question once as you read along on your paper. When I finish reading, then quickly mark your answer on your paper. There is to be NO talking during the test! Do your own work, on your own paper! No wandering eyes!"

C) Distribute the test booklets and pencils.

1) Read aloud. "Everyone, this is very important put your Group Number in the space at the top of the page. Mark either 1, 2, 3, or 4."

2) Check to see that everyone has marked their number in the appropriate space, and then go on.

3) Read aloud. "Listen carefully now as we begin with question number 1. Read along as I read the question and then answer it on your paper."

D) Project the overhead transparency of each test page as you need it and use the transparency to point out important parts of the test in accordance with the instructions, e.g. where to put answers.

1) Read aloud. "Please answer the following questions by putting a circle around Yes or No.

**QUESTION 1**

Constellations are things that can be seen in
the sky in the night time and in the day time.

(Wait 10 seconds and then proceed with test.)

**QUESTION 2**

Constellations may be fun to hear about but they cannot help us to find objects in the sky.

(Wait 10 seconds and then proceed with test.)

**QUESTION 3**

A star map can help us to find constellations in the sky.

(Wait 10 seconds and then proceed with test.)

**QUESTION 4**

A star map tells you how far away the stars are in the sky.

(Wait 10 seconds and then proceed with test.)

**QUESTION 5**

Constellations can help us to find directions on earth.

(Wait 10 seconds and then proceed with test.)

**QUESTION 6**

Constellations can help us to find other objects in the sky.

(Wait 10 seconds and then proceed with test.)

**QUESTION 7**

If you see two stars next to each other in the sky on one night, they will not be next to
each other on other nights.
(Wait 10 seconds and then proceed with test.)

**QUESTION 8**
Here is a star map. In which direction should you look to see the constellation "Bootes"? North? South? East? or West? Circle your answer below.
(Wait 15 seconds before proceeding. Also, point out the answer choices on the transparency and the constellation Bootes.)

**QUESTION 9**
Which of these star maps most looks like the sky around Orion the Hunter? Put a circle around A, B, or C.
(Wait 15 seconds and then proceed with test.)

**QUESTION 10**
On the star map below, put a circle around the brightest star.
(Wait 10 seconds and then proceed with test.)

**QUESTION 11**
On the star map below, put a circle around the dimmest star.
(Wait 10 seconds and then proceed with test.)

**QUESTION 12**
Planet Mars must be put on this star map. Mars should be in the "Southwest" part of the sky
and should be about half way up in the sky.
Put an "X" on the map for Mars.
(Wait 20 seconds and then proceed with test.)

QUESTIONS 13 - 18
Here is a map of the sky. Find each of the following things and put its number on top of its place on the map. Number 13 has already been done for you!

Further directions to read:
"Number 13 is Auriga the charioteer. Everyone, find where #13 has been put on the map and put your finger on it. You are to put the numbers for the other things on top of their place on the map. I will read the list of things once so listen carefully and then put the numbers for each of the things on top of their place on the map.
#14 is Orion the hunter
#15 is Leo the Lion
#16 is Taurus the bull
#17 is Canis Major the big dog
#18 is Gemini the twins
(Wait 2 minutes and then proceed with test.)

QUESTIONS 19 - 24
Here is a map of a different part of the sky. Find each of the following things and put its
Further directions to read:
"Number 19 is the Little Dipper. Everyone, find where #19 has been put on the map and put your finger on it. You are to put the numbers for the other things on top of their place on the map. I will read the list of things once, so listen carefully and then put the numbers for each of the things on top of their place on the map.

#20 is the Big Dipper
#21 is Polaris, the north star
#22 is Cassiopeia the queen
#23 is Cepheus the king
#24 is Draco the dragon

(Wait 2 minutes and then conclude test.)

E) Check to see that everyone has indicated their group number on the test booklet, and then collect the tests and pencils.
ASTRONOMY CONTENT TEST

PLEASE ANSWER THE FOLLOWING QUESTIONS BY PUTTING A CIRCLE AROUND YES OR NO.

1. Constellations are things that can be seen in the sky in the night time and in the day time. YES NO

2. Constellations may be fun to hear about but they can not help us to find objects in the sky. YES NO

3. A star map can help us to find constellations in the sky. YES NO

4. A star map tells you how far away the stars are in the sky. YES NO

5. Constellations can help us to find directions on earth. YES NO

6. Constellations can help us to find other objects in the sky. YES NO

7. If you see two stars next to each other in the sky on one night, they will move away from each other on other nights. YES NO

8. Here is star map. In which direction should you look to see the constellation "Bootes"? North? South? East? or West? Look at the star map and then circle your answer below.

NORTH SOUTH EAST WEST
9. Which of these star maps most looks like the sky around "Orion the hunter"? Put a circle around A, B, or C.

10. On the star map below, put a circle around the brightest star.

11. On the star map below, put a circle around the dimmest star.

12. Planet Mars must be put on this star map. Mars should be in the "South West" part of the sky and should be about half way up in the sky. Put an X on the map for Mars.
13 - 18. Here is a map of the sky. Find each of the following things and put its number on top of its place on the map. Number 13 has already been done for you!

13. Auriga the charioteer
14. Orion the hunter
15. Leo the lion
16. Taurus the bull
17. Canis Major the big dog
18. Gemini the twins

19 - 24. Here is a map of a different part of the sky. Find each of the following things and put its number on top of its place on the map. Number 19 has already been done for you!

19. the Little Dipper
20. the Big Dipper
21. Polaris, the north star
22. Cassiopeia the queen
23. Cepheus the king
24. Draco the dragon
INSTRUCTIONS FOR ADMINISTERING ASTRONOMY ATTITUDE TEST
INSTRUCTIONS FOR ADMINISTERING

ASTRONOMY ATTITUDE TEST

(Important, this test should be administered after the Content test.)

A) Requirements
1) Optical scanning answer sheets
2) #2 pencils
3) Overhead transparency of answer sheet
4) Instruction Booklet
5) Clock with second hand

B) Prior to distributing any materials, perform the following tasks:
1) Introduce the test session by quieting the group and gaining their attention.
2) Explain to the group that they now are going to complete a form telling what they think about Astronomy and the Planetarium. This is to be their honest feelings. There are no "right or wrong" answers, only the way they feel. They won't have to list their names on the paper, only their group number.

C) Instructions for answer sheets
1) Read and demonstrate the following with the transparency.

You will get an answer sheet with lots of numbers on it and five spaces next to each
number. Each space is for a different feeling. You are to fill in the space that matches your feeling about a sentence.

This is what the spaces mean:

A means 'Strongly Disagree' with the sentence.
B means 'Disagree' with the sentence.
C means 'Undecided' about the sentence.
D means 'Agree' with the sentence.
E means 'Strongly Agree' with the sentence.

Look at the faces on the drawing. They will help you to remember what the spaces mean. Here is an example of how it works.

Suppose I said:

"Vanilla is a delicious flavor of ice cream."

If you didn't think so, you would mark one of the "Disagree" spaces. If you really hated it, you would mark "A". If you just didn't like it, you would mark "B". But if you really liked vanilla, then you would agree with my sentence and mark either "D" or "E". You would mark "E" if you really loved vanilla a lot and you would mark "D" if you just liked it some. Space "C" is for when you are not sure about a sentence.
2) When the group understands the meanings of responses A - E, read the following:

I will read each question two times and then you should mark your answer sheet according to your feelings. You won't have all day to decide, so you have to work quickly. If you change your mind, you have to erase your mark completely and then mark the correct space, so be careful in answering.

D) Distribute the Answer Sheets and Pencils

1) Read aloud:

Everyone, turn your answer sheet to the empty side and write your group number on it, nice and big.

2) Check to see that everyone has done so and then proceed.

3) Instruct the class to turn the page over again and demonstrate for them the proper numbers to use in answering, i.e. 1 - 20.

E) Attitude Test

1) Read aloud:

Everyone, find the answer spaces for number 1 and listen carefully as I read it. Then mark the space that matches your feeling. Remember, the drawing will help you to remember the feeling for each space.
NUMBER ONE: Reading about Astronomy is difficult.
(Repeat, and then wait 10 seconds before continuing.)

NUMBER TWO: We spend too much time doing experiments.
(Repeat, and then wait 10 seconds before continuing.)

NUMBER THREE: I am learning a lot about Astronomy this year.
(Repeat, and then wait 10 seconds before continuing.)

NUMBER FOUR: What we do in the planetarium is what a real astronomer would do.
(Repeat, and then wait 10 seconds before continuing.)

NUMBER FIVE: In the planetarium, we study 'Today's Problems.'
(Repeat, and then wait 10 seconds before continuing.)

NUMBER SIX: I dislike coming to the planetarium.
(Repeat, and then wait 10 seconds before continuing.)

NUMBER SEVEN: I read more astronomy materials than I did last year.
(Repeat, and then wait 10 seconds before continuing.)
NUMBER EIGHT: I enjoy doing the astronomy experiments.
(Repeat, and then wait 10 seconds before continuing.)

NUMBER NINE: I can solve problems better than before.
(Repeat, and then wait 10 seconds before continuing.)

NUMBER TEN: My friends enjoy doing the astronomy experiments.
(Repeat, and then wait 10 seconds before continuing.)

NUMBER ELEVEN: What I am learning in the planetarium will be useful to me outside school.
(Repeat, and then wait 10 seconds before continuing.)

NUMBER TWELVE: I think about things we learn in the planetarium when I'm not in school.
(Repeat, and then wait 10 seconds before continuing.)

NUMBER THIRTEEN: I do not want to take any more astronomy classes than I have to take.
(Repeat, and then wait 10 seconds before continuing.)

NUMBER FOURTEEN: Reading astronomy is more fun than it used to be.
(Repeat, and then wait 10 seconds before continuing.)

NUMBER FIFTEEN: Experiments are hard to understand.
(Repeat, and then wait 10 seconds before continuing.)

NUMBER SIXTEEN: Astronomy is dull for most people.
(Repeat, and then wait 10 seconds before continuing.)

NUMBER SEVENTEEN: The things we do in the planetarium are useless.
(Repeat, and then wait 10 seconds before continuing.)

NUMBER EIGHTEEN: The kinds of experiments I do in the planetarium are important.
(Repeat, and then wait 10 seconds before continuing.)

NUMBER NINETEEN: I learn a lot from doing my astronomy experiments.
(Repeat, and then wait 10 seconds before continuing.)

NUMBER TWENTY: Most people like planetarium lessons.
(Repeat, and then wait 10 seconds before continuing.)
F) Check to see that everyone has indicated their group number on their paper and then collect the materials.
APPENDIX C

TREATMENT SCRIPTS
Leo and His Friends

The following is an adaptation of a planetarium program by the Fels Planetarium, Franklin Institute, Philadelphia, Pennsylvania.

Script adaptation by Gerald L. Mallon
OBJECTIVES

By the end of the planetarium session, the participants should be able to:

1. Define the term "Constellation" as a group of stars connected together to form a shape in the sky.
2. State that constellations can be used as "Skymarks" or signposts to locate other objects in the sky. (e.g. nebulas, planets)
3. Recognize a given set of constellations as represented on a "Star Map."
4. Demonstrate the use of a "Star Map" in locating an object or constellation in the sky.
5. Relate various pieces of factual information about the sky. (e.g. If a star is seen next to one star on one night, it will be next to that star on other nights.)

PREPARATION

1. Precession - 0 Current
2. Latitude - Home
3. Sun, set for present date
4. Turn off sun, moon, planets, NSEW lights
5. Check constellation outline alignments (if you possess them, they are not supplied in package.)
6. Set 4 hours of Right Ascension on the meridian.
7. Set slide projector(s) on first slides.
   1 Projector: Put all slides in numerical order
   2 Projectors: Put all odd numbered slides in one projector and the even numbered slides in the other projector.
   3 Projectors: (Optional: if a third projector is available, aim the sunrise slide at the sunrise point.)
8. Turn on full cove lighting, stars, and when ready, the program tape.
9. Check the light pointer.

RECOMMENDATIONS

It is recommended that you practice the program at least two or three times before actually presenting it. Please practice the timing of slides and other visuals. Directions are printed on the left hand side of the script, accompanying the appropriate part of the program.
Fade lights at beginning of fanfare until sky is a very "light polluted" blue. While fanfare is playing show slides 1-7.

To those of us who live in cities of the later twentieth century, the starry skies of a dark, moonless night are unfamiliar and exclusive. The pollution of industry, transportation, heating of homes and offices, and our many other comforts of daily living make for a man-made curtain drawn over our sphere of life—shutting off the star-studded floor of the heavens above.

Only by travelling hundreds of miles away from the disturbing influences of many, perhaps to the top of some tall mountain or better yet to the deck of a ship at sea, can we be still, look up, and ponder the darkness of night through which myriads of polka dots radiate telling us of stars other than the sun—suggesting countless civilizations—and reminding us of the vastness of our universe. To our ancestors, however, this awe-inspiring sight was visible each and every
clear night of the year. One of the things that men must have discovered very early was that the same stars shone in the same part of the sky from one evening to the next. Only by watching for many hours or many weeks could a slow change in their position be detected, and even then one star would always be seen to follow or precede another by exactly the same distance as they slowly moved across the dome of heaven. The Earth on its annual trek around the Sun views its master against the background of stars from a constantly changing position. Because of this, the Sun appears to move Eastward against the backdrop of stars. The heavens become a stage on which the Sun, Moon, and planets act out their destined roles. Only in the planetarium can the Sun's brilliant light be dimmed to allow us to see the stars of daytime.

The Summer stars are not those seen in the Winter nor are the stars of Autumn seen in the Spring. The heavens seen here are those of late Winter—in the West and early Spring—in the East. Just as there are
places on the Earth marked by unusual numbers of rocks, or particular kinds of trees and plants, so too are there places in the sky marked by especially brilliant stars or hazy glow of light. Over the centuries, man has given his favorite stars names, and grouped some of them together in his mind to form shapes and pictures, called Constellations. Thus, as the surface of the Earth was being explored, with significant features being called "Landmarks," so the face of the sky was also studied with the brighter stars and star pictures becoming "Skymarks,"

To learn the skymarks of Winter and Spring, we first have to find our directions. By this time of year, the Sun stands fairly close to the equator of the sky, and so it seems to set just about due West. If you face the direction of the sunset, you will have West in front of you, South to your left, North to your right, and East behind you. Since most of the activity, occurring as the sky goes through its seasonal changes, occurs toward the South as seen from the
northern hemisphere, we will spend most of our time today looking in that direction. For your convenience, directions are marked at the four points of the compass: West, South, East and North.

At first glance, the stars seem to be somewhat evenly scattered across the sky, and many people would guess that millions are visible on a night as clear as this. Actually, only about 3,000 can be seen at any one time, with a total of nearly 8,000 being visible if observations were made from several different places on the Earth.

By the 3rd Century B.C., the difficult job of charting and cataloguing the stars had been started by Hipparchus, a Greek astronomer. In the chart that Hipparchus drew, nearly 1,000 stars were marked. While Hipparchus' knowledge of the stars' brightness and position was very good, he did not have a particularly good idea as to what a star was. Depending on who you were, the stars might be diamonds hammered into the vault of the sky, or bonfires made by departed souls on their way to heaven.
though an occasional brave scholar had suggested that the stars were objects like the Sun, only very, very far away, this idea did not become wildly accepted until comparatively recent times. Furthermore, thanks to the telescope, we know today that there are many more stars than can be seen with the unaided eye. What then are some of the "skymarks" of tonight's sky, and what do we know about them?

Evenings in February and March are the best times to go looking for bright stars because there are more visible than at any other season, with 11 of the 16 brightest above the horizon. In the East, Arcturus and Spica have just risen. High in the south east stands Regulus, while grouped together in the southwest can be found Sirius, Procyon, Pollux, and Castor, Capella, Alderoaran, Betelgeuse, and Rigel. The last two, Betelgeuse and Rigel, are part of what many people consider the finest of all constellations: Orion, the Funter. According to one legend, Orion once boasted that there was no animal on Earth that he could not
hunt and conquer. A scorpion, overhearing him, came out of the ground and stung him on the foot, causing his death. At the request of Diana, the Moon Goddess, Jupiter placed him in the sky exactly opposite the scorpion, so the two would never oe above the horizon at the same time.

The Hunter's belt is an unmistakable line of three evenly spaced, equally bright stars. Above these are Betelgeuse and Bételgeuse - his shoulders. Orion's right arm is raised high in the air holding a club. His left stretches out in front of him where a curved line of faint stars forms his shield—a lion's skin. Beneath the stars of the Belt, Rigel and Saiph mark his feet. A chain of fainter stars hangs down from the middle of the Belt and indicates the position of his sword.

If you have an overlay of Orion, project this onto the dome.

With a bit of luck, you may just be able to imagine the outline of Orion tipped forward now as he descends toward the southwest. If this traditional constellation picture is difficult for you to make out, you may prefer to think of Orion as an hourglass-shaped
figure. The astronomer views Orion neither as a hunter nor an hourglass, but rather as a region of the sky bounded by straight lines. While a good deal less romantic than the traditional figures, the astronomer's system is uniform around the world, and covers the entire face of the sky with no gaps and no overlaps. Most persons are disappointed when they discover the traditional figures do not resemble the names they bear. But is this unusual? Do we not do the same thing today? Does the state of Washington look like George Washington — or Pennsylvania like William Penn? How about the Ben Franklin Bridge? Does it resemble good old Ben? Of course not!

Just as we honor great persons today, so did the people of long ago when they honored their Gods, Godesses, and heroes and invented stores about them to explain their presence in the heavens. All in all, there are 88 constellations although only about 40-50 are easily recognized.

Within Orion's realm lie many objects of great interest to astronomers. The two
brightest stars in particular are of interest because of the differences between them. Even a quick glance will show that Betelgeuse is reddish while Rigel is more of a blue-white color. To an astronomer, a star's color indicates its temperature. It's somewhat similar to heating up a bar of steel. As heat is applied, the steel begins to glow - first a dull red, then orange, yellow and finally white. If the heating could go on further, the now liquid steel would eventually glow with a blinding blue light. A red star, such as Betelgeuse, is one of the coolest visible stars, while a bright blue star, such as Rigel, is one of the hottest.

At least one other object within Orion is of interest to someone studying the Winter sky. If you look carefully at the middle star of the sword, you'll notice that it seems to be hazy or out of focus. Binoculars reveal a faint, fuzzy patch, but a time exposure photograph taken through a telescope reveals much detail in what is known as, The Great Nebula in Orion. This
nebula is a contracting cloud of hydrogen gas. Astronomers believe that regions such as this are the birthplaces for new stars within our galaxy. The gravitational attraction of the gas molecules and dust particles already in the cloud causes still more material to slowly be drawn into the region. As the material becomes more densely packed, molecules and particles strike each other more and more frequently, raising the temperature. If the matter becomes dense enough, the thermonuclear processes that sustain a star can begin, and a new star appears. Due to nearby stars and the ultraviolet light they give off, the gases in the nebula fluoresce, making it one of our more beautiful Winter "skymarks."

But the stars of Orion are not the only interesting objects in the sky tonight. If we use the three stars of the Hunter's Belt as a pointer toward the northwest, we can make our way to a group of stars in the shape of a letter "V". This cluster is known as The Hyades, and with Alderbaran forms the face of Taurus the Bull. Taurus is one of
the oldest of the constellations. At one time, over 4,000 years ago, it marked the Sun's position on the first day of Spring. While this is no longer the case, Taurus remains a member of the Zodiac, the band of twelve constellations stretching all the way round the sky in which the planets, Sun and Moon are seen to move.

Nearby, lie the Pleiades, sometimes called the Seven Sisters. To the unaided eye only 6 or 7 stars are easily seen, but binoculars reveal several dozen. When a photograph is made, hundreds of blue-white stars reveal themselves along with faint clouds of nebulosity. Unlike the glowing Orion Nebula, however, the nazy streamers surrounding the stars of the Pleiades shine by light reflected off of dust particles.

One other object of particular interest lies in Taurus, although it is so faint that it can not be seen without a telescope. This is the nebula assigned the number M-1, and sometimes nicknamed "The Cracol. Lying near the tip of one of the Bull's horns, the Crab Nebula is all that is left to remind us
of an extraordinary star that suddenly shone forth in this spot nearly a thousand years ago. It was so bright it was seen for 23 days during the daylight hours. Chinese astronomers watched this strange star for over a year until it completely faded from sight. The nebula is a slowly expanding cloud of gas left by this supernova.

High in the northwest, brilliant Capella helps us to find the pentagon shape of Auriga the Charioteer. Although Auriga is one of the ancient star patterns, comparatively little is known about its origins. Capella means "mother goat" when translated into English, and three nearby stars are called "the kids", but this does not seem to have any particular association with Auriga.

Just about due west and two-thirds of the way up from the horizon are the twin stars, Castor and Pollux. Each star forms the head of one of the twins. Together they form Gemini, another constellation of the Zodiac. On February and March evenings, the twins are standing upright and although their stars are only moderately bright, they none-
theless are a conspicuous group easily found with the help of Castor and Pollux. Castor is an example of a multiple star for although it appears to be a single object, when viewed with the naked eye, a telescope reveals that there are two stars in very close proximity. This fact was first noted in 1750 by the astronomer, Bradley. What Bradley did not know was that there were actually four more stars in the system bringing the total number to six!

Common to Winter and early Spring, two star patterns can be found to the southwest. Each contains one very bright star and each, supposedly, resembles a dog. Canis Minor, The Little Dog, is well named for there are only two stars easily found and only one of them, Procyon, is genuinely brilliant.

Canis Major, on the other hand, is a bright constellation. With Canis Minor, it represents Orion's hunting dogs. The star pattern seen here represents him as standing on his hind legs with his head high in the air. Sirius shines like a bright jewel set in his collar. An coincidence surrounds the
fact that Sirius happens to be in that part of the sky occupied by the Sun during mid-Summer. Since Sirius appears to be brighter than any of the other stars, ancient astronomers occasionally explained that the oppressive heat of Summer was caused by the fact that both Sirius and the Sun were in the sky together! While we know better today, we still do sometimes speak of the "dog days" during July and August, and inadvertently pay tribute to this star's presence.

With the brilliant stars of Winter scattered across the southwest, we should perhaps, search briefly for a barely visible, powdery band of light known as The Milky Way. Although the Winter portion of the Milky Way is far fainter than that which we see in Summer, it may just be glimpsed as it arches from South to northwest passing through the hunting dogs, Gemini, and Auriga. The faint silvery light is actually coming to us from billions of stars too faint to be seen individually without a telescope.

Although we frequently speak of this
faint band as being the Milky Way, this is not quite correct, for all of the stars we see when we look up at the night sky are part of this Milky Way system or galaxy.

Slide 45

Shaped like an enormous wheel it contains over one hundred billion stars including the Sun. A somewhat similar galaxy can just barely be seen in the constellation Andromeda low in the West. When photographed, it reveals itself to be one of the most splendid objects in the heavens. This nearby galaxy is the most distant object you can hope to see without optical aid. It lies nearly 2½ million light years distant, thus, you see it now by light which left it 2½ million years ago.

Slide 46

The Skymarks we have been looking at up to now are really those of the winter months. The sky here is as it would appear in Mid-March about 3 hours after sunset. Some of the stars of Spring are already visible in the East and with the passing of time, Earth's rotation causes them to rise higher, with others coming into sight over the eastern horizon. By the early part of April, many
Stop diurnal motion when 11 hour R.A. is on the meridian.

Spring constellations have come into view. Spring is the best time of the year to look for that famous group of seven bright stars known as The Big Dipper. The Dipper is almost straight up with three stars in the handle and four in the bowl. If you look closely at the second star of the handle, Mizar, you should be able to see a second faint star nearby, known as Alcor. Together they are sometimes called the horse and rider. The Big Dipper is not a constellation. A better term for it might be "asterism," for although widely recognized, it is actually only part of a much larger constellation known as Ursa Major, The Great Bear. The Dipper and its handle form the bear's back and tail while fainter stars mark her head and paws. Clearly there's something wrong because...well, bears just don't have long tails. To make matters worse, the Little Bear, Ursa Minor, also has an overly long tail. We know the Greek astronomers knew full well what a bear was supposed to look like, so their explanation for the unusual length of these particular bear
tails bears repeating. It seems that Jupiter, king of the gods, wanted for some reasons of his own, to place these two bears in the northern part of the sky.

Well, the bears were very heavy, and it was a long way up to the sky, so Jupiter took his time and thought about how he was going to get them there. At first he thought he might pick the bears up by their feet. But bears have sharp claws and he was afraid they might scratch him. He thought about it some more and decided to pick them up by the back of their necks. But then he remembered that bears have sharp teeth and he feared they might bite him. Finally, he had an idea, and he picked up both bears by their short tails. He swung them round and round and finally let go. The two bears went tumbling through the air until they came to rest in the sky, but when Jupiter took a look, he discovered that their tails had stretched out of shape. And that's how the bears in the sky got such long tails.

While looking in the direction of the two bears, we might look briefly at Polaris,
Point out procedure.

Point out approximate circle.

138

the North Star. To find it, go back to The Big Dipper. Use the two end stars of the bowl as pointers and they will guide you to Polaris. While the North Star is not very bright, it is certainly the most important star in the whole sky for someone who wants to find directions. Due to a lucky accident, the Earth's axis points almost exactly to Polaris. Thus, even as the Earth rotates, this one particular star seems to stay in place while all the others move in circles around it. No matter what the time of night or season of the year, Polaris can always be seen from places North of the equator and marks the direction of the North with an error of nor more than 1½ degrees. From our latitude, all stars within about forty degrees of the North Star are said to be circumpolar, that is, they are visible at all times somewhere in the Northern sky. Three other constellations that we can find are included in this group. If you look carefully between the Big Dipper and the Little Dipper, you may be able to make out a few faint stars. These stars
are part of the constellation "Draco the Dragon." Draco is a serpent-like object and curves from the tip of his tail near the dippers to its head.

Low in the sky to the northwest is a group of stars making a slightly crooked "W" or "M" shape. This group is known as "Cassiopeia the Queen." You may be able to imagine that the "W" shape forms the royal throne upon which Queen Cassiopeia sits, from here looking down on the Earth from the starry heavens above. One last constellation for us to look at in this area is the royal companion of Cassiopeia the Queen, that is, "Cepheus the King." Between the Little Dipper and Queen Cassiopeia are a few faint stars that when connected seem to make a rather slanted house, these are the stars for King Cepheus. The star at the peak of the roof could be a gem in his royal crown with his and body following under it.

In one Greek myth, Queen Cassiopeia and King Cepheus were placed in this special area of the sky as a punishment for Queen
Cassiopeia's vanity. Although being placed in a royal throne to look down on the Earth may not seem like much of a punishment, keep in mind that as the Earth turns, the stars will seem change their place. The stars towards the southern horizon will be seen to move across the sky from East to West but the stars to the North close to Polaris will be seen circling the North Star, Polaris. So although, Queen Cassiopeia was seen sitting upright in her throne when we began she will also spend half of her time hanging upside down in the sky! Now that's a punishment for a boastful Queen! ...but what about the other Spring constellations?

Perhaps, the most splendid of all is Leo the Lion, due South and about three quarters of the way up. In Greek Mythology, Leo supposedly came to Earth from the Moon in the form of a shooting star. While here, he ravaged the Nemean forest but was finally slain by Hercules. The gods then placed Leo among the stars to commemorate that struggle. To find Leo, look for a backwards question
mark. The bright star at the base of the
question mark is Regulus which marks Leo's
heart and was considered to be the leader of
the four Royal Stars of the Ancient Persian
Empire. Ten thousand years ago, the stars
of Leo marked the Sun's position at the
beginning of Summer. In Egypt at this time
of year, the lions of the Egyptian desert
sought to escape the heat by coming to the
Nile which was its greatest height at that
season. It has been suggested that the
constellation had its origin in this event.

Slightly west of Leo is one of the
fainter patterns of the Zodiac - Cancer the
Crab. Although none of the stars in Cancer
are brighter than the fourth magnitude, the
constellation has at least one object of
interest to amateur astronomers. This is
the open star cluster known as Praesepe or
The Beehive. Even a small telescope should
bring the cluster easily into view.

East of Leo, the sky is dominated by
two first magnitude stars, Arcturus and Spica.
Arcturus is slightly orange in color, and is
the brightest star in "Bootes the Herdsman"
Slide 65 or Bear Driver. While the stars of Bootes may suggest the outline of the Herdsman, it is probably easier to find a "kite-shaped" pattern and move on to the second of our bright stars, Spica. Easily the brightest star in "Virgo the Virgin", Spica shines with a blue-white light. Virgo is sometimes identified with Ceres, the Goddess of Fields and Growing Crops. In this connection Spica is sometimes shown as a sheath of wheat or ear of corn held in her hand. The fact that the star pattern is most readily seen from March through August, the growing season for many crops, is also probably more than coincidence. On the other hand, Virgo is also occasionally said to represent the goddess of justice, which fits well with the fact that her eastern neighbor in the Zodiac is "Libra, the scales of justice". Unfortunately, Spica aside, the stars of Virgo are rather faint, and it is difficult to imagine much more than a letter "Y" formed by them.

Slide 66 The last Spring constellation readily seen on an evening in late March or April
is "Hercules." Low on the horizon in the northeast, a double chain of stars forms his initial. One side of the "H" is a long elaborate curve. The other side is made up of only three stars. In the traditional constellation pictures, Hercules is usually shown holding a club in his hand. The figure is somewhat difficult to make out due to the fact that it is upside down when seen from the northern hemisphere.

You may wish to find some of these constellations and celestial objects on your own, on the next clear night. To help you locate constellations or objects in the sky, you can use a "Star Map." Just like on Earth, people use maps to locate places or things, people use star maps or star charts to locate places in the sky. However, a star map like this, would not be used to travel from one place to another in space, the way a map on earth might be used to go from one city to another.

On these star maps, dots represent the position of stars in the sky, as seen from Earth, for a given time. Some of these
dots may be connected together on the map to form the outline of the constellations. Now, some star maps show the whole sky in one diagram, while others divide the night sky into sections. The map that you see now divides the sky into two parts.

Many of these star maps may have horizons drawn on them, showing the direction in which you should look to find an object in the sky. For example, on this map, if an object or constellation is shown over the word "South," then you should look in the direction of South to find it in the real sky. If the object is shown on the map between "South" and "East," then you should look to the "Southeast" to find it in the real sky.

If a dot on the map is close to the horizon on the map, then it should be close to the horizon in the real sky, and thus be low in the sky. If a dot on the star map is shown far from the horizon on the map, then it should be far from the horizon in the real sky, and thus be seen high in the sky.
Some star maps show the brightness of stars by symbols on the map like the size of the dot on the map. For this map, a large dot represents a bright star and a small dot represents a dim star.

You would use the star map that you see here, for a night in the Spring, if you wanted to find objects in the sky towards the southern horizon, from East to West. For an example of its use, this map indicates that the constellation "Leo the Lion" would be found by facing the "Eastern Horizon" and looking about half-way up in the sky. But suppose you wanted to locate objects to the "North"? If this was the case, and you were using these maps, you would need to use the second part of the map.

Here is the second part of this map for a Spring evening. This sections of the map indicates the position of objects in the sky towards the "Northern horizon." For example, this map points out that the constellation "Cassiopeia the Queen" would be found in the "Northwestern" part of the
sky for a time in the early evening on a Spring night. The map also points out that you would have to look low in the sky in order to find it.

These star maps can be quite useful and fun to use. Through their use, they can help you to learn more about the starry heavens above our heads.

While we have been looking at the Sky-marks of our evening sky, we have held the stars in check. The Earth, though, with its constant spinning, does not allow this to happen in reality. And so, as you make your way among the stars and planets, clusters and galaxies of a Spring night, the motion of the sky may eventually serve to remind you that the minutes and hours are passing away. In the East, the stars of Summer begin to come into view bringing with them the glow of the richest regions of the Milky Way. Still later, the faint light of the coming dawn will begin to show itself over the eastern horizon announcing the end of night and the beginnings of the new day.
motion. Be sure that sun is well below horizon. Turn on sun projector. As music continues attempt to produce a dramatic sunrise timing the arrival of the sun with the end music. (optional: if a projector is available, use Slide 74 aimed towards the eastern horizon.) Slowly increase cove lighting as sunrise progresses. Slide 75. (The End.)

Program running time is 40 minutes.

(approximately one minute of end music remains. The concluding piece is "See the Conquering Hero Comes" from Judas Maccabaeus by Handel. This recording was performed by the Philadelphia Orchestra conducted by Eugene Ormandy and recorded on RCA, LSC-3226.)
Finding Your Star

The following is an adaptation of a planetarium program by the Holt Planetarium Lawrence Hall of Science University of California Berkeley, California

Script adaptation by Gerald L. Mallon
OBJECTIVES

By the end of the planetarium session, the participants should be able to:

1. Define the term "Constellation" as a group of stars connected together to form a shape in the sky.
2. State that constellations can be used as "Skymarks" or signposts to locate other objects in the sky. (e.g. nebulae, planets, etc.)
3. Recognize a given set of constellations as represented on a "Star Map."
4. Demonstrate the use of a "Star Map" in locating an object or constellation in the sky.
5. Relate various pieces of factual information about the sky. (e.g. If a star is seen next to one star on one night, it will be next to that star on other nights.)

PREPARATION

1. Precession - 0 Current
2. Latitude - Home
3. Sun, set for present date.
4. Turn off sun, moon, planets, NSEW lights
5. Check constellation outline alignments (if you possess them, they are not supplied in package)
6. Set 8 hours of Right Ascension on meridian.
7. Set slide projector(s) on first slide (see list)
8. Turn on daylight, stars, and entrance music
9. Be sure to have the necessary star maps readily available.
10. Check the battery-operated light pointer.
11. Check the overhead projector and transparencies.

RECOMMENDATIONS

It isn't expected that the actual script be memorized (as an actor might memorize a part) but to be used as a guide in learning, rehearsing, and improving your presentation. It is recommended that you read the script over a few times noting the questions, activities, equipment, etc., and then work with it in the planetarium, practicing the projector controls, slides,
special effects, and music. You should be able to imagine yourself presenting information, asking questions, and responding to participants.

Directions for the instructor are single spaced in the body of the script which is double spaced. Equipment directions are placed in the left hand margin beside the appropriate part of the script. Questions to which the audience is expected to respond are printed in CAPITAL LETTERS. There is no point in memorizing the narration "word-for-word" but follow the general progression of concepts and activities with your own presentation.

The most important elements of the program are the questions and the activities since these involve the audience in active learning. The program must not exceed 40 minutes, if you must shorten your presentation it is recommended that you borrow time from the narration. If you find that you have not used up the full 40 minutes then repeat the activity of locating and naming the constellations until the time is up.
Full lighting for entry and introduction.

Welcome. My name is _________ and I would like to welcome you to the _________ Planetarium. Today, you can learn about the constellations, some of the brightest stars, and how to use a star map to find objects in the sky.

The stars which you will soon see are just as they will appear tonight from our area around nine or ten P.M., if the sky is clear. Let's see if you can find one constellation without any help from me. LOOK AROUND THE PLANETARIUM SKY AND SEE IF YOU CAN FIND A GROUP OF STARS THAT LOOK LIKE A DIPPER. HOLD UP YOUR HAND WHEN YOU FIND IT.

Gradually dim lights. Stars on. (Wait until most of the participants have actually found it, then give one person the pointer to show everyone else the location. Ask him or her to slowly point out the "handle" of the Big Dipper and the "part that holds the soup." If your person found another dipper shape, be positive. Note that there are many dipper-like shapes, all good, but that we want the most familiar one. Then ask for another dipper shape to be found.)
Every civilization, all over the earth has names and stories about the stars. Usually, these stories are about a group or "constellation." A "constellation" is a group of stars that seem to form a pattern or shape in the sky. People who lived at different times, in different places, often chose the same groups of stars as constellations, but imagined them to look like the particular animals or gods that were important in their own culture. What we call the Big Dipper, for instance, was called "Ursa Major" or the Big Bear, by the ancient Romans. Why do you think that people like the Romans, who lived thousands of years ago, made up names and stories about the stars?

(Accept all answers equally, then briefly recapsulize the participants' ideas before going on.)

One of the reasons for identifying constellations which was or was not on your list is still important today -- finding directions. If you are lost in the woods, but you know that there is a city or a road to the South, for example, you can use the...
Big Dipper to find "Polaris, the North Star"
Since Polaris is always in the direction of
North, we can use it as a compass in the
dark. Now Polaris is not a very bright
star but it is important to us. DOES ANY­
ONE KNOW A GOOD WAY TO FIND POLARIS?
(Usually someone does. In any event,
use your pointer to show the "pointer stars"
Polaris, and the northern horizon and the
other directions.)

In fact, Polaris indicates North with
more accuracy than a simple magnetic com­
pass.

Astronomers today use constellations as
convenient direction markers to help name
and locate interesting objects, like the
"Great Nebula in Orion." We shall use con­
stellations this way in today's program.

NOW, TAKE A LOOK AROUND THE SKY AND
SEE IF YOU CAN FIND A GROUP OF STARS THAT
LOOK LIKE SOME KIND OF ANIMAL, PERSON, OR
THING IN THE SKY -- RAISE YOUR HAND IF YOU
HAVE AN IDEA THAT YOU WANT TO TELL US ABOUT.

(Allow three or four students to point
out their constellations and describe them
to the group -- try to help everyone to see
what the inventor of the constellation sees.
Please spend no more than 2 or 3 minutes on
this section.)
If you had lived thousands of years ago, you might have spent time making up constellations like this, just as you spend time watching TV or reading today.

(End this section by reinforcing the idea that we do all need to learn one name for each constellation though, so that we can communicate with other people about the parts of the sky.)

Bring up lights

(Use the overhead transparency of the star maps to explain their use as follows. Do not distribute the maps to the students until you are satisfied that the majority understand your directions. If you can not use an overhead transparency, then make a quick drawing on the chalkboard or display one of the student maps as you explain its use.)

These are maps of the sky which we will use to find some of the major constellations that can easily be seen at this time of year. Just like people on Earth use maps to find places on Earth, we can use maps of the sky to find places in the sky. After you have some experience using these maps right here in the planetariums, they will be yours to take home so that you can find constellations in your own neighborhood.

These maps represent the sky for April and May around 9 to 10 P.M. Although there is only 1 whole sky over our heads, the sky
is divided into two parts for our maps. So we will use one map when we look towards the South and one map when we look towards the North. If you hold either map in front of you, the dots on the paper will show you how the stars should look in that part of the real sky. Not all of the stars in the sky are on these maps however, only the brighter ones.

WHAT DO YOU THINK THIS LINE IS SUPPOSED TO BE THAT GOES ACROSS THE BOTTOM OF THE MAP?
The line across the bottom of the map is supposed to be the "horizon" -- that is the place, far in the distance, where the sky seems to meet the earth. This is what you see when you look straight out in front of you, where the tops of buildings and trees seem to touch the sky.

(Point our horizon on map and the Planetarium horizon as well.)

If a star on the map is near the words "Northern Horizon," it will be in the northern part of the real sky. (Point out.) If the star on the map is near the words Eastern Horizon, it will be in the eastern part of the sky. (Point out) WHAT IF A STAR ON THE
MAP IS IN-BETWEEN SOUTH AND EAST THOUGH.
(Point out.) WHERE WOULD YOU LOOK FOR IT IN THE SKY? We would find it in the southeastern part of the sky.

The farther from the horizon on the map a star is, the higher in the sky it will be.
(Point out.) WHERE WOULD YOU LOOK IN THE SKY TO FIND A STAR THAT WAS OVER SOUTH OR NORTH BUT WAS UP AT THE TOP OF OUR MAP?
A star shown at the top of the map over South or North, would be found high in the real sky, probably directly overhead.

As an example, let's see how to use the map to find "Orion the Hunter." Orion the Hunter is in the direction of South so we will use the "Southern Horizon" star map. Look at how the dots are arranged on the map. IS ORION THE HUNTER NEAR THE HORIZON OR HIGH UP IN THE SKY?
(Make sure that everyone agrees before going on.)

Now watch me as I use the map to find Orion the Hunter in the sky. On the map, Orion is closest to the Southern Horizon, so I know that I should face South and hold
the map in front of me, with the words "Southern Horizon" forward. When I look at the sky, about this high, I should see the same pattern of stars that appears on the map, and there it is! (Point out.) If I were looking for a constellation in the North, I would have used the other map and turned myself to face North, so that the words Northern Horizon were in front of me, and looked that way.

Remember, when using your map:

1. First locate the constellation on the correct map.
2. Determine what direction you must face.
3. Decide if it is high in the sky or near the horizon.
4. Hold the map in front of you and compare the map with the stars you see in the sky.

It will be easier to locate the brightest stars in your constellation first.

(Assign groups to locate constellations according to the appropriate chart. Encourage the group members to help each other, quietly, and only after everyone has had a chance to look for it on their own. When assigning constellations to groups (for example rows of students in the planetarium) examine the "sight lines" for the students. Students sitting near the western horizon
may not be able to see the eastern horizon because of the planetarium instrument. Therefore it would be better to assign them a constellation over south or north.

Leave reading lights on continuously, or periodically bring a little light up for students to check their maps. Fully dark skies are too full of stars, and all the constellations on these maps can be found in a "light-polluted" planetarium sky.

Offer to help individual groups one at a time, but don't rush them. Don't point out stars for anyone, but talk through the procedure for using the star map step-by-step for their constellations until they are looking in the correct direction. If some groups finish quickly, ask them to find neighboring constellations in the sky. Check to see that all groups have found their constellations before going on.)

Is everybody ready? Let me pass around a flashlight-pointer so that one member of each group can show us which stars in the sky you think make up your constellation.

Let's begin with the constellation "Taurus the Bull."

(Have one person in each group name the constellation his or her group has been assigned, and then ask everyone to find that one on their maps, and to approximate what part of the sky it should be in. Then have the person in the group point out where they decided the constellation was, star by star. If they mis-identify it, be positive and encouraging, pointing out how close the resemblance is, and ask them (or others) to try again.

As each constellation is identified, quickly provide the following information:

Slides on. 1. Project an outline of the mythological figure.

Constellations, 2. Show a slide of an interesting
and interesting objects. 3. Point out the location of the interesting object in the constellation.

4. Invite the visitors to mark that position on their maps, and look for the object themselves, using binoculars, the next time they are out under dark skies.

Mention that these objects are not physically "in" the constellations, but may be very far beyond the stars we can see (like the Orion Nebula). The stars of the constellations merely provide convenient markers or frames.

Be sure that you locate all constellations marked on the star maps. Once all of the constellations have been pointed out by the groups take a few minutes to review them by having other students locate constellations that were not their original one.

In looking for these constellations, you might be thinking to yourself, "Why did they ever imagine that? It doesn't look like that to me." Remember these constellations were made up by people using their imagination and we all have different imaginations. We're different people! Now to me, for example, the Big Dipper is just that, a big dipper; and indeed to some people in southern France, this group of stars was the Casserole, or sauce pan.

But to the Romans, the Dipper was just part of a larger constellation, Ursa Major which means "The Great Bear." TRY TO IMA-
Here is a Roman myth about the bear.

"Once the king of gods, Jupiter, fell in love with Callisto, a beautiful young girl. But Juno, the queen of the gods, was very jealous, so she turned poor Callisto into a bear. Jupiter felt sorry for Callisto, so to protect her from hunters, he placed her up in the sky where we can see her every night if we look."

To the American Indians, the Dipper was also a bear. It is remarkable that two cultures, so very far apart, came up with the same unlikely image for these stars. But the American Indians did not draw their bear exactly the same way. Many of you have seen bears in the zoo. WHAT IS WRONG WITH THIS BEAR?

(Accept ideas from audience.)

So we can see that what's wrong with this bear is its long tail.

To the early people in England, the Dipper was neither a dipper nor a bear, but was a plough, drawn by oxen. WHY DO YOU THINK THEY THOUGHT OF THIS CONSTELLATION,
WHICH IS SEEN HIGH IN THE SKY LIKE THIS, IN THE SPRINGTIME, AS A PLOUGH?

(Responses might include, "it is time to plant," "it goes around and round like a farmer ploughing his field," etc. Accept all answers.)

There is no "best" or "correct" story, of course. I hope each of you will make up your own story about the Big Dipper and the other constellations. They belong to everyone, so your own imagination can be just as valid as the ancient Romans' or anyone else's.

So we have found each of the major constellations in tonight's sky. IF WE KEPT WATCHING TONIGHT, WOULD THE STARS REMAIN LIKE THIS? WHAT WOULD HAPPEN? WHY?

(Accept ideas from the audience, amplifying and correcting as necessary, in a positive fashion.)

So we can judge that the earth is turning on its axis by watching the sky. Let's go through the entire night, speeded up so that we will come to tomorrow morning in just three minutes. Please keep track of your constellation to see what happens to it during the course of the night. ALSO, PLEASE WATCH THIS STAR, WHICH WE SAID WAS POLARIS.
Dim lights

Begin diurnal motion.

Stop diurnal motion.

It is now about 2 A.M. CAN YOU STILL SEE YOUR CONSTELLATION? WHAT HAS HAPPENED TO IT?

WHAT HAS HAPPENED TO THE BIG DIPPER?

WHAT HAS HAPPENED TO THE NORTH STAR?

DID ANY STAR LEAVE ONE CONSTELLATION AND GO TO ANOTHER ONE?

(Allow for responses and discussion after each question. Encourage general observations such as "stars seem to rise and set like the sun," "the north star always stays still," "stars always stay the same distance from each other and do not get closer or farther apart." If you have a particularly quiet group, try to draw at least these preceding three comments from the group.)

Begin diurnal motion. Turn on sun. Turn on music. At sunrise, turn on daylight & fade out music.

It is now eight o'clock in the morning - time for school and work. Please take your star maps with you when you go so you can locate the constellations in the real sky.
on the first clear night. Thank you for your attention and help today. I've enjoyed being with you today.