The application of the planetarium as an education tool

Thesis

How to cite:

© 1980 The Author

Version: Version of Record

Copyright and Moral Rights for the articles on this site are retained by the individual authors and/or other copyright owners. For more information on Open Research Online's data policy on reuse of materials please consult the policies page.

oro.open.ac.uk
THE APPLICATION OF THE PLANETARIUM

AS AN EDUCATIONAL TOOL

INSTITUTE OF EDUCATIONAL TECHNOLOGY

PhD-Thesis

by

Kurt Paul Firniss
M.Sc., ACP, Ing.VDI

1980
Any maps, pages, tables, figures, graphs, or photographs, missing from this digital copy, have been excluded at the request of the university.
APPENDIX 1
NOT COPIED
ON INSTRUCTION
FROM
THE UNIVERSITY
ABSTRACT OF THE THESIS
ENTITLED

THE APPLICATION OF THE PLANETARIUM AS AN EDUCATIONAL TOOL

Research Hypothesis

"Planetariums are considered to be educationally valuable Teaching Tools and there seems to exist a Demand for them; but for a Variety of Reasons Planetariums are underused in Education."

The study was stimulated by the fact that the planetarium as a theme has been completely neglected by educational research in the very country of its origin, Germany. Limited research done elsewhere is focussed on themes concerned with the selected application of the planetarium but no survey has been undertaken on its wider acceptance and its apparent underuse. A broad spectrum investigation has therefore been conducted, guided by the general hypothesis printed at the head of this abstract.

The thesis is presented in 3 chapters:

I Introduction with one essay on the "Science of Astronomy" and one essay on the "History, Purpose and Design of the Planetarium";

II The Educational Value and the Educational Potential of the Planetarium and Demand for School Planetariums;

III The Underuse of the Planetarium.

Actual work was preceded by initial exploratory and pilot surveys which established the relevance of the research problem, the validity of the hypothesis and the feasibility of the project.
6 opinion polls including tests with 535 planetarium visitors were conducted both internationally and nationally and also literature was evaluated in order to determine opinions and attitudes about the educational value and the educational potential of the planetarium and the demand for planetariums. All those concerned with the planetarium in one capacity or other were involved.

The planetarium's intrinsic value was assessed from a study of the scope and quality of its functions as a teaching tool.

Experiments performed in the planetarium confirmed the planetarium's effectiveness in both the cognitive and affective domains.

Demand was also established on the level of the Ministries of Education but could not be confirmed as being known to the manufacturers.

The underuse of the planetarium and many reasons responsible for it were confirmed by 9 further surveys.

20 surveys and 5 experiments involving the participation of N = 1187 subjects were conducted, and an advertising campaign with 2420 schools for school planetariums has been evaluated.

The hypothesis was essentially supported by the results of the surveys conducted.

---

Organisational Scheme of the Thesis

Abstract, Prologue, and Introduction (in Chapter 1)

<table>
<thead>
<tr>
<th>Chapter I</th>
<th>Chapter II</th>
<th>Chapter III</th>
</tr>
</thead>
<tbody>
<tr>
<td>General Introduction with 12 Paragraphs</td>
<td>Educational Value of the Planetarium and Demand</td>
<td>The Underuse of the Planetarium</td>
</tr>
<tr>
<td>Essay: &quot;The Planetarium, its History, Purpose, and Design&quot;</td>
<td>2 Preparatory Surveys</td>
<td>3 Surveys in the Cultural Scene and 1 Discussion of a Thesis</td>
</tr>
<tr>
<td></td>
<td>2 Evaluative Surveys</td>
<td>3 Surveys in the Educational Scene</td>
</tr>
<tr>
<td></td>
<td>5 Opinion Polls</td>
<td>2 Surveys with Manufacturers</td>
</tr>
<tr>
<td></td>
<td>1 Set of 5 Educational Experiments</td>
<td>Summary</td>
</tr>
<tr>
<td></td>
<td>1 Survey on Demand</td>
<td>Summary</td>
</tr>
<tr>
<td>Summary</td>
<td></td>
<td>General Summary, Evaluation, Conclusion, Implications, and Recommendations</td>
</tr>
</tbody>
</table>

Originality of the Work, the Product of the Research, Recommendations for further Research

Index of Literature

Appendix
# Table of Contents

**Prologue**

- Abstract of the Thesis  
- Statutory Declaration  
- Acknowledgements  
- List of Tables, Pictures and Figures

**CHAPTER I - THE RESEARCH THEME**

**Introduction**

- 1) General Foreword  
- 2) Justification for the Research  
- 3) The Research Problem, Theme and Purpose  
- 4) The Concept of the Work  
- 5) The General Research Hypothesis  
- 6) Methodology  
- 7) Procedure  
- 8) Rationale of the Questions  
- 9) Population  
- 10) Evidence  
- 11) Leitmotiv  
- 12) Organisation  
- 13) Terminology

**Setting the Scene**

- 1) The Science of Astronomy  
- 2) The Planetarium; its History, Purpose and Design

**CHAPTER II - THE EDUCATIONAL VALUE OF THE PLANETARIUM AND DEMAND FOR SCHOOL PLANETARIUMS**

**Introduction and Synopsis**

**The Preparatory Surveys**

- 1) Preparatory Survey of the Planetarium World  
- 2) Target Group Survey

**The Evaluative Surveys**

- 3) Evaluation of Research - and General Literature on the Planetarium  
- 4) The Planetarium's Intrinsic Educational Value. A Survey with Educ. Institutions and Media Research
The Opinion Poll Surveys

5) School Surveys "Educational Value and Demand" 156
6) Survey with Planetarium Visitors 179
7) Survey with Astronomers 210
8) Survey with Planetarium Teachers and a Knowledgeable Audience 235
9) Survey with Planetarium Manufacturers 270

Experiments
10) 5 Experiments in the Planetarium to determine its Educational Value 276

Demand
11) Survey with Ministries of Education and Manufacturers on the Question of Demand 333

The Summary of Chapter II 344

CHAPTER III - THE UNDERUSE OF THE PLANETARIUM
Introduction and Synopsis 347

The Planetarium's Position in the Cultural Scene
1) The Number of Planetariums 349
2) Planetarium Activities in West Germany 359
3) Construction of a Planetarium and Equipment Selection 367
4) The Public's Cultural Interests 377

The Planetarium's Position in the Educational Field
Introduction 385

5) Actual and Potential Reasons for the Underuse of the Planetarium inherent in the School System and in Teacher's Fears 386
6) Reasons for the Underuse of the Planetarium as inherent in the School Authorities' Budgetary System 415
7) Survey with Finance Departments of Ministries of Education 422

The Planetarium's Promotion by Manufacturers
8) Survey with Planetarium Manufacturers 439
9) An Ultimate Test - Advertising for Planetariums 445

The Summary of Chapter III 448

General Summary, Evaluation and Conclusion 451

The Product of the Research 463

Recommendations for further Research 466

Index of Literature used 468

Index of Planetarium Literature compiled 473
The Appendix

Tables, Letters, Graphs, Questionnaires

<table>
<thead>
<tr>
<th>No.</th>
<th>Description</th>
<th>Survey Ref.</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>List of Astronomical Institutes</td>
<td>II/2</td>
<td>537</td>
</tr>
<tr>
<td>2.1</td>
<td>Table School Pilot Survey</td>
<td>II/5 A</td>
<td>539</td>
</tr>
<tr>
<td>2.2</td>
<td>Cross References School Pilot Survey</td>
<td>II/5 A</td>
<td>540</td>
</tr>
<tr>
<td>2.3</td>
<td>School Pilot Survey, Comprehensive Questionnaire</td>
<td>II/5 A</td>
<td>541</td>
</tr>
<tr>
<td>2.4</td>
<td>School Main Survey, Letter to the Headmasters</td>
<td>II/5 B</td>
<td>544</td>
</tr>
<tr>
<td>2.5</td>
<td>School Main Survey, Comprehensive Questionnaire</td>
<td>II/5</td>
<td>546</td>
</tr>
<tr>
<td>3</td>
<td>Visitors Survey, List of Planetariums</td>
<td>II/6</td>
<td>552</td>
</tr>
<tr>
<td>4</td>
<td>Survey with Astronomers, Circular Letter</td>
<td>II/7</td>
<td>555</td>
</tr>
<tr>
<td>5.1</td>
<td>Meetings of Planetarium Professors, Review and List of Lectures</td>
<td>II/8 A</td>
<td>556</td>
</tr>
<tr>
<td>5.2</td>
<td>Survey with Planetarium Directors West Germany Letter</td>
<td>II/8 C</td>
<td>563</td>
</tr>
<tr>
<td>6.1</td>
<td>Experiments, Questionnaire for Planetarium Lecturers</td>
<td>II/10</td>
<td>565</td>
</tr>
<tr>
<td>6.2</td>
<td>Experiments, Test Sheet I for Students</td>
<td>II/10</td>
<td>566</td>
</tr>
<tr>
<td>6.3</td>
<td>Experiments, Test Sheet II for Students</td>
<td>II/10</td>
<td>568</td>
</tr>
<tr>
<td>6.4</td>
<td>Experiments, Group Results 1-5: 18 sheets</td>
<td>II/10</td>
<td>570-587</td>
</tr>
<tr>
<td>6.5</td>
<td>Scattergrams &quot;Achievement Cognitive Domain&quot;</td>
<td>II/10</td>
<td>588-596</td>
</tr>
<tr>
<td>6.6</td>
<td>Scattergram: Correlation &quot;Gain&quot; - &quot;Attitude&quot; I</td>
<td>II/10</td>
<td>597</td>
</tr>
<tr>
<td>6.7</td>
<td>Scattergram: Correlation &quot;Gain&quot; - &quot;Attitude&quot; II</td>
<td>II/10</td>
<td>598</td>
</tr>
<tr>
<td>6.8</td>
<td>Table: Schools in West Germany</td>
<td>II/11</td>
<td>599</td>
</tr>
<tr>
<td>7.1</td>
<td>Planetarium Activities in West Germany</td>
<td>III/2</td>
<td>600</td>
</tr>
<tr>
<td>7.2</td>
<td>Second Survey with USA Planetariums</td>
<td>III/2</td>
<td>602</td>
</tr>
<tr>
<td>7.3</td>
<td>Circular Letter sent to Planetarium Directors in the USA</td>
<td>III/2</td>
<td>603</td>
</tr>
<tr>
<td>8</td>
<td>Survey with Manufacturers, Questionnaire</td>
<td>III/8</td>
<td>609</td>
</tr>
<tr>
<td>9.1</td>
<td>Advertising Letter for School Planetariums, English Translation</td>
<td>III/9</td>
<td>611</td>
</tr>
<tr>
<td>9.2</td>
<td>Advertising Letter for School Planetariums, German Original</td>
<td>III/9</td>
<td>612</td>
</tr>
<tr>
<td>9.3</td>
<td>Catalogue on School Planetariums</td>
<td>III/9</td>
<td>613</td>
</tr>
<tr>
<td>9.4</td>
<td>Newspaper Advertisements for School Planetariums</td>
<td>III/9</td>
<td>614</td>
</tr>
<tr>
<td></td>
<td>Figures</td>
<td></td>
<td></td>
</tr>
<tr>
<td>10</td>
<td>Survey Planetarium Visitors</td>
<td>II/6</td>
<td>209</td>
</tr>
<tr>
<td>11.1</td>
<td>Experiments</td>
<td>II/10</td>
<td>331</td>
</tr>
<tr>
<td></td>
<td>Graphical Representation of Attitude Scores</td>
<td></td>
<td></td>
</tr>
<tr>
<td>11.2</td>
<td>Experiments</td>
<td>II/10</td>
<td>332</td>
</tr>
<tr>
<td></td>
<td>Graphical Representation of Undecided Votes in the Attitude Test</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
STATUTORY DECLARATION

None of the work described in this thesis has been submitted for any other academic award in this or any other University or Academic Institution.

Originality of the Work

This thesis is exclusively the author's original work and does not contain any contributions of any other party other than duly quoted citations and references.
ACKNOWLEDGEMENTS

First of all, the author would like to express his gratitude to the OPEN UNIVERSITY, who have made this study possible.

The author's gratitude also goes to the Institute of Educational Technology at the OU and especially to Dr. A. W. Bates, the internal supervisor, and to Dr. P. Whitaker of the University of Birmingham, the external supervisor for this thesis. Without their constant encouragement, their many valuable suggestions and continued guidance this work would never have been possible.

Last but not least, thanks and appreciation go to Herr Herrmann, Director of the Recklinghausen Planetarium, and Herr Mewes, Director of the Kiel Planetarium, for their most valuable assistance in performing the experiments in their Planetariums, and also to all those who have assisted me by answering questionnaires and participating in interviews and have thus helped me gather together the many small details of which this work is comprised.
CHAPTER I - THE RESEARCH THEME

Introduction

1. General Foreword:

Astronomy

From time immemorial, man has been fascinated by the starry sky and has been mystified by the periodic re-occurrences of celestial phenomena. Somewhere in the history of the development of the human mind man learned to master the laws and rules that govern the movement of the celestial bodies and that open the way to understanding the cosmos, then Astronomy was born as a science. Ancient Greece, the culture that methodically developed teaching and learning skills, also invented teaching tools. Among these tools were geocentric models of the universe. (See chapter I on the history of the planetarium).

The Planetarium

It was not until the invention of the large projection planetarium by Prof. Walter Bauersfeld and the small school-size projection planetarium by Armand Spitz that this tool found widespread acceptance in the educational world.

Research

The many claims made by the proponents of the planetarium about its high educational value as a teaching tool had not been substantiated by any educational research during the first four decades of its existence. The beginning of systematic research on the planetarium's value (effectiveness) as an educational tool dates back only to 1959/1960, (see programme II/3). Most of the research work in this field has been done in the USA, whereas general literature on the planetarium has blossomed wherever a new planetarium has been installed. The planetarium has become established as a public attraction, and it has won recognition as an educational tool. Educational
research has supported this recognition but has also produced evidence challenging the planetarium's educational value.

2. Justification of the Research:

While research on the planetarium's educational value has focused on individual selected topics as teaching themes (e.g. constellations etc.) and then made comparisons to the conventional classroom teaching situation, no wide-spectrum investigation into the planetarium's acceptance and recognition has ever been undertaken among those concerned with the planetarium in one capacity or other, nor has there ever been any investigation made into the apparent underuse of the planetarium as an educational tool.-- The planetarium, as a teaching tool, is very unevenly distributed throughout the world. About 1000 planetariums serve the educational system in the USA, only 4 are installed in France, and the country of origin, Germany, has a mere 20 in operation in the Federal Republic and 26 in the smaller Democratic Republic though astronomy is taught at all educational levels in both Germanys.

No research on the planetarium has ever been carried out in both Germanys. The planetarium's value had been taken for granted and questions about its use or non-use have been utterly neglected by educational research in the planetarium's country of origin.

For this reason, an attempt has been made to carry out a research programme concerned with the acceptance of the planetarium as an educational tool.

Limitation

The research area has been limited to West Germany in order to keep the work within manageable proportions and - as mentioned above - no research into the planetarium as an educational tool has ever been done in this target area. It is expected that the results of the research may be transferrable to other countries of a similar social structure and educational system.
3. The Theme and Purpose of the Research:

The themes of this thesis are

1.-A study of the planetarium's intrinsic value as revealed by the nature and quality of its functions as a visual medium for teaching astronomy.

An investigation of the evaluation accorded to the planetarium as an educational tool by all those concerned with the planetarium in a variety of capacities.

Investigations into the school-planetarium's educational value in both the cognitive and the affective domains by conducting practical experiments in the planetarium.

2.-An enquiry into the demand existing or not existing for more planetariums.

3.-A survey of the apparent underuse of the planetarium in education and of the reasons responsible for this underuse.

The purposes of this thesis are

1.-To provide positive or negative proof of the planetarium's educational value.

2.-To discover whether there is a demand for this educational medium.

3.-To discover whether the planetarium is underused and, if so, to indicate the apparent causes responsible for this underuse, and to point towards possible remedies.

4. The Concept of the Work:

The concept of the work comprises essentially an investigation of the underuse of the planetarium and the reasons responsible for it. This is contrasted to the apparent high estimation accorded to the planetarium as an educational tool and to an apparent demand for
school planetariums. The two themes are combined by posing the ques-
tion of why the planetarium should be underused if on the other side
of the scale, so high a value and so much demand is claimed for this
educational medium.

The existence of this value and demand is therefore thoroughly ques-
tioned and the answers found are used as a lever to unearth the
reasons for the underuse of the planetarium.

The investigation of educational value stands on three pillars:

(1) Determination of the planetarium's intrinsic value by
a deeper study of its functions, which includes the
assessment of curriculum demands and relevant
educational theories on media use.

(2) Opinion polls among those concerned with the plane-
tarium.

(3) Experiments to test the planetarium's value in the
cognitive and in the affective domains.

Demand is studied at the levels of the schools, the Ministries of
Education, and the manufacturers.

The underuse of the planetarium is studied in the cultural scene, the
educational field and in the sphere of the responsibility of manufac-
turers.

According to this overall concept and its constituent elements out-
lined above, the work is organized in separate chapters and individual
sections which form, however, a coherent entity.

5. The General Research Hypothesis:

After having conducted a preparatory study and exploratory pilot sur-
veys, the research problem has been clearly defined in the general
hypothesis which governs the work carried out for this thesis:
"PLANETARIA ARE BELIEVED TO BE EDUCATIONALLY VALUABLE TEACHING TOOLS AND THERE SEEMS TO EXIST A DEMAND FOR THEM; BUT FOR A VARIETY OF REASONS PLANETARIA ARE UNDERUSED IN EDUCATION".

6. Methodology: *)

The functions of the planetarium were studied in exploratory surveys, descriptive surveys were undertaken by empirical methods in the form of personal interviews, postal questionnaires, and by evaluation of both general and research literature. Tests have been conducted and experiments performed to test that part of the hypothesis pertaining to educational value. An explanatory survey investigated the financing of planetariums, and other explanatory and descriptive surveys investigated the underuse of the planetarium.

7. Procedure:

The scene has been set by an introduction to the science of astronomy and by the presentation of an essay on the planetarium.

Preparatory and pilot surveys have been conducted for familiarization with the area of research and for the determination of the target group, for assessment of the relevance of the research theme and the efficacy of both the hypothesis and the main measuring instruments.

For the determination of the planetarium's educational value a number of opinion polls were conducted with all those concerned with the planetarium in one capacity or other. General planetarium visitors were asked for their opinion of the planetarium's value in the cognitive domain and their attitude was measured in the affective domain. Experiments were conducted in the planetarium to establish its educational value in this way. The planetarium's intrinsic value has been assessed by a study of its functions as an educational tool. Demand was investigated by enquiries held with schools, ministries and manufacturers. Research - and general literature has been evaluated.

*) Counting the respective pages the work is divided into 51% literary work, 34% sociological work - which includes 21% for the actual opinion polls - and 15% educational-psychological work.
The underuse of the planetarium and the reasons responsible for it were investigated by conducting opinion polls with schools, educational authorities, manufacturers and ministries and by evaluating public statistical data and the advertising activities of a commercial firm.

8. Rationale of the Questions:

In the experiments a standard test was used in the cognitive domain and for the affective domain the author has designed his own measuring instrument and established its validity and reliability.

In the opinion polls and similar investigations using questionnaires the questions evolved partly from informal discussions, were extracted from general literature, or designed by the author based on his familiarity with the research problem. This familiarity with the subject was gained from both the initial pilot surveys and professional experience. The level of questions is that of the ongoing general argumentation on the subject.

Quantification has been performed for most data derived from the various surveys in order to provide a help for analysis of the findings.

9. Population:

A total number of N = 1187 participated in the surveys, tests and experiments. Involved were journalists, professors and teachers, educational authorities and administrators, general planetarium visitors and students, manufacturers, educational researchers and a commercial company which tested 2420 schools. All German geographical names are quoted in the original spelling for the sake of easier reference.

10. Evidence:

All efforts were made to base the findings of the various surveys undertaken on sound scientific evidence. It has been attempted to ensure validity and reliability of all test instruments used. With the exception of the "planetarium achievement test" all test instruments were constructed by the author.
It has been ensured that all questions posed possess content validity and face validity by phrasing and arranging them in a manner adequately covering the themes to be studied. For the test instrument in the affective domain of planetarium teaching, predictive validity has been established additionally.

Reliability of all tests has been established by various methods: Public statistical data and information given by authorities were used, and these were cross-checked in several instances where the information seemed to be in conflict with the author's personal observations. A number of tests repeatedly produced similar results, which indicated reliability. Consistency in answers given to questionnaires has been ascertained and used as an indication of reliability. Where none of the above was possible, reliability has been assumed on the grounds of specific population characteristics.

11. Leitmotiv:

The thesis is guided by the following basic and principle consideration: if the planetarium is of educational value - as is to be studied by a thorough investigation divided into three different approaches - and if actual and/or potential demand for this tool can be diagnosed, it follows that its more widespread use is desirable. The reasons for the apparent underuse of the planetarium in education must therefore be analyzed in order to be able to cast light on the question of how the more widespread use of the planetarium can be promoted.

12. Organization:

This thesis is organized into Chapters, e.g. I. These are divided into Programmes, e.g. I/1, which are also called Report, Study, Survey, Investigation, or Section. These are divided into Paragraphs, e.g. 1.1, which are also called Point or Item.

Tables are filed in accordance with the programmes to which they belong. If tables are folded into the appendix they still maintain the original reference but are additionally marked "Appendix ... ", either individually or as a group. Tables are numbered consecutively, and pages are numbered consecutively from beginning to end.
13. **Terminology:**

A) **Astronomy**

Achievement Test: Means W.T. Bernard's 75 item true-false test on "Heavens" as used by Delivee L. Wright.¹)
(Used by the author in an abbreviated and slightly modified form.)

E) **Educational Value:** is defined as fulfillment of educational objectives in an effective manner.

D) **Demand:** is defined as wanting or desiring a thing in the common meaning of this word, but it is also used in the strictly economic sense of wanting and being ready to buy at a price.

P) **Planetarium:** means the institution or only the projection instrument and its auxiliary equipment. The term also describes earlier mechanical types of planetariums. (Orreries and star globes.)

P) **Planetarium Attitude Test:** means a test designed by the author and administered to test groups in the planetarium to measure engagement in the affective domain.

---

"SETTING THE SCENE"

Prior to entering into the description of the various surveys and studies performed, it is thought expedient to set the scene with an introduction into the science of astronomy, the very domain the planetarium is intended to serve.

It is likewise thought expedient to provide a description of the planetarium, its history, purpose and design. This will set the scene for the theme of the thesis:

THE APPLICATION OF THE PLANETARIUM AS AN EDUCATIONAL TOOL.
THE SCIENCE OF ASTRONOMY

A Brief Review of the Science which the Planetarium
is designed to Serve

The science of astronomy has a long history with roots in ancient Mesopotamia and in classical Greece. Following the burning of the library at Alexandria, however, most of the acquired knowledge was lost or forgotten until its rediscovery by the Arabs. As early as the 8th century, Harun-al-Rashid ordered a translation into Arabic of Ptolemy's Almagest. After the Arabic conquest of Spain the construction of astronomical observatories and mathematical centres followed rapidly at Cordoba and Toledo. Thus astronomy came to medieval Europe via the Arabic seats of learning in Spain to which the scholars of Europe flocked in the 8th to the 11th centuries. They studied astronomy there and translated the books of Albumazar, who had taught astronomy at Baghdad in the 9th century, but Astronomy, that dignified science, was again corrupted into Astrology. Only the reintroduction of the heliocentric system by Copernicus in the 16th century, and, more importantly, the insistence by people like Tycho Brahe and Kepler on the importance of accurate observations and recordings of astronomical data finally swung this important field back to pure scientific inquiry and to a purely scientific level.

Astronomy is in fact the oldest of the sciences. Its early cultivation was stimulated by the beauty and mystery of the starry sky, and in its early beginnings it was associated with ancient religions and mythologies. Its usefulness in guiding voyagers over seas and deserts was soon discovered. The Greek philosophers, the ancient inhabitants of Mesopotamia, the ancient Chinese, and the original people of America all studied astronomy and wrote down their lists of constellations and observational data in almanacs.

Astronomy as a teaching and research subject occupies itself with the investigation of the cosmos of which the earth is a part. Astronomy is interested in the present physical state of cosmic bodies and in cosmic evolution. Astronomy is subdivided into classical astronomy, astrophysics and extraterrestrial astronomy as a division of extraterrestrial physics.
Classical astronomy is largely optical astronomy. The most important task that classical astronomy has given itself is the determination of the location and motion of celestial bodies. These include fixed stars, planets, satellites (moons), comets, star clusters, and galaxies, as well as interplanetary and interstellar matter appearing as luminous nebulae and as dark absorption areas in the sky.

The large variety of these objects demands classification and cataloguing. Of additional importance is the determination of relative distances, and the position of a celestial body in the sky is of particular interest. The branch which occupies itself with this investigation of celestial bodies is called astrometry.

In addition the motion of celestial bodies is studied and also the laws governing those motions. The mathematical treatment of these motions is called sky mechanics.

Stellar astronomy and stellar dynamics combine classical astronomy and astrophysical methods in order to determine the three-dimensional structure and the cinematics of complex star systems with billions of stars and star clusters with the interstellar matter they contain. The study of distant galaxies, many of which show spiral structure, and of recently discovered quasars and pulsars and their position in the cosmos forms an introduction to the fields of cosmology and cosmogony.

The science of astrophysics deals with the physical nature of matter in the cosmos. It inquires into the structure of a celestial body, its evolution, its origin and its properties and the nature of the radiation it emits. The observation of a comet occupies the classical astronomer and the astrophysicist in different manners. Classical astronomy observes, according to the laws of sky mechanics, the course of the comet in the solar system, whereas astrophysics uses the radiation received from the comet in order to determine the matter that composes the comet and tries to clarify why, under the influence of solar radiation, the comet develops a tail and what material the tail consists of. The realm of astrophysics seems as unlimited as the universe itself. There are fixed stars of very varying masses, size, density and radiation, young stars and old stars, pulsating stars and magnetic stars, double stars, neutron stars and finally our sun. Solar physics is an important branch of astrophysics, not in the least because of the far-reaching influence which
the sun exerts on many natural occurrences on our earth.

Research into interstellar matter has developed into an important branch, as this matter seems to be of importance with regard to the origin of new stars. The radiation of remote fixed stars suffers absorption when traveling through these fields of interstellar matter, thus allowing their identification by spectrographic methods. Likewise the existence and direction of interstellar magnetic fields can be verified. Astronomy deals with material and energies of particular nature and mostly under such extreme conditions as can scarcely, or not at all, be reproduced in an earthbound laboratory. Hence, whatever astronomy has to say is of vitally important interest to physics in general, and one can rightfully call the universe a cosmic laboratory.

Extra-terrestrial physics uses high altitude rockets, artificial satellites and space probes as research media, thus offering new possibilities to the astronomer. It is possible in this way to measure stellar radiation in wave-length ranges not attainable on the earth's surface because of the protective absorption that the earth atmosphere provides. Such radiation may be in the far ultraviolet range or even in the range of X-rays. Additional research is done in the earth's high atmosphere, into meteorites and sun winds. "Sky Lab" has been such a celestial research laboratory.

The earthbound observation of celestial bodies depends on the radiation emitted from such objects and its penetration of the earth's atmosphere. In the short wave range, which includes the visible light of the spectrum, optical astronomy using optical telescopes has its domain, whereas in the long wave range from 1 mm up to several meters, radio astronomy finds its field of occupation. Radio astronomy is a relatively young branch of astronomy, but has rapidly gained a most important position. Radio astronomy is not limited to night time observation nor does radio astronomy suffer from general weather conditions. A radio astronomy observatory, however, should be protected against interfering signals from radar or telecommunication stations.

James C. Maxwell proved the electro-magnetic character of light waves and Heinrich Hertz proved in his famous experiments the existence of electric waves, the radio waves. Sir Oliver Lodge was the first scientist to express the view that the sun may emit long wave radiation, i.e. radio waves.
Jansky at the Bell Laboratories was the first to detect such radiation in 1933 and thereafter Reber built the first radio telescope in 1937. He produced maps of the milky way on the basis of radio signals received from a variety of sources in it. In 1942 Hey mapped the first radio signals received from the sun. Such signals from space appear at various wavelengths and various frequencies. In 1951 at a wavelength of 21.105 cm and at a frequency of 1420.4 MHz the radio spectral line of neutral atomic hydrogen was discovered. Hydrogen is the predominant constituent element in the universe, but there are others as well, and today one speaks already of astrochemics as a new branch of analytical astronomy.

The emission of this hydrogen line is produced by a hyperfine transition, i.e. a reversal in the electron spin of the hydrogen atom that causes a small change in the amount of internal energy and results in the radiation of a radio quantum of 21 cm wavelength. Radio astronomy supplements optical astronomy, and both branches nowadays form the two main instrumental pillars on which astronomy stands.

Optical telescopes serve not only as visual aids, increasing the sight angle of the human eye to such an extent as to render minute far-away objects visible, but when combined with sensitive cameras allow photographs of celestial bodies to be taken. This permits star positions to be determined by astrometry, and at the same time forms the basis for photometric measurements. Telescopes are aided by spectrographs which analyze the spectrum of radiations thus allowing the determination of the substances composing such celestial bodies. These optical observational and analytical instruments are housed in observatories away from the influence of large cities. Astronomical data gained in the observatory are evaluated in astronomical institutes of a university associated with the observatory.

The large amount of astronomical data collected by both optical and radio astronomy, and other forms of astronomical observation, are nowadays processed and evaluated by computer methods.

Astronomy, as the oldest of the natural sciences, has had a great influence in the later development of mathematics and physics and has in general exerted an influence on the spiritual history of mankind. Ptolemy's conception of a geo-centric universe - with the earth in its centre - had its impact on the total philosophical conception of the medieval ages. The subsequent thesis of Copernicus on the heliocentric

system - with the sun in the centre of our planetary system - and the
defense of this system by Galileo created an immense spiritual revolu-
tion. Its own impact together with the subsequent philosophies of the age
of enlightenment has created a new conception of life altogether. The
modern ages began with astronomy at the trigger.

Astronomy is a progressing science. A large range of important astro-
nomical discoveries has helped mankind to a better understanding of the
universe and to a better understanding of mankind's position within it.

In October 1957 the first man-made satellite went into orbit. The space
age had begun. Public interest in space research and space travel has
increased with every new successful exploit to conquer space.

In the classical planetarium, better still in the modern planetarium, the
celestial phenomena, and even space travel can be demonstrated and simu-
lated, and the planetarium promises to keep on fascinating its audiences,
but it is noted that its potential as a teaching tool are not sufficiently
realized by educational authorities in West Germany.

In the following study a comprehensive description is given of the plane-
tarium, its history, purpose and design.
# Table of Contents

<table>
<thead>
<tr>
<th>Topic</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>Foreword:</td>
<td>26</td>
</tr>
<tr>
<td>Antecedents:</td>
<td>27</td>
</tr>
<tr>
<td>Celestial Globes</td>
<td>28</td>
</tr>
<tr>
<td>Early Mechanical Planetariums</td>
<td>30</td>
</tr>
<tr>
<td>Modern Mechanical Planetariums</td>
<td>30</td>
</tr>
<tr>
<td>The Projection Planetarium</td>
<td>32</td>
</tr>
<tr>
<td>The Planetarium Chamber</td>
<td>33</td>
</tr>
<tr>
<td>The Planetarium Spectacle</td>
<td>33</td>
</tr>
<tr>
<td>Table: History of the Planetarium</td>
<td>35</td>
</tr>
<tr>
<td>Variety in Planetariums Production</td>
<td>36</td>
</tr>
<tr>
<td>The Luminous Star Globe</td>
<td>36</td>
</tr>
<tr>
<td>The Projection Planetarium, Constructional Characteristics</td>
<td>37</td>
</tr>
<tr>
<td>Slide Projection</td>
<td>37</td>
</tr>
<tr>
<td>Lamp Image Projection</td>
<td>37</td>
</tr>
<tr>
<td>Competition</td>
<td>38</td>
</tr>
<tr>
<td>Classification</td>
<td>38</td>
</tr>
<tr>
<td>Midget Planetariums</td>
<td>39</td>
</tr>
<tr>
<td>Small Planetariums</td>
<td>40</td>
</tr>
<tr>
<td>Medium Small Planetariums</td>
<td>41</td>
</tr>
<tr>
<td>A New Planetarium Concept</td>
<td>43</td>
</tr>
<tr>
<td>The Hyposphere</td>
<td>44</td>
</tr>
<tr>
<td>Medium Large Planetariums</td>
<td>44</td>
</tr>
<tr>
<td>Large Planetariums</td>
<td>45</td>
</tr>
<tr>
<td>Large Planetarium - New Version</td>
<td>47</td>
</tr>
<tr>
<td>A Demanding Public, The Computer Image Creation</td>
<td>50</td>
</tr>
<tr>
<td>Planetarium Programmes</td>
<td>52</td>
</tr>
<tr>
<td>Distribution of Planetariums</td>
<td>54</td>
</tr>
<tr>
<td>Budgets for Planetariums</td>
<td>54</td>
</tr>
<tr>
<td>The Planetarium an Underused Medium</td>
<td>55</td>
</tr>
<tr>
<td>Table: Census of Planetariums</td>
<td>56/57</td>
</tr>
<tr>
<td>Conclusion</td>
<td>58</td>
</tr>
</tbody>
</table>
THE PROJECTION PLANETARIUM
AN EDUCATIONAL TOOL

Professor Walther Bauersfeld (1875 - 1959)
the inventor of the Projection Planetarium

Zeiss Model I - The Worlds first Projection Planetarium

Zeiss Model VI - Projection Planetarium - the latest Design

PLANETARIUM and OBSERVATORY, Bangkok / THAILAND
Foreword

Even among the well-educated classes, there prevails a widespread ignorance and confusion about even elementary celestial laws and events. How can this situation be remedied? The ingenious invention of Professor Bauersfeld of Jena, the projection planetarium, offers - as educators seem to agree - a most impressive method of teaching astronomy and related subjects not only to schools but also to the general public. A planetarium is an attractive cultural institution and, if its performances are well conducted, a faithful clientele will grow who will return over and over again to participate in continuously changing programmes, the possibilities for which seem scarcely limited.

In the following pages a description is given of the history of the planetarium, its purpose and the various constructions and concepts available nowadays.

All large projection planetariums, and even those of medium size, retain the optical illusion that the celestial events demonstrated are infinitely distant, which is a decisive factor in the overall illusion of being actually out in the open under a clear night sky.

Planetarium directors and linguists seem to be still at odds as to whether the plural of planetarium should be planetaria or planetariums. Dr. Harlow Shapely, astronomer/philosopher and late director of the Harvard observatory, and Dr. Armand Spitz "authorized" some twenty years ago an American dictionary publisher to use "planetariums",* and this example is followed in the present paper.

Antecedents:

From time immemorial man has marvelled at the starry sky. Awe and religious mysticism have prevailed throughout many thousand years as the main elements of man's attitude towards the sky above him.

Man learned at some time in history to observe the regularities in the movement of the celestial bodies and, while the necessities of the recurrent floods inspired the science of mathematical geometry and calculation, man learned at the same time to apply the newly learned geometrical laws to the observation of the universe.

Mathematicians have gazed at the heavens for centuries past and the astronomers of ancient Mesopotamia and of ancient Egypt learned to calculate the time of the day and the year; they measured the tilt of the earth's axis and the height of the sun and were able to devise a calendar. Astronomical observations in ancient times were exact enough to allow the Egyptians to devise a very accurate 365-day calendar including a quadrennial leap year. Crude astronomical measuring instruments are known to have existed thousands of years ago. The ancient Greeks built the armillary sphere containing models of various celestial bodies and they used this model for calculating astronomical data and their calendar. The armillary sphere is a model of the universe featuring the skeleton of the celestial sphere. Non-essential parts are cut away, leaving only rings representing the band of the zodiac, equator, tropics, meridian, and the polar axis.

The astronomers of the great Arabic cultural period had studied ancient Greek texts and they reconstructed Greek mathematical instruments which they mounted into the astronomical observatories that were installed at the various seats of learning in the Arab World.
Besides the giant mathematical measuring machines which we see in ancient paintings and find described in ancient scripts, the "astrolabe" was invented, most probably by the Greeks, and refined by the Arabs. The astrolabe is a small handy instrument which served as a universal astronomical observation and measuring instrument used also for astronomical navigation. It is known that Columbus used such an astrolabe on his famous voyage. The astrolabe works like a sextant allowing the angle that sun and stars form against the horizon to be measured, thus allowing the determination of the latitude and the time of day. The astrolabe also carried a star map which could be rotated to find the position of the stars on any night.

In the history of educational media, the astronomical astrolabe and the early mathematical measuring machines bear witness to the ingenious notions of educational necessities. For the early scientists were researchers and teachers alike.

 Celestial Globes:
Besides individual observations of events in the starry sky man has always been fascinated by the total view, and man has tried to construct models of the celestial phenomena and motions in accordance with the then prevailing conceptions of the universe. The impetus for the construction of such celestial models can safely be ascribed to the Greek urge for exercising their artistic talent; and their philosophy of a perfect beauty and all-encompassing harmony found in the round celestial globe a welcome object in which to manifest itself. But purely scientific curiosity also helped to create a perfect model to experiment with, which allowed for condensation of time in reproducing celestial events. Last but not least, a rotatable star globe was a perfect teaching tool for the training of young mathematicians and navigators.

Ptolemy had postulated that the universe was a globe with the earth at its centre. This geocentric conception of the universe prevailed until the period of Copernicus (1473 - 1543) who reintroduced the Greek theory of a heliocentric system of the universe.
The early Greek mythology believed in a flat heaven, and ancient pictures show Hercules carrying the heaven in form of a massive rectangular plate studded with stars.

The ancient Egyptians had portrayed the Goddess Nutt arching over the earth. Her body was star-covered and she swallowed the sun each evening and gave birth to it each following morning.

Anaximander, in the 6th century B.C. in ancient Greece, believed in the spherical form of the sky. The invention of the celestial globe as a model of the universe is ascribed to him. In Greek legends, Atlas was the hero who had to carry the globe of the universe on his shoulders and the legend inspired artists to built such Atlas globes. The museum at Naples in Italy possesses an ancient Atlas globe of 65cm diameter showing mythological star configurations. This globe carried by Atlas was sculptured at the time of the birth of Christ.

In the 3rd century B.C. the poet Aratus wrote a famous poem on astronomy, which inspired artists to create the so-called Aratus globe which has been reproduced over and over again. These Aratus globes not only showed the constellation figures but also showed the ecliptic, the orbit that the sun follows through the 12 constellations of the Zodiac in the course of a year. Also the celestial equator and celestial meridians were chiseled in the marble or bronze globes. These celestial globes were fitted in a meridian ring and could be rotated. Some were mounted in an additional horizontal ring, so that the rising and the setting of the stars and constellations could be exactly studied. (1)

Ptolemy describes in his hand book of astronomy a particularly sophisticated star globe. It incorporated in its gears the astonishing feature of simulating precession, the 26 000 years gyration by which the earth's axis rotates around the ecliptic pole thus producing a slow, continuously changing view of the positions of the fixed stars relative to the axis of the heavens. The triple rotation in Ptolemy's celestial globe corresponded to the natural movement.

(1) Helmut Werner, "From the Aratus to the Zeiss Planetarium", Verlag Gustav Fischer, Stuttgart 1957, page 17.
Early Mechanical Planetariums:
Archimedes (250 B.C.) invented the first exactly functioning planetarium, a geocentric system of the universe which also simulated the motions of the sun, moon and planets as seen from the earth. This planetarium could also demonstrate the eclipses of the sun and the moon. It was naturally a mechanical model and various movements were driven by a water mechanism. We do not know exactly what this ingenious contrivance looked like. We know, however, that Archimedes' planetarium was greatly admired by his contemporaries and by several later generations until it disappeared. Cicero and Ovid commented on the Archimedes planetarium. Several models were built later but have all vanished. Some small remnants of an ancient mechanical planetarium were found recently in the wreck of an old ship in the Mediterranean, revealing some bronze gear wheels of unusually high precision.

The Arabs preserved the ancient sciences and enormously enriched them. Also the Arabs built several planetariums. The Khalif Qusayr' Amrar had in the 8th century a complete dome in the image of the sky painted in a palace south of Damascus. This painted planetarium contained not only the constellations and the great circles of the northern part of the celestial globe but it also included parts of the known southern regions. This seems to be the earliest existing dome with celestial images, the first forerunner of today's projection planetarium dome.

Modern Mechanical Planetariums:
Andreas Busch built in the years 1644 to 1664 a large mechanical star globe, a rotatable holosphere which could be entered. On the interior surface the northern and southern stars were depicted in their proper constellations. The sphere had a diameter of 4 m and on the external surface the contours of the earth globe were painted. 10 people could sit inside the globe. The globe could be rotated by a water-driven mechanism. This rotatable planetarium became known as the Gottorp globe.

Erhard Weigel had built a similar hollow globe in Jena in 1699 and Roger Long built such a globe in Cambridge in 1758.
Christian Huygens constructed a Copernican planetarium in 1682. Huygens devised the mathematical basis for his precision gears which allowed him to build an exact solar system model.

Olaus Römer (1644 - 1710) built a Copernican planetarium in Denmark and Charles Boyle, the 4th Earl of Orrery (1676 - 1731), had such a Copernican planetarium built for himself. This Orrery planetarium became well known and later copies of it were given the name "Orrery".

Eise Eisinga, a West Frisian mechanic, built a mechanical Copernican planetarium which still operates today. It shows 6 planets including the earth and the sun in the centre. It is an exactly functioning model in which the planetary movements are simulated exactly in the natural time; Saturn for instance takes 29 1/2 years for its orbit around the sun.

The astronomical clock in Strasbourg with its large celestial globe may also be considered a planetarium. Its unusual high precision and architectural beauty additionally make it a marvellous masterpiece of clock building.

The German Museum in Munich erected in 1920 in a 12 m diameter round chamber a perfect mechanical planetarium according to the Copernican system. The planets are represented by moveable electric bulbs and the natural celestial movements can be accelerated for demonstration purposes, one year taking 12 minutes to simulate, etc. Moon phases and eclipses can be perfectly simulated in this mechanical planetarium. Several replicas of this mechanical planetarium were built, one of them was installed in the Natural History Museum in New York and another one in the Morehead Building of the University of Chapel Hill.

As ingeniously as all these mechanical planetariums were built, they failed to create the perfect illusion of the starry sky at night. All of them were only models. Dr. Wallace Atwood built a celestial globe for the Museum of Chicago, Academy of Science, in 1912/13 which for the first time in the history of planetariums approached the natural illusion quite closely. It has a globe diameter of 4,5 m and resembles the Gottrop planetarium.
The globe has 692 small apertures of varying sizes representing
the fixed stars to the 4th magnitude. Illuminated from the outside,
these bright pin holes give an observer in the inside of the globe
the illusion of a starry sky. The sun is represented by an electric
lamp which can be moved along the ecliptic. Some planets are
represented by similar holes in the globe's sphere. Electric
motors provide the necessary motion of the globe.

The Projection Planetarium:
In the history of the development of visual media it is significant
that for once it was science and education which approached industry
with a request to perfect the existing mechanical planetariums in
such a way that a perfect illusion of nature could be achieved and
that exact astronomy could be taught in such a planetarium. In many
other instances it was industry which initiated the application of
their product for educational purposes.

Prof. Max Wolf, director of the observatory in Heidelberg, suggested
in 1912 that fixed stars could be simulated by small electrical
bulbs mounted inside a sphere with sun, moon and planets represented
by movable bulbs in front of the fixed star sky. Oskar von Miller,
the director of the "Deutsches Museum" in Munich, who had already
ordered the perfect mechanical planetarium described above, took
up Wolf's idea and approached the Zeiss factory in Jena to get them
to build Wolf's planetarium. Zeiss, however, were busy with other
tasks during the period of the First World War and it was not until
1919 that Prof. Bauersfeld of the Zeiss factory brought forward a
completely new idea for the construction of the planetarium.

Bauersfeld suggested replacing the large mechanical models by a
movable projector which would be driven by precision gears that
could simulate the daily motion and the movements of the planets
with great exactitude. The projector could be built at a much
cheaper price and with much higher precision, and could project
images of the fixed stars and planets and other celestial bodies
on the surface of a fixed hemisphere which could represent the sky.
Bauersfeld erected a 16 m diameter dome for this purpose and in
August 1923 he demonstrated for the first time a projected star
field to a marvelling audience.
The "Deutsche Museum" in Munich bought the Bauersfeld projection planetarium and opened it to the public on the 21st October 1923. A new era in teaching astronomy had begun. This first projection planetarium consisted of 31 individual projectors clustered on a globe. They projected 4500 star images created by small slide-like diapositive plates in a procedure which is perfectly identical to the projection of ordinary lantern slides. Sun, moon and 5 planets were projected by differently geared additional projectors in a separate planetary framework attached to the main star projector. 30 small special projectors projected the names of mythological constellation figures. Besides creating a nearly perfect illusion of the natural starry sky there was the added advantage of condensing time by accelerating the motion motors.

Zeiss have continuously improved the original model and erected several dozens of these great planetariums around the world as places of culture and learning and erudite entertainment. Bauersfeld's ingenious idea of the projection planetarium was later copied by several other firms which first began to build smaller planetariums, all based on Bauersfeld's projection principle. This original basic principle has been maintained throughout 50 years until today.

The Planetarium Chamber:
Though smaller projectors came into existence for correspondingly smaller domes, all planetariums looked essentially the same. A circular auditorium with cylindrical walls was topped by a dome and in the centre under the dome the planetarium projector was installed. Seats were arranged in circular rows around the planetarium projector, so that all spectators could observe the performance more or less with equal ease. Only in recent times has the planetarium experienced a considerable change in arrangement of the auditorium and in construction of the planetarium projector. The size of the audience depends on the dome size and may vary from 20 to 600 spectators.

The Planetarium Spectacle:
In the planetarium the night sky is artificially created at any time during the day. The events in the sky can be dramatically
presented, all motions of the celestial bodies can be simulated as in nature and the precision gears of the planetarium projector allow the planetarium presentation to be positioned at any time in the present, past or future, and as seen from any point of earth. The more recently introduced modern planetariums allow even the perfect simulation of space travel, taking the spectator away from earthbound observation. As all motions of the earth and other celestial bodies can be immensely accelerated it is thus possible to demonstrate events that could otherwise never be observed.

Special projectors in the planetarium allow the mystic star configurations of various cultures to be superimposed on the star field. Star parallax and star aberration can be simulated, scales for time angle, precession dials, one for the northern and one for the southern pole of the ecliptic can be shown, parallels of altitude scales can be projected, a star angle scale allows the determination of the sidereal hour angle as is used in celestial navigation, the nautical triangle can be created in the reference grids of the latitude and meridian scales. These additional devices allow exact studies of celestial motions, exact measurements of celestial events and enormously facilitate the teaching of astronomy and related sciences such as mathematics and geography.

The planetarium has always fascinated its audiences and will surely continue to do so, especially in its more modern form where the planetarium proper has been incorporated into a multi-media space theatre.
### TABLE 1

**HISTORY OF THE PLANETARIUM**

<table>
<thead>
<tr>
<th>Period</th>
<th>Person</th>
<th>Contribution</th>
</tr>
</thead>
<tbody>
<tr>
<td>6th century B.C.</td>
<td>ANAXIMANDER</td>
<td>Postulated the spherical shape of the universe. First star globe.</td>
</tr>
<tr>
<td>3rd century B.C.</td>
<td>ARATUS — Greek Poet</td>
<td>Inspired the construction of the Aratus star globe.</td>
</tr>
<tr>
<td>287 – 212 B.C.</td>
<td>ARCHIMEDES</td>
<td>Invented an exactly functioning planetarium including tellurium simulating the eclipses of sun and moon.</td>
</tr>
<tr>
<td>1st century B.C.</td>
<td>POSEIDONIOS — Greek Philosopher</td>
<td>Copied the Archimedes planetarium.</td>
</tr>
<tr>
<td>100 – 180 A.D.</td>
<td>PTOLEMY</td>
<td>Described a perfectly rotatable star globe.</td>
</tr>
<tr>
<td>8th century A.D.</td>
<td>KHALIF QUSAYR AMRAR — Arab</td>
<td>First known dome painted in the image of the sky.</td>
</tr>
<tr>
<td>1279</td>
<td>MOHAMED BEN MUYID EL ORDHI — Arab</td>
<td>Built a planetarium.</td>
</tr>
<tr>
<td>1289</td>
<td>Arab Astronomers</td>
<td>Built a star globe planetarium, kept in Dresden.</td>
</tr>
<tr>
<td>1397</td>
<td>DONDI DE GIOVANNI OF PADUA</td>
<td>Described his planetarium.</td>
</tr>
<tr>
<td>1594</td>
<td>JOST BÜRGLI — Mathematician</td>
<td>Built a gold-plated small star globe.</td>
</tr>
<tr>
<td>1644 — 1664</td>
<td>ANDREAS BUSCH — German Mechanic</td>
<td>Built a 4 m dia. rotatable star globe holosphere, the &quot;Gottorp globe&quot;. Stars painted on the inner sphere.</td>
</tr>
<tr>
<td>1682</td>
<td>CHRISTIAN HUYGENS — Dutch Physicist</td>
<td>Built a Copernican planetarium.</td>
</tr>
<tr>
<td>1644 — 1710</td>
<td>OLANS RÖMER — Danish Mechanic</td>
<td>Built a Copernican planetarium.</td>
</tr>
<tr>
<td>1676 — 1731</td>
<td>CHARLES BOYLE — English Earl of Orrery</td>
<td>Had a Copernican planetarium built.</td>
</tr>
<tr>
<td>1699</td>
<td>ERHARD WEIGEL — German Mechanic</td>
<td>Built a Gottorp globe in Jena.</td>
</tr>
<tr>
<td>1758</td>
<td>ROGER LONG — English Astronomer</td>
<td>Built a Gottorp globe in Cambridge.</td>
</tr>
<tr>
<td>1770</td>
<td>DAVID RITTENHOUSE — USA</td>
<td>Built an Orrery in Philadelphia with the Keplerian movement.</td>
</tr>
<tr>
<td>1773 — 1780</td>
<td>EISE EISINGA — West Friesian Mechanic</td>
<td>Built a Copernican planetarium moving in natural time.</td>
</tr>
<tr>
<td>1912 / 13</td>
<td>DR. WALLACE ATWOOD — American Scientist</td>
<td>Built a Gottorp type planetarium with 692 star apertures illuminated from outside.</td>
</tr>
<tr>
<td>1913</td>
<td>HINDERMANN (BASEL)</td>
<td>Built the Orbitoskop, a shadow projection Solar-Planet Planetarium.</td>
</tr>
<tr>
<td>1920</td>
<td>The Deutsches Museum in München</td>
<td>Built a 12 m dia. auditorium planetarium with electrical bulbs representing the stars.</td>
</tr>
<tr>
<td>1923</td>
<td>PROF. BAUERSFELD of CARL ZEISS CO. German Scientist</td>
<td>Built the first projection planetarium.</td>
</tr>
<tr>
<td>1949</td>
<td>S.K. MICHAILOV and K.J. SCHITOWSKI</td>
<td>Built UP4, 12 m Dome Planetarium. (Soviet Union)</td>
</tr>
<tr>
<td>after 1947</td>
<td>ARMAND SPITZ, USA</td>
<td>Introduced small size projection school Planetariums.</td>
</tr>
<tr>
<td>1950</td>
<td>R.H. EMMONS</td>
<td>Built a university Planetarium in Kent, Ohio.</td>
</tr>
<tr>
<td>1952</td>
<td>California Academy of Science</td>
<td>Built the Morrison Planetarium.</td>
</tr>
<tr>
<td>1960</td>
<td>Rostov Movie Equipment, Soviet Union</td>
<td>Built transportable Planetariums.</td>
</tr>
<tr>
<td>1961</td>
<td>SIEGRIED MENDE, German Mechanic</td>
<td>Built the Planetarium in Elsfleth.</td>
</tr>
<tr>
<td>1962</td>
<td>FEHRENbach, German Teacher</td>
<td>Built the Freiburg Planetarium.</td>
</tr>
<tr>
<td>1974</td>
<td>DR. LEN SKOLNIK of SPITZ CO. American Engineer</td>
<td>Built the first space theatre planetarium.</td>
</tr>
</tbody>
</table>
VARIETY IN PLANETARIUM PRODUCTION

In the following pages the various types of planetariums are briefly described.

The Luminous Star Globe:
The simplest and yet quite impressive form of a planetarium is the luminous star globe manufactured by several companies. Seen from the outside it is an ordinary star globe showing the stars in reverse order. It represents a three-dimensional model of the universe and is therefore much superior to the two-dimensional star-map. This celestial globe is made of Plexiglas and has a built-in "tellurion". When looked upon from the outside the sphere appears completely dark. With the interior sun, which is a bulb, switched on the globe becomes transparent on the observer's side and one observes the stars on the opposite side in a model representation of the natural curvature of the heavens. The dimensions of the globe do not, of course, allow a true-to-scale representation, but a good compromise has been achieved.

The luminous star globe can be mounted under a small dome and, by means of the built-in bulb, star images can be projected on the surface of the dome, similar to the large projection planetarium performance. This planetarium can demonstrate the inter-relationship of the daily rotation of the earth and its annual movement around the sun, the relationship between the earth equator and the celestial equator between the earth's orbit and the ecliptic, the variations in the visibility of the constellations throughout the course of a year, and the difference between sidereal day and solar day. The various seasons of the year can be demonstrated as well as the phases of the moon, and the apparent orbit of the sun and of the moon. This luminous star globe or planetarium globe is produced in several sizes between about 50 cm to 130 cm.

When used as a projection star ball, naturally, all images, figures and grids are projected simultaneously and may be considered a bit confusing simply by their very number. In a real projection planetarium all can be shown in sequence or mixed to order. The star constellation diagrams and the graduation grids
will appear as precise dark shapes against a somewhat bright sky. Consequently, when used as a projector the star globe planetarium does not give one the illusion of being actually under a starry sky as is the case in a real projection planetarium, where the stars appear as luminous points on a dark sky.

The Projection Planetarium:
Bauersfeld's ingenious invention, the great projection planetarium, has fathered many offspring. Several sizes of planetariums are available nowadays and could be classified according to their sizes, the dome sizes they have been built for, and additionally could be classified according to the projection method applied.

Slide Projection:
There are two distinct different projection methods possible with a planetarium and the projection method has a direct influence on the brilliancy of the star field. The Bauersfeld planetarium operates on the principle of a slide projector. An objective projects a number of stars which are pierced into a metal plate representing the diapositive slide. As in an ordinary slide projector there is a condenser for the equal illumination of the slide and for converging the light of the projection lamp.

Lamp-Image Projection:
The second method invented by Armand Spitz of the USA is to depict an image of the light source onto the planetarium sky. If the lamp were an incandescent bulb then the image would be the incandescent wire and only at a certain distance would this image condense itself to the apparent image of a star. Nowadays, however, with gas discharge lamps of a point-like luminous shape this difficulty has been totally overcome. With the latter method the image of the luminous source may be depicted either by pinhole projection - as is the case with simplier planetarium projectors - or by individual star lenses.

The Brilliance in lamp-image projection:
The diameter of the pin hole or of the aperture of the projection lens is then responsible for the brightness of the star image, while the sizes of the images do not differ nor do distortions
appear if the diameter of the aperture is kept within certain defined limits. SPITZ is using this method in their projectors and they claim to attain a brilliancy range of $1/2146$ in 95 steps against 65 steps in the classical ZEISS projector.\(^{(1)}\)

The very method of projecting star plates, i.e. the metal dia-
positives in the classical star projector makes the diameter of the star-aperture-hole in the diapositive representing each star responsible for the projected brightness of that star. It is thus obvious that a large diameter aperture will project a large star image which produces the illusion of being a bright star, and in contrast a small diameter aperture will produce a small diameter star giving the illusion of a celestial body of lesser brightness. The diameter of the projected star has, of course, to be kept at a certain limit in order to make it look like a fixed star. This entails a limited brilliancy range for the classical projector which, however, can largely be compensated by using filters. Filters are also used to create artificially the colour temperature of coloured stars.

**Competition:**
Both projection methods are in lively competition with each other and the decisive factor in choosing one or the other system seems, as experience shows, to be more a matter of personal taste than of judicious comparison. The fact is that the astronomical spectacle provided by each of the planetarium types is found so fascinating by the public that scarcely anybody would take a yard-stick and measure the diameter of the projected stars in order to compare the quality of one projector to the other.

**Classification:**
In the following description of various planetarium projectors, the projection method which the projector applies will always be indicated. Besides large planetarium projectors, such as the original Bauersfeld projector, industry produces also smaller projectors nowadays, as was mentioned above. Planetariums can be most easily classified according to the size of the dome for which they are built. The author suggests the following classification:

\(^{(1)}\) Helmut Werner, op.cit. page 16
GROUPS OF PLANETARIUMS:

A. **Midget** Planetarium Projector
   = dome size about 3 m diameter

B. **Small** Planetarium Projector
   = dome size 4 m - 7 m diameter

C. **Medium Small** Planetarium Projector
   = dome size 7 m - 10 m diameter

D. **Medium Large** Planetarium Projector
   = dome size 10 m - 13,5 m diameter

E. **Large** Planetarium
   = dome size 16 m - 23 m diameter and more.

The number of stars that a projector can produce is a lesser yardstick for classification as some manufacturers - for reasons of competition - tend to overload their planetarium sky with star images. If the natural illusion is to be kept, the designer has to see to it that in the star field of his planetarium sky the apparent natural distances are reproduced. One may gain more space for more star images by reducing these apparent distances at the price of loosing the illusion of reality. It would be a worthwhile study to determine with the highest degree of exactitude how many stars each planetarium sky diameter can tolerate. The later models of the original ZEISS planetarium projector can project a total of approx. 9,000 stars, and it has been argued that with greater dome sizes beyond the standard 20 m diameter an additional 1,000 stars or so would be an advantage. On the other hand, the number of stars visible to the naked eye amounts to only 3000 at any given time or position and to not more than about 5700 added together for both hemispheres. (2)

**Midget** Planetariums:

A midget size planetarium is being built by Messrs. GOTO of Japan, model EX-3, suitable for a 3 m diameter dome. Projection is achieved by a pin-hole system, except for the solar system which is projected by objectives. 500 fixed stars up to the 4th magnitude and the milky way are projected, the solar system with sun, moon, and 5 planets, meridian, equator, and ecliptic coordinates can likewise be projected. The diurnal motion is motor-driven and the latitudinal change is manually operated. This is a portable low cost classroom type planetarium that may be erected very easily anywhere where

the room can be darkened.

GOTO produce another very small planetarium, model E-5, which is on the borderline of the midget size planetarium to the small planetarium. This model comprises a star ball with a pinhole projection system for the northern and the southern hemisphere. However, the southernmost stars cannot be projected due to the mounting of the star ball at its lower pole. An additional planetary network comprises sun, moon and 5 planets. Diurnal and annual motion are electric-driven, latitudinal and precessional movement are for manual operation. About 650 stars up to the 4th magnitude, with the milky way added, can be projected. The instrument is built for a dome size of ca. 4 m diameter. As such a small dome can be hung from the ceiling of a classroom, the model E-5 can be considered as lying somewhere between a fixed planetarium and a portable planetarium.

Messrs. MINOLTA of Japan also produce a small/midget planetarium of the pin hole projection type with a planetary network showing the visible planets. This projector is suitable for dome sizes between roughly 3.5 m to 7 m.

Messrs. ASTRO-DOME Inc., Ohio, manufacturers of observatory domes and planetarium screens offered several years ago a similar small/midget size planetarium called "Astro-Dome 5100", a pin-hole projector showing about 650 fixed stars and several grids, and the solar system with 5 planets. Domes between about 4 m to 7 m were offered.

Small Planetariums:
Spitz offer with their NOVA III model 373 a planetarium of the small category. The projector produces 950 fixed star images together with the solar system comprising sun, moon and the 5 "naked eye" planets. The celestial coordinates (equator, ecliptic and meridian) as seen from any point on earth and the precession scale are likewise projected. The small instrument allows for precise time condensation and can astronomically take the observer to any point of the earth, past, present or future. Auxiliary projectors show a large range of celestial and meteorological
phenomena. The small apparatus can also be automated so that a complete performance can reel off automatically including sound. This is a great help to a busy teacher who can observe and direct his audience while the celestial spectacle is under way. The projector is built for dome sizes between roughly 5 to 7 m. It seems that the number of stars projectable with the model 373 of SPITZ is well in harmony even with the larger dome of roughly 7 m diameter. The dome is made from fibreglass and can be easily installed in an available chamber of sufficient dimensions. The pinhole method is used.

Medium Small Planetariums:
In the range of the medium planetariums the Japanese companies GOTO and MINOLTA offer various models for dome sizes between 8 and 13.5 m diameter. Also the East German ZEISS company have a medium size planetarium projector in their programme. They all are smaller copies of the large sophisticated original ZEISS projector. They have two different globes, one for the northern and one for the southern hemisphere and also two different planetary networks, like the well-known large classical ZEISS projector. Most of them show also the planets invisible to the naked eye and command a great range of celestial phenomena. All movements are electrically driven. The MINOLTA projector is offered in an automated version, so is the East German ZEISS projector.

Unique in this range is the SPITZ projector, model 512. Whereas the medium size planetarium projectors mentioned above use the classical slide projection method, the SPITZ projector depicts the small glowing centre of a xenon gas discharge lamp which delivers an unusually brilliant star field. It is a single globe projector with attached planetary cage and an array of auxiliary projectors. Projection is done partly by pin holes and partly by individual lenses. The southernmost stars are produced by means of prismatic systems. The very small diameter of the struts in the planetary network avoid the necessity of providing double projectors for the planets. The projector can be completely automated.

Planetariums of the medium size frequently install a number of slide projectors around the rim of the dome for the projection of lunar landscape scenes or other artificially created planetary scenes.
A CLASSROOM PLANETARIUM 10 m Ø AUDITORIUM

MIDGET PLANETARIUM
3 m Ø AUDITORIUM

MEDIUM SIZE PLANETARIUM
7 m Ø AUDITORIUM

SMALL SIZE PLANETARIUM
4 - 5 m Ø AUDITORIUM
Additional effect projectors simulate dusk and dawn, lightning, meteors, meteor showers, aurora, the rising sun, rainbows and clouds. Usually a multi-channel sound system is installed to provide taped lectures and background music.

The seating capacity in the medium size planetariums lies somewhere between 50 and 150 seats depending on the dome size. Most of the planetariums retain the classical seating arrangement of circular rows around the planetarium projector situated in the middle under the zenith. The SPITZ projector 512 has a different arrangement of the auditorium, explained later in these texts.

Medium size planetariums and small size planetariums owe their existence to the fact that schools and colleges do not need a very large planetarium with 400 seats or more, and on the other hand would in many instances not have the budgets to buy a rather expensive large planetarium projector and large planetarium dome plus the many sophisticated auxiliary projectors that go with large planetariums.

A detailed comparison of the medium size projectors would be an interesting and worthwhile study.

A New Planetarium Concept:
The SPITZ company a few years ago patented a 4th axis rotation for the planetarium projector. This special device for azimuth rotation incorporates a completely new philosophy of planetarium design. The credit goes to SPITZ for having, in close cooperation with educationalists, redesigned the planetarium chamber in such a way that the seating is unidirectionally arranged in horseshoe shaped rows all facing the front of the auditorium where a speaker's desk is installed like in an ordinary classroom. This classroom shape arrangement allows for multimedia performances of a unique fashion. The auditorium retains its round structure but has a defined front and rear by the unidirectional seating arrangement. The azimuth rotation of the planetarium projector permits the rotation of the sky field, which creates an optical effect equal to rotating the complete audience. The complete hemisphere remains visible to the audience at all times, but those sections of the compass that are
of particular interest during a lecture can be brought to the front of the audience. A rear projection screen installed in front of the auditorium behind the speaker's place allows for additional effects like projecting slides on space travel from a rear screen projector while the ordinary planetarium show proceeds. In the rear of the room a cinema projector can be installed. This is not possible in a round auditorium with circular seats without sacrificing more than half of the seating capacity during the cinema show. Many educators agree that this new unidirectional arrangement makes the planetarium chamber a most effective part of a whole teaching environment. The company has designed an elevator which permits the 512 planetarium projector to be lowered out of the sight line, so that neither the demonstration table in front nor a cinema projection screen nor the rear projection screen will be obscured by the planetarium projector while other demonstrations occur.

The Hyposphere:
From there it was only one step more to first raising the rear seats a little higher above the planetarium auditorium floor to allow for better vision and finally to tilt the complete planetarium including the dome. This tilting angle ranges from 15° to 30° and allows the creation of a most fascinating teaching environment. Whereas in the ordinary planetarium auditorium the spectator has to look up into the artificial sky with the horizon 2.20 to 3 m above him, a spectator in a tilted dome planetarium has the horizon very near to his sight line so that he is totally immersed in the spectacle. SPITZ call this tilted dome a hyposphere as the front of the dome extends below the horizon. The special construction of the SPITZ projector 512 allows full operation even in this tilted position. It seems that SPITZ are the only company supplying a tilted system. All other projectors are built for a strictly horizontal dome equator.

Medium Large Planetariums:
GOTO, MINOLTA and SPITZ offer medium large projectors for dome sizes of approx. 16 m following the classical planetarium concept. All of them are copies of the classical Bauersfeld projector, reduced in both size and performance. Again SPITZ is the pioneer
in producing a planetarium system allowing unidirectional seating. The space age has induced all planetarium producers to manufacture small extra projectors which will demonstrate the functions and courses of an artificial satellite. SPITZ have computerized their medium size "STP" planetarium projector, which eventually allows them not only to demonstrate the paths of a satellite but to actually simulate space travel. For that reason they call this projector the "Space Transit Planetarium", STP. It has a three-axis drive system. The star field can be rotated about any preselected axis, so that the heavens can be viewed from any planet within the solar system. Roll, pitch and yaw of a maneuvering space ship can be perfectly simulated. The appearance of the sky, including the earth in full colour as seen from the moon, can be simulated. Like the classical planetarium according to which the other existing planetariums of medium large size are shaped, the SPITZ STP projector also has a northern and southern hemisphere star ball. Also with the medium large projector SPITZ use their unique direct light source image projection which provides a particularly brilliant star field, whereas the other projectors follow the classical system of multiple slide projection.

All medium large planetariums offer more details of the celestial spectacle than the small planetarium projectors could possibly provide. Nebulae and star clusters and galaxies are shown, the milky way becomes much more pronounced in appearance, aurora and gegenschein, exactly phased eclipses, larger ranges of constellation figures and a highly increased number of stars for the far larger screen are the additional features of medium large projectors. SPITZ are the first company to have completely computerized a projector and replaced the complicated high precision mechanical gears by an electromechanical analog system, which allows for higher versatility in changes of eras or epochs on the planetarium sky. MINOLTA now also offer an automated version of their projector.

Large Planetariums:
ZEISS of West Germany introduced some time ago their latest model VI, which more recently has also been automated. The first fully automatic ZEISS planetarium is operating in Stuttgart in West Germany
and its director describes it as the absolute optimum in planetarium techniques with not much scope for further development.\(^{3}\)

The basic system has not changed with the new projector but numerous improvements have been made in order to create an almost perfect illusion of the starlit night. A new gas discharge lamp of a colour temperature of 6000° K provides more star brilliancy, likewise the projection lenses have received larger apertures (\(f=2,5\) compared to \(f=4,5\) with earlier projectives). Star apertures in the chromium-plated fixed star plates have been reduced in diameter which provides more puncti-form star images. The projection of all other celestial phenomena has been significantly improved over former models, space flights can be demonstrated and with zoom projectors also simulated to a certain extent.

The ZEISS planetarium has been rightfully praised as a technical wonder. It consists of more than 29,000 individual parts of approx. 2000 different kinds including more than 170 different gears and more than 230 ball bearings. Its overall mechanical functions are of unrivalled mechanical precision.

The German Government presented the United States on the occasion of its 200th Anniversary with a ZEISS Planetarium, Model VI, which was installed in Washington and has recently been automated by Messrs. Gyro-Systems.

GOTO offer a large planetarium projector in the classical fashion.

Individual institutes and individual inventors have built planetariums. The California Academy of Sciences built their own large star projector, the Morrison Planetarium, which was installed on 6th November 1952 in San Francisco. It is a large planetarium with a 20 m dome. In Freiburg, West Germany, Richard Fehrenbach built a medium size projection planetarium housed in a 10 m diameter dome. Others have succeeded in constructing similar apparatus. See History Table no. 1, page 38.

Large Planetarium - New Version:
A great leap forward in the construction of large planetarium projectors has been made by Messrs. SPITZ, U.S.A. This company has left the principles of the construction of large classical planetariums behind and devised a completely new concept. Broadly speaking, their new large planetarium follows the idea of the inclined hyposphere medium size planetarium with unidirectional seating, but in a much larger hall between 20 and 23 m diameter. This new SPITZ planetarium has become a true multi-media space theatre. It comprises a new type of planetarium projector, a nearly hemispherical 70 mm cinema projector, and, in the rear of the planetarium auditorium, a 70 mm cinema projector is installed with a super-wide-angle lens. In front of the planetarium projector, place is kept for a colour TV projector. All individual projectors interact in producing a most entertaining and erudite space theatre show. The Spitz space theatre auditoriums are usually inclined by 27° and the horizon is not 3 m above the spectators as in the classical planetarium but very near to the natural sight line of the observer, so that the observer is practically inside the dome. The planetarium projector itself and all auxiliary projectors, including the cinema projectors, are computer controlled and the show is performed completely automatically while retaining the possibility of manual operation from the control desk.

The main projector utilizes the speed and flexibility of digital drive and control techniques. It can be set backwards or forwards in time much faster than any of the conventional classical planetariums. The projector is one single large star ball with thousands of smaller and larger objectives for the individual projection of more than 10,000 fixed stars including clusters and nebulae, variable stars, the milky way, and many other known celestial phenomena. The projector is mounted in a stiff 3-axis gimbal assembly driven by precision servo-motors. No jitter or irregularities in motion are visible while the starfield moves. A number of special effect planetarium projectors complete the assembly. Besides the medium size projector 512, as mentioned above, the SPITZ single sphere STS planetarium projector is the only existing one that will allow projection in an auditorium inclined by as much as 27°.
MODERN PLANETARIUM
DESIGN
UNIDIRECTIONAL SEATING
INCLINED AUDITORIUM
MULTI-MEDIA FACILITIES
THE MOST MODERN MULTI-MEDIA
SPACE THEATER-PLANE\TARIUM

NOTES:
\- MOST MODERN PLANETARIUM
INSTRUMENT-STS
\- COWE ILLUMINATION
\- FLAT FLOOR WITH SOME WOODEN
UNDERSTRUCTURE TO ELEVATE REAR
SEATS
\- HYPERSPHERE DOGE EXTENDING BEYOND
180° IN FRONT OF AUDIENCE
\- PLANETARIUM PROJECTION INSTRUMENT-
STS AT A LOW PROFILE
\- VISION IN THIS DESIGN IS AT THE POSSIBLE
OPTIMUM
\- PLANETARIUM INSTRUMENT CAN BE
OPERATED IN LOWER POSITION WITH THE
INCLINED HORIZON AND IN UPPER
POSITION WITH THE FLAT HORIZON FOR
PLANE ASTROMETRIC EXPERIMENTATION
AND LECTURES
\- GSP HEMISPHERICAL CINEMA PROJECTOR

DESIGN:
Kurt P. Firthiss
The first model of the new space theatre was erected in San Diego, California, and has immediately met with great success. Several more STS space theatres have been erected in the meantime and several additional prospective planetarium owners have decided on the new STS system.

A Demanding Public:
The new multi-media facility captivates an audience apparently even more than the classical planetarium does. The fact is that today's general public is very much spoiled by colour TV, 3-dimensional cinema, cinerama and plastorama and panorama cinemas, by live TV shows transmitted over satellites covering distances of many thousand kilometers, or even many hundred thousand kilometers as was the case when man landed on the moon. It seems that the directors of the San Diego Space Theatre have taken the psychological situation of today's public successfully into account when commissioning SPITZ to produce for them a really revolutionary design for a multi-media space theatre. It seems that the new installation is attracting additional sectors of the general public that may not so far have shown a particular interest in astronomy. On the other hand, as a pure planetarium, the STS projector performs all the functions of the classical planetarium projector and additionally is capable of taking the audience away from the earth-bound view of the universe to any position anywhere within 100 astronomical units of the sun. A space flight can be dramatically simulated. Special hemispherical films on space flight themes supplement the planetarium performance and completely surround the audience so that the illusion becomes a perfect one. There is such a 3-dimensional effect created that the show becomes an exciting kinetic experience for the viewer.

A full technical comparison of the new planetarium technology versus the classical planetarium technology will be a worthwhile and interesting study. It seems that up to now no relevant publication is available.

Computor Image Creation:
The latest technique in planetarium projection is the computor created image. Its effect on planetarium construction cannot yet be assessed.
THE CLASSICAL PLANETARIUM PROJECTOR
ZEISS MODEL V
Designed for an Auditorium with
Round Concentric Seating
Double Star Ball Design

SPACE – AGE
PLANETARIUM PROJECTOR
SPITZ – MODEL STS
Designed for an
Auditorium with
Unidirectional Seating
Single Star Ball Design
Planetarium Programmes:

At high school level, astronomy is very rarely taught as an independent subject. Basic astronomy, however, is an integral part of most curricula on geography. The space age has given rise to an expanded interest in astronomy and also teachers of history, sociology, and other fields have to prepare themselves for answering questions that the pupil may have on space travel itself and its manifold implications and repercussions.

When selecting media for teaching astronomy, maps and charts, globes and even a simple mechanical tellurium ought to be found in many, if not most, high schools in the industrialized countries. Experience and several publications in the field seem to prove that among the better informed educators there prevails a unanimous opinion that no medium is better for teaching astronomy than the planetarium. (4)

Colleges, universities, naval colleges and technical institutes that teach astronomy as a major subject similarly prefer the planetarium as their teaching medium. But also teachers of other subjects make use of the planetarium for dramatising their lectures.

A typical planetarium programme for a mathematics department could be similar to the following enumeration:

**SUBJECT: Geometry** - triangles, squares, polygons, spheres, circles, ellipses, parabolas, hyperbolas, the oblique spherical triangle, the right spherical triangle, terrestrial circles, arcs and triangles.

Geometry of a Sphere - great circles, spherical distances, spherical angles, spherical triangles, polar triangles, the earth as a sphere, orthographic projection of points on sphere to a plane.

The right spherical Triangle - Napier's rules of circular parts, solution of the right spherical triangle, birectangular and trirectangular triangles.

---

(4) Prof. Alfons Perlik, "Astronomie in der Schule" in "Blick in das Weltall", City of Bochum 1964, page 34
The oblique spherical Triangle - law of sines, law of cosines for sides, for angles; half angle formulas, Gauss equations, solutions for oblique spherical triangles, area of spherical triangles.

Prof. Freeman Miller from the University of Michigan, who professes himself to be a very reserved user of media, believes that the average undergraduate student will learn more truly if he discovers certain phenomena himself through planetarium observations. (5) He furthermore states that when teaching such topics as coordinate systems etc. the planetarium is a great time saver. Prof. Claudia Robinson of the Dallas Planetarium in Texas recommends the planetarium for special courses designed for astronomically "retarded" adults. (6)

Hundreds and thousands of different lectures have been devised for planetarium demonstrations. Teaching astronomy proper may be split up into many dozen planetarium lectures accompanied by practical observations with the telescope. The great work of Tycho Brahe, Galileo, Copernicus, Kepler and finally the exploits of the astronauts can most convincingly be presented in a planetarium.

A typical planetarium catalogue comprises not only lectures in pure astronomy and mathematics but includes special lectures devised for history, social sciences, geography, physics and even chemistry. There is absolutely no lack of possibilities of fascinating the same audience over and over again by continuously changing programmes. Some planetariums like the San Diego Space Theatre have the same show going for weeks and months. Courses for the general public, as well as for schools and universities, can be arranged at any level of comprehension. There are shows for kindergarten children and demonstrations to learned societies. Some universities in the United States offer special courses in planetarium management and planetarium demonstration techniques. Also planetarium manufacturers offer, as a rule, special courses to planetarium personnel.


(6) ibid, page 65 - 68, Claudia Robinson "The Planetarium and adult education".
Distribution of Planetariums:
In table 2 the author has compiled a list of all planetariums existing in every part of the world. When transferring the figures to a world map one may stumble over the fact that most planetariums are found in the United States and in Japan. This fact is all the more astonishing as all industrialized countries share more or less comparable standards of living and uphold similar standards of education.

The planetarium census contained in the annexed list is compiled from various sources and must remain subject to revision when new information becomes available.

Midget planetariums are not counted in this list as no census exists anywhere for the very small planetariums. Messrs. GOTO claim in their catalogue to have sold approx. 50,000 of their umbrella dome midget planetariums in Japan.

Budgets for Planetariums:
Not only the governments of the super powers have realized the importance of space research, but also the European countries are spending part of their research budgets for that special domain. The erection of large planetariums has mostly been the work of large museums, city councils, governments or private donors; medium size planetariums have frequently been bought from university or college budgets but have been, especially in the United States, also donated to institutions by individual citizens. It is remarkable in this context that the city of Copenhagen, Denmark, refused the donation of a modern large ZEISS Planetarium offered by the Karlsberg foundation. The city council gave as a reason that they did not know how to meet the annual running costs. Apparently, it was overlooked that a major planetarium can be operated like a cinema or a theatre and earn an income, while running costs are comparatively low as the software needed for the spectacle is inherently built into the planetarium projector.
The Planetarium an Underused Medium:

Of the more than 1,300 existing large, medium and small planetariums around the world, about 900 are found in the United States and about 170 in Japan. England has 12 and West Germany possesses 20 planetariums, France in contrast only 4, while a comparatively poor country like Yugoslavia has 5 planetariums.

The figures indicate that the planetarium seems to be an underused visual medium not only in the country of its origin but in the whole of central Europe. Part of this thesis is devoted to investigating the reasons for this apparent underuse of a supposedly valuable teaching tool. There seem to be serious reasons involved which make a planetarium an ordinary teaching tool in one country and condemn it to near obscurity in another country.

The investigation of the reasons responsible for the underuse of the planetarium in West Germany will be preceded by a systematic investigation of the planetarium's educational value. For if the planetarium had no - or only an inconsiderable - educational value, there would not be much purpose and sense in commencing a research programme on its underuse.

Prices:

A price list for school planetariums is contained in table 28 of survey III/7 on page 426.
<table>
<thead>
<tr>
<th>CONTINENTS</th>
<th>COUNTRIES</th>
<th>Size A</th>
<th>Size B</th>
<th>Size C</th>
<th>Size D</th>
<th>Size E</th>
<th>Undefined</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>AFRICA</td>
<td>Egypt</td>
<td>-</td>
<td>-</td>
<td>3</td>
<td>-</td>
<td>1</td>
<td>-</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td>Libya</td>
<td>-</td>
<td>-</td>
<td>1</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>Nigeria</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>1</td>
<td>-</td>
<td>-</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>South Africa</td>
<td>-</td>
<td>2</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>-</td>
<td>5</td>
</tr>
<tr>
<td>AMERICA</td>
<td>North A.</td>
<td>Canada</td>
<td>-</td>
<td>-</td>
<td>3</td>
<td>5</td>
<td>-</td>
<td>8</td>
</tr>
<tr>
<td></td>
<td>Mexico</td>
<td>-</td>
<td>1</td>
<td>2</td>
<td>-</td>
<td>3</td>
<td>-</td>
<td>6</td>
</tr>
<tr>
<td></td>
<td>U.S.A.</td>
<td>(22)</td>
<td>268</td>
<td>464</td>
<td>116</td>
<td>23</td>
<td>25</td>
<td>896</td>
</tr>
<tr>
<td></td>
<td>Central A.</td>
<td>Cuba</td>
<td>-</td>
<td>-</td>
<td>4</td>
<td>1</td>
<td>-</td>
<td>5</td>
</tr>
<tr>
<td></td>
<td>South A.</td>
<td>Argentine</td>
<td>-</td>
<td>-</td>
<td>1</td>
<td>-</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>Brazil</td>
<td>-</td>
<td>1</td>
<td>2</td>
<td>4</td>
<td>1</td>
<td>-</td>
<td>8</td>
</tr>
<tr>
<td></td>
<td>Chile</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>1</td>
<td>-</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>Columbia</td>
<td>-</td>
<td>-</td>
<td>1</td>
<td>-</td>
<td>1</td>
<td>-</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>Ecuador</td>
<td>-</td>
<td>-</td>
<td>1</td>
<td>-</td>
<td>2</td>
<td>-</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>Peru</td>
<td>-</td>
<td>2</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>Uruguay</td>
<td>-</td>
<td>-</td>
<td>1</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>Venezuela</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>1</td>
<td>-</td>
<td>1</td>
</tr>
<tr>
<td>ASIA</td>
<td>Burma</td>
<td>-</td>
<td>-</td>
<td>2</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>Ceylon</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>1</td>
<td>-</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>China</td>
<td>-</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>-</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td>Hong Kong</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>2</td>
<td>-</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>Indonesia</td>
<td>-</td>
<td>-</td>
<td>1</td>
<td>-</td>
<td>1</td>
<td>-</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>Japan</td>
<td>approx.</td>
<td>34</td>
<td>81</td>
<td>45</td>
<td>9</td>
<td>-</td>
<td>169</td>
</tr>
<tr>
<td></td>
<td>Korea (North)</td>
<td>-</td>
<td>-</td>
<td>1</td>
<td>1</td>
<td>-</td>
<td>-</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>Korea (South)</td>
<td>-</td>
<td>-</td>
<td>4</td>
<td>2</td>
<td>-</td>
<td>-</td>
<td>6</td>
</tr>
<tr>
<td></td>
<td>Mongolian Peop-</td>
<td>-</td>
<td>-</td>
<td>1</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>les Republic</td>
<td>-</td>
<td>-</td>
<td>1</td>
<td>1</td>
<td>-</td>
<td>-</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>Philippines</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>1</td>
<td>(?)</td>
<td>-</td>
<td>1 (?)</td>
</tr>
<tr>
<td></td>
<td>Singapore</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>1 (?)</td>
<td>-</td>
<td>1 (?)</td>
</tr>
<tr>
<td></td>
<td>Taiwan</td>
<td>-</td>
<td>1</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>Thailand</td>
<td>-</td>
<td>1</td>
<td>-</td>
<td>1</td>
<td>-</td>
<td>-</td>
<td>2</td>
</tr>
<tr>
<td>AUSTRALIA</td>
<td>and NEW ZEALAND</td>
<td>-</td>
<td>1</td>
<td>2</td>
<td>1</td>
<td>-</td>
<td>-</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td></td>
<td>-</td>
<td>2</td>
<td>1</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>3</td>
</tr>
<tr>
<td>CONTINENTS</td>
<td>COUNTRIES</td>
<td>SIZE A</td>
<td>SIZE B</td>
<td>SIZE C</td>
<td>SIZE D</td>
<td>SIZE E</td>
<td>Undefined</td>
<td>Total</td>
</tr>
<tr>
<td>------------</td>
<td>----------------------</td>
<td>--------</td>
<td>--------</td>
<td>--------</td>
<td>--------</td>
<td>--------</td>
<td>-----------</td>
<td>--------</td>
</tr>
<tr>
<td>EUROPE</td>
<td>Austria</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>1</td>
<td>-</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Belgium</td>
<td>-</td>
<td>-</td>
<td>1</td>
<td>1</td>
<td>-</td>
<td>1</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>Bulgaria</td>
<td>-</td>
<td>-</td>
<td>1</td>
<td>-</td>
<td>-</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Czechoslovakia</td>
<td>-</td>
<td>3</td>
<td>-</td>
<td>1</td>
<td>-</td>
<td>4</td>
<td></td>
</tr>
<tr>
<td></td>
<td>England</td>
<td>-</td>
<td>10</td>
<td>1</td>
<td>1</td>
<td>-</td>
<td>12</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Finland</td>
<td>-</td>
<td>3</td>
<td>1</td>
<td>-</td>
<td>-</td>
<td>4</td>
<td></td>
</tr>
<tr>
<td></td>
<td>France</td>
<td>-</td>
<td>1</td>
<td>2</td>
<td>1</td>
<td>-</td>
<td>4</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Germany (East)</td>
<td>-</td>
<td>22</td>
<td>1</td>
<td>3</td>
<td>-</td>
<td>26</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Germany (West)</td>
<td>-</td>
<td>10</td>
<td>3</td>
<td>-</td>
<td>7</td>
<td>20</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Greece</td>
<td>-</td>
<td>-</td>
<td>1</td>
<td>-</td>
<td>-</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Holland</td>
<td>-</td>
<td>-</td>
<td>1</td>
<td>-</td>
<td>-</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Hungary</td>
<td>-</td>
<td>2</td>
<td>-</td>
<td>1</td>
<td>-</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Ireland (North)</td>
<td>-</td>
<td>-</td>
<td>1</td>
<td>-</td>
<td>-</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Italy</td>
<td>-</td>
<td>1</td>
<td>-</td>
<td>2</td>
<td>-</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Poland</td>
<td>-</td>
<td>7</td>
<td>1</td>
<td>1</td>
<td>-</td>
<td>9</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Portugal</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>1</td>
<td>-</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Rumania</td>
<td>-</td>
<td>4</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>4</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Spain</td>
<td>-</td>
<td>2</td>
<td>9</td>
<td>1</td>
<td>-</td>
<td>12</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Sweden/Norway</td>
<td>-</td>
<td>2</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Switzerland</td>
<td>-</td>
<td>1</td>
<td>-</td>
<td>-</td>
<td>1</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Yugoslavia</td>
<td>-</td>
<td>5</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>5</td>
<td></td>
</tr>
<tr>
<td>NEAR EASTI</td>
<td>Iraq</td>
<td>-</td>
<td>-</td>
<td>1</td>
<td>1</td>
<td>-</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Kuwait</td>
<td>-</td>
<td>2</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Saudi Arabia</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>1</td>
<td>-</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Turkey</td>
<td>-</td>
<td>2</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>PACIFIC ISLANDS</td>
<td>Guam</td>
<td>-</td>
<td>-</td>
<td>1</td>
<td>-</td>
<td>-</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>U.S.S.R.</td>
<td>-</td>
<td>-</td>
<td>35</td>
<td>1</td>
<td>7</td>
<td>several hundred</td>
<td>43</td>
<td></td>
</tr>
<tr>
<td>WORLD TOTAL</td>
<td>-</td>
<td>313</td>
<td>695</td>
<td>192</td>
<td>83</td>
<td>25</td>
<td>1,319</td>
<td></td>
</tr>
</tbody>
</table>

Note: Midget Size Planetariums (A) are not countable. Estimated number in Japan amounts to approx. 75,000.

The 22 midget planetariums mentioned for the USA are mostly FARQUHAR planetariums, which are essentially luminous celestial globes, and this type is not counted anywhere else. They are not added to the total for USA or to the grand total.

(II) The Soviet Union has several hundred mobile planetariums acc. to Prof. D. Martynov of the Moscow planetarium (see report II/8). These are not counted in the total.

Footnote: Comparison of Density Ratio

<table>
<thead>
<tr>
<th>USA population (1974)</th>
<th>Planetariums 896 = 235,926</th>
</tr>
</thead>
<tbody>
<tr>
<td>West German (1970)</td>
<td>60,650 600 = 20 = 3,032,530</td>
</tr>
</tbody>
</table>

Compiled by:
Kurt Firnis
Conclusion:

The planetarium belongs to the oldest teaching media that the human inventive spirit has devised. With the invention of the projection planetarium, this ingenious teaching tool has received the potential of becoming a school mass-medium, a possibility that has materialised only in Japan, with similar propensities visible elsewhere only in the United States.

Many different models and two competing systems of two different projection systems and auditorium arrangements are nowadays found on the market.

The planetarium seems to be underused in Western Europe in contrast to Japan and the USA. A study is recommended for a technical comparison of the various existing planetariums together with a survey into the reasons responsible for the pronouncedly disproportionate distribution of planetariums.

This thesis is limited to a survey of conditions prevailing in West Germany including some meaningful comparisons to conditions prevailing in the USA.
CHAPTER II

SURVEYS ON THE PLANETARIUM'S EDUCATIONAL VALUE AND DEMAND FOR SCHOOL PLANETARIUMS

Introduction and Synopsis

In regarding the situation of the planetarium as a major educational tool, the research problem of this thesis requires that the educational value of the planetarium, the demand for planetariums, the existence of an underuse of planetariums and the reasons leading to such an underuse should be investigated. To define the research problem the general hypothesis brought forward reads as follows:

PLANETARIUMS ARE BELIEVED TO BE EDUCATIONALLY VALUABLE TEACHING TOOLS AND THERE SEEMS TO EXIST A DEMAND FOR THEM; BUT FOR A VARIETY OF REASONS PLANETARIUMS ARE UNDERUSED IN EDUCATION.

This basic hypothesis first states that the planetarium exists as a teaching tool, it asserts a belief in its educational value and a possible existence of demand for planetariums and puts this in contrast to the apparent underuse of the planetarium in education.

Investigations:
While the first part of this statement is supported by the description of the planetarium given in chapter I and while it can also safely be assumed to be common knowledge, one of the main purposes of chapter II of this thesis is to investigate the further statement contained in the general hypothesis concerning the educational value of the planetarium. The author does not want to state axiomatically that the planetarium is a valuable teaching tool - though many claims are made to this effect. For it is also possible that serious doubts concerning the educational value of the planetarium exist, and this may be one of the reasons for its apparent underuse.

The planetarium's educational value has been investigated by three different approaches:
First an investigation into the planetarium's intrinsic educational value was made which is subdivided into 3 parts:

a) A study of the meaning of "educational value" with regard to means and methods of teaching astronomy in schools.

b) An investigation into the planetarium's potentials and functions in serving the school curriculum of astronomy as opposed to alternative media.

c) A discussion of prevailing theories on the justification of the use of modern teaching media.

In the second approach opinions and attitudes concerning the planetarium were tested by empirical methods. 32 titles of planetarium literature and 21 papers on lectures of planetarium personnel have been evaluated, and are integrated into the overall image created by the polls. A total number of N=835 subjects of different categories were interviewed in various forms, partly personally, partly by telephone conversations, partly by questionnaires sent through the mail, by private correspondence, or by evaluating their publications. - A list of the population involved in the surveys and studies undertaken is printed after this synopsis. (Table 3)

The third approach took place in the form of experiments:

In the later part of chapter II attempts are described that were made to substantiate experimentally the claim that planetariums are of educational value. The qualification "educationally valuable" is equated there to the qualification "educationally effective". Research literature and general literature on the planetarium have been evaluated in order to register any manifestations of the planetarium's educational value in the work of others for use as a background to the own work.

Demand:

The general hypothesis also assumes that there seems to exist a demand for planetariums. But, as above, the author does not take this for granted, as a lack of demand may be another very serious reason for the assumed underuse of the planetarium.
While a special survey treats the question of demand for planetariums on an official level, the treatment of this question at the school level has been included in the framework of 2 surveys on the planetarium's value conducted with schools in West Germany. This seemed expedient as the investigation on value is naturally complementary to the investigation on demand. The expression of attributing educational value to the planetarium and the demonstration of an interest in the planetarium entails of necessity the notion of at least a potential demand for this educational tool.

**Planetariums:**

As nearly all the planetariums in existence serve the educational systems, no strict differentiation has been made here between large central public planetariums and the mostly smaller school planetariums. Only where their specific differences were considered to be of weight has a border-line been drawn.

**Target Area:**

While the greater part of work in this and all following sections focusses on West Germany as the target area, the scene is enlivened by some investigations on a more international level in the persuasion of several particular research programmes forming the individual components of this thesis.

Some of the work performed for this section has hence been done in the USA, whose educational system is roughly comparable to the West German system in construction, goals and needs. Certain questions concerning the educational value of the planetarium could be highlighted by such larger scale investigations, which tends to add weight to the findings in the final, more limited geographical research area, West Germany.

**Pilot Surveys:**

Two pilot surveys preceded the actual research programmes and delivered both the basis and the encouragement for their execution. The first was a preparatory survey aimed at a thorough familiarization with what the author likes to call "The Planetarium World". This also helped to define the research problem.
The second pilot survey was a broad-scale survey carried out with a small but structurally representative sample of the total school population of West Germany, which is the final target group of the research. This survey provided a widespread spectrum of basic data helpful for all phases of the overall research project, i.e. the planetarium's value as an educational tool and its educational potential; demand for planetariums, and the underuse of the planetarium in education.

Target Group:

As to the target group on which the main weight of the final research has essentially been focussed, the author decided in favour of the general school system in West Germany, as the research problem seemed to be particularly strongly pronounced there, whereas on the level of higher education in West Germany the research problem seemed to be more marginal in importance. This decision was initially based exclusively on observation and experience, but has subsequently been substantiated by a survey.

Opinion Polls:

In conducting opinion polls on the planetarium's educational value with all groups concerned with the planetarium, reference is made to that part of the general hypothesis saying that "planetariums are believed to be valuable teaching tools ...".

It is a known fact of general life experience that it is what is believed that counts when decisions are being made. This holds also true for the use or non-use of educational media. This basic truth renders the opinion poll investigations particularly valuable to the overall study, as they may deliver weighty reasons for the underuse of the planetarium.

No claim, however, is made that a mere opinion - as recorded in this study - can be counted as an actual measure of value, but opinions are the decisive factors on which the fate of the planetarium as an educational tool is based. None of the many opinions recorded and analysed in this study is supported by any kind of scientific research. Observation and experience, intuition and imagination and also hearsay have apparently sufficed to form strong views and attitudes.
As opposed to the opinions which have been measured and recorded, the separate study of and the experiments conducted into the planetarium's intrinsic value will deliver concrete data which should serve to justify the prevailing opinions about the planetarium's value and provide a coherent assembly of results from the three approaches. Should the results obtained not justify or be in conflict with these opinions, then the data would have to be analyzed from other points of view as this would complicate and confuse the investigations into the planetarium's underuse to a great extent.

Limitation due to Bias:

The population involved in the opinion polls is divided in 2 main categories: a) the a priori neutral group and b) the a priori biased group.

The former group comprises teachers, planetarium visitors and perhaps the astronomers in West Germany (who seem rather to be interested in telescopes than in planetariums). The second group comprises planetarium teachers and other protagonists of the planetarium and, of course, manufacturers.

Journalists writing general articles on the planetarium may belong to either group. This is difficult to decide. The nature of an article they may have produced - may it be favourable or unfavourable - is no a priori proof for belonging to either group. But these journalists are voicing an opinion and are influencing in this way the use or non-use of the planetarium, and for that reason they are included in the population of this study.

Whilst the a priori neutral group could be treated by routine empirical methodology employing questionnaires with mixed positive and negative questions, the biased group had to be treated differently, as no critical statements came from any member of this group.

This is not a sample with a broad spectrum of opinions which would deliver a bell-shaped normal distribution graph of statements as is preferred in statistics. The members of the biased group would scarcely allow negative questions to be posed, as attempts made during the surveys showed. The surveys with this group were hence essentially limited to an investigation of their knowledge and opinion on the planetarium's educational potential and function.
The descriptions on the planetarium's educational potential found in this way served to express their conception of the planetarium's value as an educational tool. In this way it was attempted to discount some of the elements of bias which would otherwise have distorted a more general survey on their opinions. It is believed that the method employed has produced a valuable contribution to the survey inasmuch as it delivered - based on observation and experience - an indication of the planetarium's intrinsic value (e.g. "The planetarium is a valuable medium as it fulfills best such and such educational functions"). These opinions can be checked against the essence of the findings of the separate systematic study of the planetarium's intrinsic value. In this fashion these opinions may be enhanced or, if they are found not to conform, may be discarded as being of lesser value. The result of this would be to complicate the survey on the underuse of the planetarium.

Strong as the limitation is which has to be made concerning bias, this study would not be complete without also including the a priori biased groups as they tend to form a weighty lobby for more planetariums, and as they definitely form a prominent part of "all groups concerned with the planetarium in one capacity or other".*

Rank Order:

There is no particular rank order provided for the three so profoundly different approaches made in the study of the planetarium's educational value. Each one of these approaches supplies valuable data in its own right, and at the same time these three approaches supplement one another in this study.

Outlook:

Finding a justification for the planetarium's existence and use in education by a determination of its positive educational value and demand for this tool will justify the further research on the underuse of the planetarium in chapter III of this thesis.

* Footnote: It may be argued that planetarium visitors are biased by virtue of their decision to visit a planetarium. This interpretation is, however, too strict in the author's opinion, and he prefers to draw the border line at a point where the vested interests of the proponents of the planetarium are concerned.
### TABLE 3

---

**CHAPTER II**

Activities and Participants

<table>
<thead>
<tr>
<th>Survey No.</th>
<th>Investigation</th>
<th>Population</th>
<th>N</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Planetarium World</td>
<td>Educational Authorities</td>
<td>70</td>
</tr>
<tr>
<td>2</td>
<td>Target Group</td>
<td>Statistical Counts</td>
<td>undefined</td>
</tr>
<tr>
<td>3</td>
<td>Research Literature</td>
<td>Scientists</td>
<td>13</td>
</tr>
<tr>
<td></td>
<td>General Literature</td>
<td>Journalists</td>
<td>19</td>
</tr>
<tr>
<td>4</td>
<td>Educational Value</td>
<td>Curricula - Plan. Progr.</td>
<td>undefined</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Educ. Literature</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>Schools</td>
<td>Teachers</td>
<td>230</td>
</tr>
<tr>
<td>6</td>
<td>Planetarium Visitors</td>
<td>General Public</td>
<td>313</td>
</tr>
<tr>
<td>7</td>
<td>Astronomical Institutes</td>
<td>Astronomers</td>
<td>51</td>
</tr>
<tr>
<td>8</td>
<td>Planetariums</td>
<td>Plan. Teachers</td>
<td>166</td>
</tr>
<tr>
<td></td>
<td>An Academic Meeting</td>
<td>Scientists</td>
<td>31</td>
</tr>
<tr>
<td>9</td>
<td>Manufacturers</td>
<td>Factory Personnel</td>
<td>12</td>
</tr>
<tr>
<td>10</td>
<td>Experiments</td>
<td>Students</td>
<td>222</td>
</tr>
<tr>
<td>11</td>
<td>Demand</td>
<td>Ministries and Manufacturers</td>
<td>11</td>
</tr>
</tbody>
</table>

**Total N = 1143**

This table enumerates the studies, surveys and experiments described in Chapter II and also lists the population involved in the research conducted on the planetarium's educational value and the demand for Planetariums.
A PREPARATORY SURVEY INTO THE PLANETARIUM WORLD

1. Introduction:
Familiarization with the "Planetarium World" through reading; visits to planetariums; discussions with planetarium directors and lecturers and also with the planetarium visitors; excursions to the workshops where the equipment is manufactured; conversations with planetarium architects, especially those who have created new styles and designs; discussions with the engineers, who install and service the equipment; and finally discussions with the teachers who take their pupils to the planetarium for instructions in the dignified science of astronomy - all these preparations and studies seemed to be an important pre-requisite for the research finally undertaken, and the author, partly through private effort and partly in connection with his professional work, has had many opportunities for dealing with these pre-requisites prior to tackling the actual task of the research on the planetarium.

2. Theme and Purpose:
The theme of this report is the description of investigations into the planetarium world and the purpose of the investigations conducted was to achieve an intensive personal familiarization with the philosophies governing the activities of those concerned with producing and selling planetariums, those buying and erecting them, those operating them and finally those visiting the planetariums. The investigation was to include studies of those problems that may hinder, prevent, or otherwise influence the activities of all those concerned with the planetarium.

This initial pilot survey served the above purpose of familiarization with the "world of planetariums". The survey was directed towards finding the definition and the justification for the research, but also helped to ascertain that all those dealing or intending to deal with the planetarium in one capacity or other were ready to cooperate in a systematic research on the value and the use of the planetarium.
3. Methodology:
A descriptive survey has been conducted by personal interviews, private and official correspondence, reading publications on the planetarium and by the study of relevant literature of the manufacturers. All these preparatory contacts and studies were informal in nature and undertaken wherever the opportunity offered itself, rather than in a systematic and organized manner. This informality allowed for direct questioning, multiple questioning and indirect approaches, in an attempt to provide valid and reliable answers.

4. Population:
The author has conducted numerous interviews with members of the above groups and also with astronomers, administrators, and prospective planetarium owners including two kings, several prime ministers and ministers of education, as well as university rectors and deans; a perfect bevy of dignitaries intending to have a planetarium (or seeking excuses for not having one) for the general public or for the cultural or educational sector for which they are responsible. More than 70 interviews have been conducted in this way; in addition, numerous publications have been studied.

5. Findings:
5.1 Installation of Planetariums
During this period of the exploratory pilot survey, the author has witnessed the disproportional amount of effort which had to be invested by those who wanted to see a planetarium installed. The author has learnt about the interplay of the many factors that have to be jointly organized in order to allow a planetarium to come into being in the first place and then to let it become successful as a cultural institute of educational value. The author has also learnt of the many individual elements or complete groups of obstacles which can combine and prevent either or both of these aims.

5.2 Operating a Planetarium
The author has also witnessed the enthusiasm and idealism invested by devoted instructors in the job of running a planetarium and entertaining an audience. This is, as it seems, more
a vocation than a business.

The author has only recently received a letter from an elderly professor who runs a planetarium in the north of West Germany, saying that his "whole heart" was in the matter of teaching in the planetarium, "this wonderful teaching institution".

5.3 The Educational Value of the Planetarium

The author has learnt during this initial survey and the many informal interviews conducted of the value ascribed to the planetarium as a teaching tool; claims based on experience and intuition rather than on research into the efficiency of the equipment. The author met with no other criticism of the planetariums than that it is far too expensive for widespread installation.

The author has witnessed audiences sitting spell-bound in the planetarium, fascinated by the performance and subsequently speaking with enthusiasm about their newly acquired knowledge.

5.4 The Underuse of the Planetarium

If it is true that the planetarium is of high, even exceptionally high, educational value, as many of its advocates claim, then why is it that so few of these precious institutions are in existence in the very country of origin and elsewhere, in spite of the fact that industry seems to produce various types of equipment suitable "for every purse", so to speak? The author has learnt about some of the difficulties of various natures that prevent a more widespread use of the planetarium.

6. Conclusion:

The many interviews and other preparatory work conducted during this exploratory phase produced a stock of reliable experience, capable of being activated for all phases of the present research, and these early experiences should contribute considerably to the search for the wealth of support needed for the general hypothesis eventually brought forward in definition of the research problem.
Although data were not collected in a form that could easily be subjected to quantification and statistical evaluation, enough insight has been gained and plenty of encouragement has been received to perform the research. The research problem has been clearly realized, and the feasibility of the research project has become obvious. As a result, a research project is carried out on the educational value and the use of the planetarium.

In the following survey the target group for the overall research will be defined.
"THE SCHOOLS IN WEST GERMANY ARE THE MOST PROBABLE TARGET GROUP FOR RESEARCH ON THE PLANETARIUM."

Definition of the Target Group for the Research

1. Introduction, Theme and Purpose:

Based on experience and observation and armed with the background of the findings and impressions obtained from the pilot surveys described in the earlier part of this thesis, it was initially decided to focus the research on the school system in West Germany as a target group, rather than to carry out the investigations at the level of higher education. It was felt, however, that this decision should be substantiated by a survey supplying hard and undisputable facts and figures as providing a sounder basis for the decision taken. The theme and the purpose of this investigation is hence the determination of the main target group for the research.

2. Methodology:

A descriptive survey has been performed. Official reference books were used. Private correspondence with several of the sources of information was conducted, data collected for other surveys - as described later in this thesis - have been evaluated. Validity and reliability of the data are self-understood as we are dealing with public figures.

3. Procedure and Findings:

The official statistical year book for West Germany was consulted to establish the number of schools likely to be actual or potential places for a planetarium.¹)

The numbers of pupils belonging to these schools were counted as being the actual or potential student clientele of such possible planetariums. The figures obtained for the schools were contrasted to those found for the university level.²)

¹) see list of West German schools in the appendix on page 598.
²) see list of the West German astronomical institutes in the appendix page 537.
It was found that nearly 5000 schools, supposedly suitable for the installation of a planetarium, were confronted by only 20 university institutes of astronomy, and an impressive 3 million pupils contrasted strongly with only approximately 80 full scale post-graduate astronomy students in the institutes of higher education. The total number of astronomers in West Germany is not higher than approximately 300.

The Astronomers:
-------------
Additionally, the evaluation of a university survey\(^3\) produced the fact that of 51 astronomers interviewed, only 24 (= 48\%) favoured the planetarium for university use in the cognitive domain and only 18 (= 36\%) favoured it for use in the affective domain. Supplementary personal discussions with astronomers produced evidence of an apparently widespread belief among astronomers that the student of astronomy, as a rule, did not "need" the planetarium as a stimulus to develop an interest in and a love for his field of study. The majority of the West German astronomers was thus not in favour of the planetarium at the university level: however, the vast majority of them favours the planetarium for use as a teaching tool for schools.\(^4\) Many favourable comments were also received from astronomers favouring the planetarium as a public institution.

The Schools:
-----------
In the schools, the situation seems to be quite different. As the results of the school pilot survey show, of 28 school teachers speaking for their schools, 23 expressed their interest in having a planetarium. Only 4 were against having a planetarium, and 1 was undecided.

None of the universities in West Germany owns a planetarium, but 4 schools do, plus 4 naval colleges. (A trifling percentage only, in fact, but perhaps a beginning.)

---

3) See programme II/7, pp 179 - 209.
4) See programme II/7, question 15 in the table No. 10 A, page 213.
Teaching of Astronomy:

As to the curriculum, there are no undergraduate students in astronomy proper in the universities of West Germany. An undefined number of students of mathematics and physics and students of education (at an intelligent guess not more than a few hundred altogether) do supplement their studies with some astronomical subjects, but astronomy proper is taught only at the post-graduate level in the universities of West Germany.

In the schools basic astronomy is widely taught; full courses in astronomy are offered in many schools and selected topics of astrophysics in other schools. Most of the subjects taught in the schools are typical themes for planetarium demonstrations, as is pointed out in more detail in other reports. 5)

4. Conclusion:

In view of the above data it is concluded that at the university level in West Germany the research problem is more marginal, while it seems to be more strongly present at the school level. The respective hypothesis has thus been supported and the decision to concentrate on the schools of West Germany has been justified.

Table no. 4 summarizes the results of this investigation.

5) see table 19, survey II/11 on page 338
REVIEW SURVEY HELD IN WEST GERMANY AS A BASIS FOR DECIDING THE TARGET GROUP OF THE RESEARCH

<table>
<thead>
<tr>
<th><strong>A. UNIVERSITY LEVEL:</strong></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>1) Number of Astronomical Institutes without affiliated facilities: Potential places for a Planetarium.</td>
<td>20</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2) Number of Planetariums owned by Universities</td>
<td>0</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3) Number of Students of Astronomy</td>
<td>80</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4) Number of Astronomers</td>
<td>300</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5) Number of Astronomers contacted</td>
<td>60</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>6) Number of Astronomers who responded</td>
<td>51 = 85%</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>7) Number of Astronomers estimating the Planetarium as being useful in the cognitive domain for Universities</th>
<th>Strongly Agree</th>
<th>Agree</th>
<th>Undecided</th>
<th>Disagree</th>
<th>Strongly Disagree</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>8</td>
<td>16</td>
<td>11</td>
<td>14</td>
<td>2</td>
</tr>
</tbody>
</table>

| 8) Number of Astronomers estimating the Planetarium as being useful in the affective domain for Universities |   |   |   |   |   |
|----------------------------------------------------------------------------------------------------------------|
|                                                               | 5              | 13     | 12        | 17       | 4                |

<table>
<thead>
<tr>
<th><strong>B. SCHOOL LEVEL:</strong></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>1) Number of Schools being actual or potential places for a Planetarium</td>
<td>4867**</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2) Number of Planetariums owned by schools</td>
<td>4</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3) Numbers of Students</td>
<td>3 million**</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4) Number of Schools contacted</td>
<td>36***</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5) Number of teachers who responded</td>
<td>29</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>6) Number of teachers interested in using a Planetarium</td>
<td>24</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>7) Number of Astronomers who favour the Planetarium for School Use</td>
<td>40 = 78.43%</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Summary

An investigation has been conducted in order to determine the main target group of the research within the educational system of West Germany. It has been established that in the field of higher education the number of suitable institutions is very small and an interest in the planetarium is not strongly pronounced. A larger scale survey seems therefore not to be justified. The schools, however, are both high in number and seem to be more interesting for the research problem, "The application of the Planetarium as an educational Tool." The schools in West Germany have therefore been selected as the main target group for the research.

*The number of schools and institutions are taken from official references

**Only high schools and intermediate schools are counted here

***See Chapter II, Programme 5
"EDUCATIONAL RESEARCH CREATES DOUBT IN THE PLANETARIUM'S EDUCATIONAL VALUE"

A.) Review and Assessment of Planetarium Research Literature

1. Foreword

Research literature on "the educational value of the planetarium", generally termed as "effectiveness of the planetarium as a teaching tool", is extremely rare and, in fact, not easy to find. The "Encyclopedia of Educational Research and Review of Education Research" (1) by the American Educational Research Association contains no reference to planetarium research.

Paul Saettler does not mention the planetarium in his "A History of Instructional Technology". (2)

Erickson and Curl wrote "Fundamentals of Teaching with Audiovisual Technology" (3) and gave no references to the planetarium.

Romiszowski does not mention the planetarium in his book "The Selection and Use of Instructional Media". (4)

Publications of Planetarium Societies seem to be the best references. (5)

(3) Erickson, Carlton W.H. & Curl David H. "Fundamentals of Teaching with Audiovisual Technology", 1972, MacMillan
(4) Romiszowski, A.J. "The Selection and Use of Instructional Media", 1974, Kogan Page
(5) I.P.S. Newsletter, International Planetarium Society, Abrams Planetarium, Michigan State University, East Lansing, Michigan 48824
2. Theme and Purpose

The theme of this survey is an investigation of research literature on the planetarium. The purpose of this survey is to find positive or negative evidence, at the level of research conducted on the planetarium, for the operational hypothesis printed at the heading to this report and, in this, to seek the same evidence for that part of the general hypothesis saying that planetariums are educationally valuable teaching tools.

3. Methodology and Procedure

Relevant research literature has been read and critically assessed.

4. Findings and Discussion

The papers reviewed are presented and discussed below:


Wright compares 4 groups of 8 large public school classes. All of them had participated in astronomy courses in their respective schools. 3 groups of the 4 attended planetarium programmes, one did not. One of the planetarium groups experienced an additional special preparation by the classroom teacher and had a follow-up exercise and the other planetarium groups went through the same experience but were prepared by the planetarium lecturer. All 4 groups took an astronomy achievement test. 59 school classes participated in the experiment. All students of the planetarium groups experienced the same tape-recorded planetarium programme and were given the same subsequent achievement test consisting of 80 questions. 40 minutes was allowed to take the test. The planetarium lecture-demonstration lasted 20 minutes for the experimental groups. The control groups were taught the same astronomical concepts in a 40-minute lecture-demonstration in the classroom. This means that the teaching effect of only one short planetarium session had been tested. Tests were administered immediately after the lecture-demonstrations.

Wright found planetarium teaching to be significantly superior to classroom teaching. There was no statistically significant
difference in the comparisons made for the other groups. She consequently concluded that both preparation and follow-up neither increase immediate learning nor retention when applied to planetarium field trips.

Other researchers came to different results concerning the value of preparation and field trips in general. They concluded from their studies that preparing for a field trip provided a better background for observation and learning, and that the subsequent test served to sum up the experience, to clarify unclear points, and to integrate the experience into the general teaching programme. It was found that these methods significantly aid learning as well as retention. Wright quotes and discusses three sources: Atyeo (5), Evans (6), Cronholm (7).

Drawbacks to Wright's study may be that neither pupils nor teachers were matched, and that only one single planetarium demonstration and one specific classroom session were used as a basis for comparison. The latter point may have introduced a set of uncontrollable variables. The much better average of the experimental groups may have been contributed to by an unmeasured stimulus exerted by the planetarium environment on the newcomers. This may have activated the normally lazier section of the students or those normally less interested in sciences. This assumption is supported by the fact that the two groups that were specially prepared for the planetarium trip scored less highly than the unprepared group. It can, therefore, be suspected that the environmental stimulus effect of the planetarium, normally causing wide-spread attention, may not have been so effective with the group that was prepared. The preparation may have dimmed their curiosity.

(5) Atyeo, Henry C., "The Excursion as a Teaching Technique", May 1939 Columbia University, Teachers College, New York
The absence of matching, on the other hand, may have been compensated for by the very large sample size and random distribution.

The positive result that Wright produced is all the more astonishing as she taught her planetarium classes only for 20 minutes, which is scarcely sufficient, according to experts, to even come to the full enjoyment of the spectacle due to the time required for darkness adaptation.

Keller\(^{(8)}\) writes that medical science allows 38 minutes as being an average value for full darkness adaptation, while he himself believes that 8 to 15 minutes is sufficient for the planetarium, depending on whether the daylight outside the planetarium chamber is bright or subdued. From the author's experience, 5 to 7 minutes seems to be a good average time. Keller concludes that a 20-minute performance is too short, and Zeiss recommend 40 minutes as a good average performance time. The comparatively short time that Wright allowed for the planetarium performance also speaks against the possibility of a negative influence of the "mystic effect", mentioned by Ridky\(^{(9)}\). It may not be wrong to guess that the planetarium environment exerted a positive stimulating effect on the test groups in Wright's experiments, which would speak for it being a strong factor in the affective domain. However, no attempt was made to measure this.

The observations made invite the conclusion that a comparison based on a longer sequence of planetarium sessions might have produced more reliable results.

Wright's experiments test only the cognitive domain. It may, however, be advisable to test the affective domain as well, as it is easily possible that the value of the planetarium as an educational tool is partly or predominantly found in this section of the human behavioural spectrum.


\(^{(9)}\) Ridky, Robert William, op.cit.
For the group of students taught and tested under the given conditions the use of the planetarium has obviously produced a higher achievement in the astronomical test applied by Wright as compared to classroom teaching.


Smith has also tested the effectiveness of the planetarium by comparing a planetarium lecture - demonstration with a classroom lecture-demonstration on the same topic. Involved in the experiment were a total of 30 sixth grade classes randomly divided into test and comparison groups. The experiment consisted of a 40-minute lecture-demonstration immediately followed by a 25-question test of 20 minutes duration. Smith also had his test groups in the planetarium only once. Pupils and groups were not matched but the classes were randomly divided. The test covered only the cognitive domain, the affective domain was not touched. The teachers of the various classes were prewarned as to which group they belonged to, test or comparison. Smith taught all lessons himself; he visited the classes in their respective schools and invited the test group class by class to the planetarium where he lectured each class individually. Of the lectures and the subsequent tests, a disproportionally large part was devoted to recognizing star constellations. 9 of the 25 test questions dealt with star constellations; 3 questions dealt with phases of the moon.

While the control groups were tested in their conventional classrooms, where also the specific test-lecture had taken place, the experimental group had to leave the planetarium chamber and go to an adjacent classroom to be tested.

Each lecture demonstration was followed by a 5-minute question and answer session.
Smith came to the conclusion that the classroom - lecture - demonstration on his selected astronomical concepts was significantly superior in achievement to the planetarium - lecture - demonstration as measured by his teacher-constructed final test. Smith admitted that the more familiar learning situation of the classroom environment may have contributed towards the better result achieved in the classrooms.

Smith's procedure and test invites the following criticisms:

a) Using only one single planetarium demonstration as a basis may not be sufficient to pass judgement on the planetarium's effectiveness. Students may not have had enough "warm-up time" in the planetarium environment to really concentrate on all the information fed to them in a comparatively short session of 40 minutes. The whole environment of the planetarium chamber, the "mystic effect" that Ridky describes in his thesis, may have exerted a strong distracting influence.

b) A large section of the lecture and tests were devoted to constellations. Constellations were taught in the classroom from individual pictures, each one showing only the constellation to be learned. In the planetarium demonstration, these pictures were not used but obviously constellations were pointed out on the planetarium sky from the starfield of the planetarium projector. The author thinks it a fallacy to expect the same results from the two methods. While the planetarium demonstration simulates the natural environment and teaches the student to find a certain constellation from a large cluster of stars covering the total hemisphere, and tends to imprint on the pupil's mind the image of single constellations, the subsequent test calls for a recognition of more or less isolated single images. The real purpose of both methods of teaching, practised with the test- and control groups respectively, is to enable a student to discover constellations out in the open. The test should therefore have been made there, which admittedly is a difficult thing to do. The author does not think that the two methods should compete with one another but likes to stress his conviction that both methods should supplement each other.
c) Another objection is brought forward against the test method: while the classroom students remained in their familiar environment, the planetarium groups were subsequently led to an adjacent classroom to have the test administered. These students might have done better in the tests if they had been allowed to do them in the planetarium chamber where the teaching had taken place.

d) Smith conducted the lecture demonstrations himself in both groups, but he does not mention how much teaching experience he had as a planetarium demonstrator. One can do much wrong there. (*)

e) Reliability of the tests was not established, and also content validity remained undetermined, though the test instrument was constructed with the assistance of several science educators.

For the given groups and the given circumstances Smith comes to the conclusion that the planetarium is inferior to the classroom as a teaching institution.


Reed is the first researcher to include the investigation of the affective domain in his survey while performing the already classical comparison of the two media, planetarium and classroom, on the basis of one single instruction-lecture.

(*) Footnote: A teacher answering questions in the large school enquiry conducted in West Germany, see appendix on pages 546 - 551, criticized 3 different professional performances as having been much too fast for anything to be learned.
He performed his experiments with college students, using as a design the posttest-only control group with randomized-group technique. The objectives of his test were immediate attainment in the cognitive domain, and retention tested 4 weeks, 8 weeks, and 12 weeks after the administration of the initial test. The initial test was given immediately after experimental performances which were conducted in each case by Reed himself.

His tests are subject to the same limitations as the previous ones by giving only one treatment to both groups. He took, however, the precaution of performing his test twice: once in the fall semester with 24 groups and once in the spring semester with 18 groups. Groups were also tested in the affective domain. The first test consisted of 24 questions, 5 of them being in the affective domain. The second test consisted likewise of 24 questions including 7 questions dealing with the affective domain. The concepts taught were chosen in such a way that they could be presented equally well in both environments: classroom, as well as planetarium. The two tests dealt with slightly different topics. First, concepts of diurnal and yearly motions of stars, superior planets and the sun were treated, and in the second test, the celestial sphere and precession were used. Validity and reliability of the test were ascertained.

The results of the experiment run counter to Reed's obvious expectations, as he ascribed to the planetarium a priori the effect of (strong) motivation due to "the arousal of interest" in the audience. Similarly, he sees an advantage in the field of translation for the same reason, as "the learner would seem to be more involved in the planetarium situation, thus making the placement of concepts and principles into the learner's conceptual scheme apparently easier". 

---

* Footnote: insertion in brackets by the author.
*2 Footnote: see page 22 of Reed's thesis.
Conclusion:

Reed finds classroom blackboard - globe teaching to be significantly superior to planetarium teaching with regard to immediate learning and with regard to retention over a time. Further, he finds no indications for any differences in the affective domain; both teaching situations produced an equally higher interest in the subject matter.

Reed believes, but produces no support for this belief, that the value of the planetarium may lie in the affective domain.*

Criticism:

The main argument that can be raised is again the fact that Reed also uses only the teaching situation of 1 single lecture-demonstration as a basis for comparison, as well as leaving the college students of the control group in their natural environment and putting the experimental group in the unfamiliar environment of the planetarium. The "mystic effect" apparently works both ways. It may promote as well as impede learning.

Reed, though being a recognized planetarium teacher today, does not state what amount of experience he had at the period of conducting his experiments. He concedes that the person of the instructor may have been a limiting factor. He also concedes that the single planetarium visit may not have been sufficient and that the student should rather have become familiarized with the new learning situation in the planetarium prior to the lecture demonstration.

As to testing retention, it seems that Reed has surveyed the method of teaching and learning itself rather than the medium used. Observation and experience teach that one does not learn from one single lecture demonstration without some sort of repetition. "Repetitio est mater studiorum" was one of the rules governing learning in classical Rome.

* Footnote: Reed has meanwhile become a devoted planetarium lecturer, as it seems, giving courses in planetarium teaching techniques. He has many publications in the field to his credit. In a private correspondence of recent date conducted with the author he confirms his conviction that the value of the planetarium lies in the affective domain.
The noted German specialist on the learning procedure, Frederic Vester, advocates that the same information be fed through several media supplementing each other.\textsuperscript{(10)} Vester describes the physiological process of learning and memorization and makes repetition a vital necessity for retention.\textsuperscript{(*)}

Reed himself concedes that classroom and planetarium should be integrated with each other, an idea which has had other precursors and that may eventually lead to the combined classroom - planetarium chamber as described in chapter I of this thesis.

Reed was the first person to have tested the affective domain besides the cognitive domain, which makes his study more valuable.

For the given population under the given circumstances Reed finds that the planetarium is inferior to the blackboard - globe teaching situation in the classroom.


Ridky's study is the most comprehensive that has ever been undertaken. His research was directed towards finding out in which ways the classroom or planetarium may be better as a teaching medium and not only which medium is the better. "What is it the planetarium can do that the classroom activities cannot?"

Further, he intended to find out whether the planetarium should be used exclusively in teaching astronomy courses or in combination with the classroom, and whether students need an orientation session in the planetarium before any teaching can become effective. He also wanted to research students' perception of the various educational media, for which he used a science related semantic differential instrument. He also measured retention.

\textsuperscript{(10)} Frederic Vester, "Denken, Lernen, Vergessen", Deutsche Verlagsanstalt Stuttgart, 1975
\textsuperscript{(*)} ibid.
The practical aims of Ridky's research were the better use of existing facilities and to seek a possible justification for the expenses of the planetarium equipment.

The actual test procedures were preceded by a pilot study intended to determine the prevalence of a "mystic effect", i.e. a complex of emotions, attitudes and stimulations involved in the planetarium environment and performance. He used the pretest/posttest design employing two groups of students, one of the groups having had an orientation session prior to the actual planetarium instruction that made the participants familiar with the planetarium equipment and its functions.

Ridky undertakes the main study at two educational levels: 8th grade middle-school students and college students using an \( N = 100 \) and \( N = 80 \) population respectively. The design of the study was the pretest-posttest-3-group-design according to Stanley and Campbell. Four instruments were used for data collection: a pretest, a posttest, a retention test, and a measure of student perception. The planetarium instruction experience was contrasted to the classroom inquiry activity and finally both treatments were combined for the third group.

The planetarium treatment group received one orientation session and subsequently 5 astronomical sessions. The classroom group received only 5 sessions of astronomical instructions dealing with the same concept. All lectures were given from tape-recordings to exclude the teacher variable. Group 3 received combined instructions in either the planetarium or the classroom and the concepts were randomly distributed in the two activities.

The high-school students were taught in a small Nova planetarium in a 16 foot diameter dome; the college students were taught with a Spitz A-3-P projector in a 30 foot diameter dome. (It may be mentioned that the latter arrangement gives a much better astronomical performance.) * Reliability and discrimination of each test question was ascertained.

* Footnote: Insertion in brackets by the author.
Results, Interpretation and Criticism:

Ridky established that the orientation group performed significantly better than the non-orientation group in the planetarium. This indicates the presence of a "mystic effect", though the causes for this mystic effect could not be identified by the test. The test showed that the influence of the mystic effect can be controlled by inserting an orientation session before the actual planetarium instruction.

As the result of other research and based on observation and experience, the author believes that there is a mystic effect prevailing in the planetarium whose influence, however, can be accelerating as well as retarding depending on circumstances not yet determined till now. As the danger of a retardation is always there, according to the results of Ridky's research, it may well be expedient to have this orientation session prior to the actual planetarium performance. If, however, only one single performance can be reserved for a certain group, then the planetarium demonstrator should devote several minutes of "warming-up" time to familiarize his audience with the environment and the function of the equipment.

In the main test performed with the high-school group, Ridky came to the conclusion that the planetarium group showed a slight increase in achievement between pretest and posttest, the classroom group showed a slight decrease, and the combined group which had been taught in the planetarium as well as in the classroom was the only one that showed a significant improvement in performance. This invites the conclusion that the combination of classroom and planetarium is more effective than the exclusive use of either of them.

This tends to support the author's view that the media should not replace one another but supplement one another. However, this conclusion seems a bit too easy when applied to the present case. The fact is that the same concepts were taught in both situations, planetarium and classroom. There was no attempt made to distinguish between concepts particular to planetarium teaching and such concepts which seem more easily teachable in a classroom situation. Consequently there is no clear reason
given why the combination made should have been more successful. Additionally, a taped lecture is not at all typical of classroom teaching. The sterile atmosphere thus created hardly provides a realistic basis for comparison. Still, a strong tendency has been established towards higher benefits deriving from the combined situation. More and better defined research in this direction may be advisable.

At college level, all treatment groups achieved equally well in all situations, which suggests the conclusion that the planetarium does not promote immediate attainment at college level. Ridky suggests that the tests might be responsible for this result since they had been more demanding for the high-school students than for the college students. Additionally, the college students might have been better able to conceptualize the experimental unit than the high-school students.

Retention at the high-school level was greater for the combined group. College students achieved and retained the motion concepts equally well in either treatment group; the planetarium had obviously brought no advantage over the classroom. For the non-motion concepts, however, the combined college group showed a significantly greater retention score than the other two groups. This is especially noteworthy as one usually believes that the planetarium is superior in achieving immediate understanding and retention of motion concepts. Ridky consequently qualifies the result by mentioning that the combined group may have been exposed to other influences during the period after which retention was measured.

As to perception change, it was shown by the experiment that junior high school students as well as college students achieved the greatest gain for the planetarium groups.

From this latter test Ridky concludes that "the effectiveness of the planetarium appears not to lie in facilitating content achievement, but rather in effecting attitudinal change". Ridky suggests that the planetarium's apparent ability of positively changing students perceptions or attitudes should be taken into account when constructing planetarium performance programmes.
The comparison between high-school students and college students is limited by the fact that two completely different planetarium environments were used in the experiments. The Nova planetarium used for the high-school students experiment is a rather modest piece of equipment, projecting not more than about 900 stars; the dome is of a small diameter, too small in fact to produce the illusion of being out in the open. The college students experiment used a much better facility that gives the illusion of being out in the open, which should accelerate the attitudinal change that Ridky ascribes to the planetarium.

For the given circumstances and valid for the tests conducted Ridky finds that the combination of classroom and planetarium is more beneficial in immediate attainment as well as in retention than either of the two facilities used alone. He sees the value of the planetarium predominantly in the affective domain.

The author likes to conclude from the review of Ridky's research that the combined planetarium - classroom chamber, the classroom-type planetarium of modern design, may be the best teaching facility as it seems able to combine the advantages of the two teaching methods in one and the same environment.

While the other researchers had their groups treated during one single session only, Ridky had his groups exposed to the treatment for as many as 5 sessions with an extra session for the preparational group in the planetarium. This tends to lend weight to the result of his research.

Research not undertaken at the Doctorate Level:

The above 4 works represent research at a doctorate level. There exists another interesting study undertaken by the Madison Public School Authority involving a large number of school children while controlling a very comprehensive range of factors:
5.) Yee, Albert H.; Baer, Joyce M; both University of Wisconsin, Madison, and Holt, K. Douglas; Madison Public Schools: "AN EVALUATION OF THE EFFECTIVENESS OF SCHOOL PLANETARIUM EXPERIENCES", 1968.

The above 3 researchers undertook their experiment in order to evaluate the effectiveness of a single planetarium lecture - demonstration intended to improve pupils' achievement and attitude. 74 classes of 5th grade pupils participated in the experiment. Classes were randomly assigned to either experimental or control groups, care being taken to distribute students equally according to their socio-economic status; also groups were balanced in morning and afternoon visits to eliminate the influence of the time of the day on behaviour and responses of the students. Care was taken that classes did not differ significantly with regard to classroom preparation and teachers' attitudes towards children. It was believed that randomisation compensated differences in aptitude achievement and previous planetarium experiences, as well as other extraneous variables.

The experimental design consisted of a modified posttest-only control group design. The experimental group was given a posttest immediately following the planetarium lecture and the control group was tested without any treatment. To test retention 10 classes were randomly selected from both groups and given a second test in their own classroom between two and three weeks after the first test. All groups were taught by the same planetarium lecturer and it was ascertained that the treatment was identical. The performance was preceded by an orientation period in the planetarium. Time was allotted for pupils' questions. The planetarium lesson lasted for about 50 minutes and was supported by a series of slides. Several fields of astronomy were covered by the lecture. The test questions were designed to measure knowledge of facts, intellectual understanding and attitude. Class behaviour was measured during each presentation. Teachers' attitude regarding prior and future classroom activities and the attitude towards science and planetarium teaching was likewise measured.

*) Footnote: The control group was actually tested without any treatment and reference is being made to experiments developed by: Campbell, D.T.&Stanley, J.C. "Experimental and quasi-experimental designs for research in teaching", Chicago, Rand McNally, 1963
In analysis the total sample was sub-grouped according to sex.

Results:

The overall performance of the experimental group showed a highly significant difference to the performance of the control group. Boys scored significantly higher than girls. Astonishingly enough, there was no significant difference between the two groups in the attitude scores. According to the researchers' conclusion, this would suggest that a planetarium lesson does not change pupils' attitude towards astronomy. It is concluded that the planetarium experiences had a positive effect on learning and understanding of astronomy while attitudes were not promoted.

Teachers' attitude towards the planetarium was found to be positive or even enthusiastic. In the final conclusion of the paper the existing planetarium was labelled a valuable facility.

In the following, several theses are mentioned whose summaries were found in the catalogue of University Microfilms International, Ann Arbor, Michigan / USA. Numeration will continue from above.


Burnette tested a total school population of 5400 students of the 4th, 7th, and 8th grades. The objective was to find out whether the planetarium had a significant effect on the attitudes of the students towards the study of astronomy. Additionally, he tested the gain in knowledge of selected astronomical concepts with 4th and 8th grade students. Results for 4th grade students showed a "positive and significant improvement in attitude on three test items and a small but not significant change on the remaining 3 items". For the junior high-school students the same attitude test showed positive and significant changes on 6 out of 7 test items. Tests in the cognitive domain also showed increases. Positive changes in attitude and
achivement were very pronounced for junior high-school students.

According to Burnette's research, the planetarium had proved its value as an educational tool in the affective and cognitive domains.

7.) Bondurant, Russell Lynn, Jr.: "AN ASSESSMENT OF CERTAIN SKILLS POSSESSED BY 5TH GRADE STUDENTS USED TO SUCCESSFULLY IDENTIFY CONSTELLATIONS IN A PLANETARIUM", Ph.D.-thesis, Michigan State University, 1975.

Bondurant tested a total sample of 120 fifth grade students in order to construct a diagnostic method to determine if 5th grade students can demonstrate the necessary skills for identifying constellations. The classroom and the planetarium situations were compared. From the results of the study it was concluded that 5th grade students do not possess all the skills required to locate and identify a constellation in the planetarium sky. Bondurant recommends that the necessary instruction for the students must "involve the use of the (planetarium) sky itself rather than pictures or slides". Bondurant's study reveals the usefulness of the planetarium in the limited field of teaching stellar constellations to 5th grade students.


Smith tested children, teenagers and adults. The three groups were taught constellations by means of 35 mm slides in the classroom, 35 mm slides in the planetarium (against the planetarium's starfield as a background?) and under the planetarium sky without additional slides.

* Footnote: Insertions in brackets by the author.
The results revealed that all three groups did equally well under the real sky. A paper and pencil test revealed the superiority of those who had received instructions in the planetarium aided by 35 mm slides. It must be assumed that the slides in the planetarium were projected against the planetarium's starfield as a background, as otherwise there is not much sense in projecting such constellation slides against an empty planetarium sky. Based on this assumption, Smith's study has revealed the usefulness of the planetarium for the limited purpose of teaching constellations aided by slides.


Heyward performed 4 pilot studies and one major experiment, the latter involving 471 sixth graders divided into 3 groups: 1 planetarium group, 1 classroom group, 1 group without instruction. Heyward concludes from his research that planetarium and classroom groups do equally well in some fields; "however the planetarium was significantly superior to the classroom on many mean and criterion scores for content objectives and significant use of higher order processes and skills was established by planetarium instruction."

"The planetarium made significant gains both absolutely and in relation to the classroom in using space/time relationships, inferring and concept application." Heyward's research established the superiority of the planetarium as a teaching tool compared to the classroom teaching situation in several specified fields; he finds both teaching media equal in some other specified fields; he does not state that the planetarium is inferior in any of the tested fields.
The enumeration of research work on the educational value of the planetarium is continued with short summaries of several theses or dissertations that have been reviewed by the writers of the first 4 theses treated above. This is done in an attempt to provide a more complete picture of previous research in this field.


Emmons surveyed the educational value of his home-made planetarium by analyzing 120 letters received from teachers and students of 32 school classes who had visited his planetarium.

He concluded that a noticeable progress in factual learning had been achieved through the planetarium visit.

Though no experimentation had been made, Emmons is one of the first to have recognized the need for some kind of survey concerning the educational value of the planetarium.

Within the very limited confines of this survey, Emmons comes to a positive conclusion regarding the planetarium's value as an educational tool.


Chamberlain's research is among the first attempts to investigate teaching in the planetarium. From a survey with 2000 school teachers in New York City he concluded that the planetarium was rated by the vast majority (93.2%) as being useful. He came, however, to the belief that its main value may lie in its potential to form attitudes. He made no comparison with the classroom nor any systematic survey in the affective domain.
Within the limits of his work, Chamberlain finds the planetarium useful as a teaching tool.


Tuttle was one of the first investigators to experiment with the planetarium in order to establish its value as a teaching tool. He matched two 6th grade classes and allocated them into one planetarium and one classroom group. Pretest and posttest were administered.

Tuttle produced a very positive result, showing significant gains in three dimension spatial relations, in two dimension spatial relations and in content achievement.

A second, larger, experiment conducted with 400 sixth grade pupils produced no significant difference for the two teaching situations. Tuttle was not able to bring forward a consistent result concerning the educational value of the planetarium. Tuttle ascribes this inconsistency to the teacher variable.


Rosemergy contrasted the planetarium to the classroom but he had his groups more than once in the planetarium. He tested a population of 339 sixth grade students in 3 different teaching arrangements:

1.) 5 classroom sessions in astronomy,
2.) 4 sessions in the classroom and 1 in the planetarium,
3.) first and fifth session in the planetarium and the central 3 sessions in the classroom.
Pretest- and posttest were administered and no significant differences were found between the three arrangements. Only the cognitive domain was measured.

Rosemergy could not establish any superiority of the planetarium over the classroom under the given circumstances of his work.

5. Summary

In compiling this report 13 research papers have been reviewed and evaluated. All but two compared the planetarium to the classroom. Various procedures and group arrangements were devised for the experimentation conducted. Table No. 5 presents a review of the various authors' work, the population and sample sizes involved, maximum time spent in the planetarium, and the results in the three domains: attainment, retention and attitude. No uniform pattern can be seen. Even if longer hours are spent in the planetarium, no consistency of results is produced.* Most authors dealt with students of a rather young age and the next group treated is found to be already at the college level. The group between 14 and 18 years of age has not been tested by any of the researchers, only Smith (8) may have this group in his population, but this is not known from the summary of his work used in this study. Only research work done in the USA was reviewed as the author was unable to trace any other. Of 16 tests in attainment 10 come to positive conclusions and 6 come to negative conclusions. Of 3 tests in retention, 2 have produced a positive result and 1 has produced a negative result. Of 6 tests in the affective domain 3 are positive, 2 establish positive tendencies and 1 is negative in result.

6. Conclusion

It is impossible to come to any harmonious final result as we have found that the results of the work reviewed do not allow any generalisation due to the inconsistency of the findings brought forward by the various authors. Not even where conditions and procedures were very similar did results conform. No consensus could be confirmed between the results of the various research work undertaken.

* Compare results of 4) and 13) in table no. 5.
Not much profit can be drawn from the planetarium research under review for the planetarium as an institution. The justification for the planetarium's existence and use is questioned only with regard to isolated teaching themes. Until the complete school curriculum were to have been treated for its teachability in the planetarium, the results of the present surveys would have to be shelved and for the time being cannot deliver much weight and help in decision making pro or contra the planetarium. Much of the planetarium's value may lie in the affective domain.

The results of the survey support the operational hypothesis.

Approximately 1/3 of the research findings being negative does cast a certain amount of doubt as to the planetarium's educational value.

The general hypothesis is not fully supported by planetarium research in that part saying that planetariums are believed to be of educational value.

General implications from the survey on the planetarium literature are drawn at the end of part B of this survey.
Outlook

When accepting the general praise heard for the planetarium from so many quarters, one would wish for better methods of scientific research that may do better justice to the planetarium as an educational tool.

The research methods applied do not seem to enable researchers to produce a more uniform result that could serve as a general guideline for a prospective planetarium owner. He may have to go somewhere else to find the justification for the fulfillment of his dreams.

The author agrees to Ridky's(*) statement: "The question of which is better, the planetarium or the classroom has, by itself, little meaning." Nevertheless, this is the question governing most research. It should rather be attempted to define what one may rightfully expect of the planetarium itself and then to test whether or not expectations are met.

It must be stated that no researcher found that the planetarium did not by itself promote learning. But did children learn more happily there and with more enthusiasm? No one had asked this question. Attitude seemed to be defined by those, who treated this aspect at all, in terms of interest in the subject matter.

In line with the above, and also influenced by additional factors mentioned later, the author's own experimentation in the planetarium is limited to the question of attitude and learning in the planetarium without comparison to outside learning situations. See survey II/10.

The following table summarizes part A of this study.

Part B of this study deals with general planetarium literature.

(*) Ridky, op.cit., page 8
### Table 5

**Research Literature on Experimentation to Establish the Planetarium's Educational Value.**

<table>
<thead>
<tr>
<th>No.</th>
<th>Year</th>
<th>Author</th>
<th>Population</th>
<th>Max. Plan Time</th>
<th>Attainment</th>
<th>Retention</th>
<th>Attitude</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>1966</td>
<td>SMITH, B.A.</td>
<td>30 school classes, 6th grade</td>
<td>40 min.</td>
<td>-</td>
<td>o</td>
<td>o</td>
</tr>
<tr>
<td>2</td>
<td>1968</td>
<td>WRIGHT, D.L.</td>
<td>59 school classes, 8th grade</td>
<td>20 min.</td>
<td>+</td>
<td>o</td>
<td>o</td>
</tr>
<tr>
<td>3</td>
<td>1970</td>
<td>REED, G.P.</td>
<td>42 college groups</td>
<td>1 lecture</td>
<td>-</td>
<td>-</td>
<td>maybe</td>
</tr>
<tr>
<td>4</td>
<td>1973</td>
<td>RIDKY, R.W.</td>
<td>a) 100 middle school + b) 80 college students</td>
<td>5 lectures</td>
<td>a) +</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>b) -</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td>5</td>
<td>1968</td>
<td>YEE, A.H. et al</td>
<td>74 school classes, 5th grade</td>
<td>1 lecture</td>
<td>+</td>
<td>o</td>
<td>-</td>
</tr>
<tr>
<td>6</td>
<td>1976</td>
<td>BURNETTE, W.N.</td>
<td>5400 school students, 4,7,8th grade</td>
<td>1 or more lectures</td>
<td>+</td>
<td>o</td>
<td>+</td>
</tr>
<tr>
<td>7</td>
<td>1975</td>
<td>BONDURANT, R.L.</td>
<td>120 school students, 5th grade</td>
<td>70 min.</td>
<td>+</td>
<td>o</td>
<td>o</td>
</tr>
<tr>
<td>8</td>
<td>1974</td>
<td>SMITH, Th.V.</td>
<td>3 groups: presumably N=103</td>
<td>a) 1 lecture</td>
<td>a) -</td>
<td>o</td>
<td>o</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>b) +</td>
<td>b) +</td>
<td>o</td>
<td>o</td>
</tr>
<tr>
<td>9</td>
<td>1975</td>
<td>HEYWARD, R.R.</td>
<td>471 school students, 6th grade</td>
<td>1 lecture</td>
<td>+</td>
<td>o</td>
<td>o</td>
</tr>
<tr>
<td>10</td>
<td>1950</td>
<td>EMMONS, R.H.</td>
<td>32 school classes</td>
<td>presumably</td>
<td>+</td>
<td>o</td>
<td>o</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>1 lecture</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>11</td>
<td>1962</td>
<td>CHAMBERLAIN</td>
<td>2000 school teachers</td>
<td>1 lecture</td>
<td>+</td>
<td>o</td>
<td>maybe</td>
</tr>
<tr>
<td>12</td>
<td>1966</td>
<td>TUTTLE, D.E.</td>
<td>a) 2 6th grade classes + b) 400 6th grade students</td>
<td>presumably</td>
<td>a) +</td>
<td>o</td>
<td>o</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>1 lecture</td>
<td></td>
<td>b) -</td>
<td>o</td>
<td>o</td>
</tr>
<tr>
<td>13</td>
<td>1968</td>
<td>ROSEMARY, J.C.</td>
<td>339 6th grade students</td>
<td>4 lectures</td>
<td>-</td>
<td>o</td>
<td>o</td>
</tr>
</tbody>
</table>

+ = positive, - = negative, o = not tested.

**Summary:**

13 publications on planetarium research have been surveyed and assessed. Their results are inconsistent and thus do not allow any generalisations beyond the confines of the experiments conducted.
"GENERAL LITERATURE ON THE PLANETARIUM PRAISES ITS EDUCATIONAL VALUE"

B.) A Survey of General Literature on the Planetarium

1. **Introduction:**

   The widespread acceptance which the projection planetarium has found ever since its inauguration in München in 1923 is not only due to the word-of-mouth propaganda of enthusiastic visitors, but owes much to not less enthusiastic newspaper articles and magazine reports written on this new public attraction.

   Of the many publications available on the planetarium, only a few are written about the educational value of the planetarium. Most of the publications are of a technical nature or describe new planetarium installations. Other descriptions of planetariums were written in general praise of the planetarium and comment in many ways on the purpose and importance of this educational and cultural institution. As the list of literature printed in the appendix shows, educational research on any aspect of the planetarium has been published only more recently.

2. **Theme and Purpose:**

   The theme of this study is a review and assessment of general literature on the planetarium and the search for themes dealing with the educational value of the planetarium. The purpose of this investigation is to seek evidence in general planetarium literature supporting or defuting that part of the general hypothesis saying that planetariums are educationally valuable teaching tools.

   **Limitation:**

   The author could not trace any negative article on the planetarium's educational value.
3. **Methodology and Procedure:**

The methodology employed consisted of reading and evaluating general publications on the planetarium. The procedure employed consisted of collecting special reprints from newspaper and magazine articles available from planetarium manufacturers.

4. **Findings:**

The following selected citations are given as examples of the many positive descriptions written about the planetarium:

4.1 The Roman poet **Ovid** (46 BC - 18 AC) praised the planetarium constructed by Archimedes (287 BC - 212 BC): ".. the sphere as a model of the limitless universe".

4.2 **Helmut Werner**, (1953), described in his book "Vom Arat Globus zum Zeiss Planetarium" the invention of the projection planetarium as a cultural achievement of the first order. He described in much detail the value of the planetarium as an educational tool by giving a minute account of the achievement of the planetarium in demonstrating celestial events.

4.3 **Dr. Joseph Miles Chamberlain**, (1957), in his article entitled "The Development of the Planetarium in the United States" wrote that "the planetarium in the United States was more than just an exhibit, it was to be an institution with several masters to serve: education, science, pleasure and the realm of the spirit". He quoted Dr. Charles F. Lewis, Director of the Bull Foundation (1939) as saying that man's oldest curiosity was about the stars and that this curiosity is infinitely worth satisfying, and that the study of astronomy, as made possible by the planetarium, is worthwhile. From his own early experiences as an astronomy teacher, he described the educational value of the planetarium in permitting him "to transfer the flat confusing blackboard drawings into the 3-dimensional characters of the skies in a simple and meaningful manner."
4.4 The journal "Educational Equipment & Materials" printed in December 1963 an article entitled "Using a Planetarium as a Natural Part of the Science Laboratory Programme", and quoted Mr. Earl C. Funderburk, Divisional Superintendent of Schools in the Fairfax County School System, Virginia / USA, as saying that the planetarium had a "tremendous instructional potential". The article further rates the planetarium as "one of the greatest teaching devices made to show the universe, the galaxies, the sun, moon, planets and other components of the astronomical system".

4.5 The same journal printed in winter 1964 another article on the planetarium entitled "College takes Ike's advice - builds modern planetarium". The article describes the planetarium of the San Antonio College and rates the planetarium as being "an important part of the community life in San Antonio". The article says further that "programmes create interest in astronomy".

4.6 In the fall of 1964, the same journal published a further article on the planetarium entitled "All interrelated subjects are coordinated in one earth and space science laboratory". The article describes the Frederick Planetarium in Maryland / USA. The article says about the planetarium that "everybody is thrilled by the realistic projection we have here. Projecting on a flat surface cannot do the job properly." The instructors are quoted as saying that "teachers feel that we are teaching something they could not accomplish in their classrooms". The planetarium teachers feel that, "based on teacher response, student interest and adult acceptance, we are accomplishing our purpose.

4.7 The same journal has printed many more articles on the planetarium giving an account of the unique achievement of the equipment in many newly established planetarium institutions. In spring 1965 another article was printed which is worthwhile quoting. The article is entitled "Planetarium is a versatile teaching instrument". The article says of the planetarium that it "does far more than provide awe-inspiring views of night skies. In addition to teaching astronomy to high school students, it is used effectively to aid in teaching mathematics, physics, history, geography, English, biology, and Latin." This refers to the Arlington High School Planetarium, Indianapolis / USA. The article describes
further how the planetarium motivates teachers and pupils alike in the study of astronomy.

4.8 The journal "The Science Teacher", issue October 1964, published an article written by Marjorie H. Gardner, Science Teaching Centre, University of Maryland / USA, entitled "The planetarium as an educational tool". This article introduced a group of similar articles of which Marjorie H. Gardner writes "This group of articles has been planned to acquaint teachers and administrators with the opportunity to extend and enrich the school science program through the use of the planetarium." She continues: "Units on astronomy are almost universally a part of elementary school science. A trip to the planetarium for a lecture-demonstration enriches the classroom presentation of the teacher and the text-book." She writes further: "The school planetarium might well serve as a valuable and innovative proving ground ...". She concludes from other publications: "... that the planetarium is a remarkably versatile means of teaching science - science in depth, science in a dramatic manner that has impact value calculated to increase the interest of students and the retention of science concepts."

4.9 Hart Raff, (1969), stated in his article "Das moderne Projektionsplanetarium" that the planetarium was constructed as a teaching tool for celestial geometry and elementary sky mechanics. He further states that the modern planetarium is capable of demonstrating practically all astronomical phenomena, permitting a broad spectrum of audio-visual teaching methods. He states that the realism of the demonstration has a positive influence on the learning process, and that additionally the planetarium demonstration creates a positive emotional impact.

4.10 The journal "Science Activities" - "The Teacher's Classroom Guide" printed in its January 1971 issue an article entitled "The Planetarium Explosion" describing the growth of the planetarium community in the USA and comments on the planetarium LaPorte, Texas / USA "enthusiasm among students visiting the planetarium... increases with the younger student. The enthusiasm among high school students is very high, so one can just imagine what it is like for the first-grade student."
4.11 Frank C. Jettner, State University of New York, and John J. Soroka, Waverly Public Schools, Lansing / Michigan, USA, (1972) published a paper entitled "The Planetarium in Modern Science Education". The authors see the value of the planetarium in the many disciplines in which it can serve as an instrument to enliven lectures. They list 20 different subjects which could gain from the use of planetarium as a teaching medium.

4.12 Dr. Hans Ulrich Keller, Stuttgart, (1974), wrote a small booklet entitled "Sternentheater Planetarium". He praises the great versatility that the planetarium offers in demonstrating celestial events.

4.13 Deborah Hauss (1976) described most vividly in an article entitled "Planetarium draws pupils oohs and ahs" the enthusiasm created in school children by planetarium shows.

4.14 Prof. Charles F. Hagar, Planetarium Institute, Dept. of Astronomy & Physics, San Francisco State University, has published an article entitled "Walter Bauersfeld and Kepler's laws in the Planetarium" in the ZEISS information journal, June 1976 issue. He says of the planetarium "If Kepler were alive today, he would be most intrigued with such mechanisms", and he sees the special value of the planetarium as being in its extreme high precision which allows the most complicated sky mechanics to be demonstrated.

4.15 Prof. Alfons Perlick, Professor of the Pädagogische Hochschule, Dortmund, has written an article entitled "Astronomie in der Schule" in a booklet published by the observatory - planetarium of Bochum / West Germany, with the title "Blick in das Weltall". Prof. Perlick writes "The best possibility to disseminate astronomical knowledge to schools is offered by the ZEISS planetarium". "The planetarium is a magnificent, exemplary institution for teaching and experimentation".
4.16 Caroline Bolognese published an article entitled "Schools' Planetarium really a Laboratory" (1977). She describes the Arcola School Planetarium in Eagleville, near Philadelphia/USA. Her article describes the planetarium as being a laboratory for astronomy where people experiment rather than learn by memorizing. She describes how experimenting keeps the students interested in the subject of astronomy.

4.17 Dr. Hans Ulrich Keller published in the German Journal "Bild der Wissenschaft", issue May 1977, an article entitled "Himmelsuhrwerk Planetarium", in which he calls the planetarium an "ingenious idea".

4.18 Prof. Dr. Hans Elsässer added a short comment to the above article in the same journal stating that no visitor could escape the magic encompassing him under the planetarium dome.

4.19 Dr. Arthur Young, San Diego State College (1969) published a paper entitled "Quantitative Measurements and Demonstrations in the Planetarium". He states that many qualitative observations in the planetarium can unquestionably lead to a better appreciation and understanding of the sky. He sees in the planetarium the potential of also supplying quantitative information, and he suggests the auxiliary equipment and methods necessary to achieve this goal.

The list of 19 citations, enumerated above, could easily be very much extended by going through each of the many publications listed in the appendix. It seems essential to note that all the positive comments on the educational value of the planetarium seem to be solely based on observation and experience. In the article on the Frederick County Planetarium, cited above, the planetarium teachers are even quoted as saying "...there is no way to evaluate precisely what we are accomplishing (it is not measurable as is the case of teaching English or some other basic subjects)...". It seems that there has indeed been no widespread research work done concerning the value of the planetarium as a teaching tool, besides several theses based on limited experimentation.
5. **Summary and Evaluation:**

The more salient comments are summarized below, partly in an abbreviated form:

<table>
<thead>
<tr>
<th>Abbreviated Arguments</th>
<th>Citation No.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Model of the universe</td>
<td>1</td>
</tr>
<tr>
<td>Cultural achievement of the first order</td>
<td>2</td>
</tr>
<tr>
<td>Transfer of flat drawings into 3-dimensional characters in a simple and meaningful manner</td>
<td>3</td>
</tr>
<tr>
<td>Tremendous instructional potential - one of the greatest teaching devices</td>
<td>4</td>
</tr>
<tr>
<td>Important part of community life - programmes create interest in astronomy</td>
<td>5</td>
</tr>
<tr>
<td>Everybody is thrilled --- could not be accomplished in the classroom</td>
<td>6</td>
</tr>
<tr>
<td>Versatile teaching instrument</td>
<td>7 + 12</td>
</tr>
<tr>
<td>--- teaching other subjects --</td>
<td>11</td>
</tr>
<tr>
<td>Motivates teachers and pupils alike</td>
<td>7</td>
</tr>
<tr>
<td>Enriches the classroom and textbook presentation - increases interest and retention</td>
<td>8</td>
</tr>
<tr>
<td>Demonstrates all celestial phenomena - positive influence on the learning process -</td>
<td>9</td>
</tr>
<tr>
<td>creates a positive emotional impact</td>
<td></td>
</tr>
<tr>
<td>Enthusiasm among visiting students</td>
<td>10 + 13</td>
</tr>
<tr>
<td>Demonstrates most complicated sky mechanics</td>
<td>14</td>
</tr>
<tr>
<td>Best possibility to disseminate astronomical knowledge to schools</td>
<td>15</td>
</tr>
<tr>
<td>People experiment rather than learn by memorizing - keeps students interested in astronomy</td>
<td>16</td>
</tr>
<tr>
<td>Ingenious idea</td>
<td>17</td>
</tr>
<tr>
<td>No visitor could escape the magic</td>
<td>18</td>
</tr>
<tr>
<td>Leads to a better understanding of the sky</td>
<td>19</td>
</tr>
</tbody>
</table>
The favourable descriptions given about the planetarium's educational value encompass 4 fields:

1.) technical perfection, versatility and teaching potential;
2.) the cognitive domain of teaching and learning and the affective domain of teaching and learning;
3.) the cultural importance;
4.) the entertainment aspect.

As comments rarely overlap, a wide spectrum of opinions is found.

General articles on the planetarium - as on most serious matters, it seems - reach a much wider public than research theses on the same subject. Such articles are a strong factor in creating public opinion, and since none of those articles cited above is the product of fantasy but is - as a rule - based on judicious observation, the influence of such an article - especially if the author is a prominent scientist, engineer, or scientific journalist - can be weighty.

6. Conclusion:

The results of this study support the operational hypothesis printed at the heading to this survey and, in this, support that part of the general hypothesis saying that planetariums are believed to be educationally valuable teaching tools in terms of a collection of statements found in general planetarium literature.

7. Implication:

Before drawing wider implications from this survey on general and research literature on the planetarium, it must be mentioned here that research literature on the planetarium does not seem to be known to teachers in West Germany, as the later survey conducted with schools in West Germany has proved (see survey III/5). General literature, however, seems to be known to this group.
Research literature does not stand in the way of educators in West Germany in seeing a justification for the existence and the use of the planetarium as an educational institution. General literature known to them praises the position of the planetarium. This eliminates the effect of literature as one possible factor for the underuse of the planetarium.

The following survey attempts to define educational value for the planetarium in an absolute manner by a survey of its potentials and functions in the fulfilment of curriculum requirements.
"PLANETARIUMS MAY NOT MEET THE REQUIREMENTS OF SCHOOL CURRICULA OF ASTRONOMY NOR MAY THEY FIND PROMOTION BY MEDIA RESEARCH"

A Survey conducted with Educational Institutions and Media Research

Part A: THE EDUCATIONAL VALUE OF MEDIA IN THE LIGHT OF CURRICULUM DEMANDS

1. Introduction:

1.1 Goals of Education

The purpose of all teaching is to help the student to learn a certain skill, understand a process, remember facts, to train his intellect and to broaden his mind; and also to promote in him the formation of desirable attitudes and to assist him in employing the knowledge and abilities gained to his own satisfaction and the benefit of others inside and outside of the society to which he belongs.

These general goals of education seem to be recognized by educationalists and seem to be the guiding principles underlying the educational system.

In order to attain these goals of education in an effective manner, and in order to facilitate the conveyance of educational messages, philosophers and teachers have developed educational methods and technologies and have either devised or adopted a variety of teaching media for this purpose.

1.2 The Planetarium

The planetarium was created for teaching astronomy and it ranks, in fact, among the oldest teaching aids, as has been shown in chapter I of this thesis. Familiarity with its construction and functions is a prerequisite for conducting the present study.
1.3 Astronomy

In the "quadrivium" of the "artes liberales", i.e. the range of subjects taught in classical antiquity and in the early medieval schools in Europe, astronomy had its firm place. After a long period of oblivion, it has, in recent decades, again become a scholastic discipline in many of the high schools of West Germany and, to a lesser degree, even in intermediate and primary schools. At a very elementary level astronomy has, in fact, always been taught in the schools of West Germany. It is at the more comprehensive higher level where this subject had disappeared from school curricula.

2. Theme and Purpose of the Study on the Planetarium's Educational Value:

The operational hypothesis guiding this survey is intended to test that part of the general hypothesis saying that planetariums are believed to be of educational value. In seeking a definition for this hypothesis the following principle questions pose themselves:

In the fulfillment of which educational functions does the value of the planetarium lie?

To whom is the planetarium of value?

Do both students and teachers benefit from it?

How is its value rated in the opinions of those concerned with it?

How can the planetarium's value, if any, be determined on an absolute scale?

The purpose of this part of the study is to seek a definition for the planetarium's educational value - if any - on the level of the planetarium's prospective clientele, the school system.

3. Methodology:

Goals, directions and curricula as laid down for the school discipline of "Astronomy" and as issued by several Ministries of Education in West Germany were studied and evaluated for this survey.
The programmes of several planetariums were consulted for their correlation to school curricula in astronomy. Several publications of planetariums were evaluated. - Validity and reliability are ensured as we are dealing with public facts and figures. Evidence for the findings presented is derived from the official publications mentioned above.

4. Procedure and Population:

The 11 Ministries of Education in West Germany, including West Berlin, were approached by the author in the framework of a different survey*) and asked for any relevant information pertaining to the school subject of astronomy. Four of the replies received contained curricula for astronomy. Two of them were selected for evaluation as they are the most comprehensive ones of the four and as they essentially represent the two different types of curricula in use in West Germany, i.e. one for full courses and one for a limited course subordinated to physics.

5. Findings:

5.1 Astronomy as a School Subject and its Behavioural Objectives

Astronomy is taught widely today in the schools of West Germany and the educational authorities in three West German states even expressly recommend the planetarium as an educational tool, but only 4 states have printed a curriculum for astronomy.*)

5.1.1 Baden-Württemberg

In the state of Baden-Württemberg the Ministry of Education has introduced astronomy into the high schools. This has not been done in order to teach a particular skill to the student but with the aim of increasing his knowledge about the universe of which the earth is but a small part and in order to enhance his capability of methodical reasoning. The text of the official curriculum for astronomy issued by the ministry for the high schools leads to this interpretation.1)

*) See survey II/11 "Enquiry with the 11 West German Ministries of Education", pp. 333 - 343.

1) "Lehrplan für das Fach ASTRONOMIE" Kultusministerium Baden-Württemberg, 1976
In this curriculum it is pointed out that the discipline of astronomy has been introduced in order to present the students with the subject matter of astronomical research and to give them some conception of the construction and development of the cosmos. It is said that the science of astronomy allows observation and measurement only in a limited way and in this differs from other natural sciences.

Astronomy provides scarcely any scope for experimentation but demonstrates particularly clearly the interaction between observation, hypothesis, theories and renewed observation. Astronomy is rather close to physics, but it is not intended at the high school level to concentrate on the derivation of exact physical laws from the observations made. The teacher's method is rather to provide a continuous interaction between observation, description, and supplementary information from pure physics and some of its relevant laws. The methods involved in working with models and the relevant verification of facts found through careful observation are intended to supply an interdisciplinary view and to sharpen the student's mind for work in all other natural sciences.

The above is the author's summary of the key statements contained in the introduction to the official curriculum and the "Basic Course 1 of Astronomy."

5.1.2 Rheinland-Pfalz

This West German state has not introduced astronomy as a major subject into the high school curriculum. Some astronomical themes, however, are treated in the framework of physics.

The objectives defined in the respective curriculum for the subject of physics are enumerated in 42 statements with a defined rank order of educational importance. "Mere knowledge" ranges lowest and "ability to substantiate and to unfold" ranges higher in this order. To realize the essence of scientific reasoning, methodology and experimentation, the transfer of acquired facts into other realms of life, and to understand the social and cultural implications of physics as a science
in addition to acquiring and retaining a solid stock of facts and figures is the gist of the set goals. ²)

5.2 The Curriculum for the Subject of Astronomy

5.2.1 Baden-Württemberg

The curriculum under review essentially comprises the following topics:

1. Synopsis of the science of astronomy
2.1 Apparent diurnal motion of the stars
   2.1.1 Stars and stellar configurations as celestial objects on a sphere
   2.1.2 Changing nocturnal view of the sky
   2.1.3 Celestial equator and poles
   2.1.4 View of the sky at various geographical latitudes
   2.1.5 Hour angle and declination
2.2 Apparent annual motion of the stars
   2.2.1 Changing annual view of the night sky
   2.2.2 Apparent motion of the sun against the fixed star sky
   2.2.3 Ecliptic, constellations of the zodiac
   2.2.4 Equinoxes, right ascension, sidereal time
   2.2.5 True and mean solar time
2.3 Motion of the planets against the fixed star sky as a consequence of the motions of the planets and the earth and their relative positions within the solar system
   2.3.1 Geocentric and heliocentric universe
   2.3.2 Spatial positions of planets
   2.3.3 Kepler's laws, Newton's law of gravitation
   2.3.4 Radius of the earth's orbit as an astronomical measure of length
3.1 The moon (with many sub-themes)
   3.2.1 The planets (with many sub-themes)
   3.3.1 The comets
   3.3.2 Interplanetary matter
4.1 The sun (with many sub-themes)
5.1.1 Trigonometric determination of distances

²) See Kultusministerium Rheinland Pfalz "Entwurf zum Curriculum Leistungskurs Physik". Year?

FOOTNOTE: The summary made of the lengthy original text is the author's interpretation of that text.
5.1.2 Apparent star brightness and definition of magnitudes
5.1.3 Absolute star brightness and brilliancy, module of distance, determination of stellar distances on grounds of star brightness

These are the themes of "Basic Course 1" including the beginning of "Basic Course 2", positions 5.1.1 to 5.1.3. The latter course concentrates mainly on astrophysics, galaxies and cosmology.

Models are recommended for the demonstration of the celestial events and related data as contained in this curriculum. Star globes, telluriums and star maps are named as being helpful media, but above all the small school type of projection planetarium is recommended by the responsible ministry, and they strongly recommend the schools to visit a large planetarium.

5.2.2 Rheinland-Pfalz

The astronomical themes contained in the physics curriculum for Rheinland-Pfalz are:

Gravitation, planetary motions, space travel.
Metamorphosis of the human conceptions of the universe and the philosophical consequences resulting from it.
Kepler's laws.
Determination of the mass of celestial bodies.
Orbital speed, escape velocity and limiting speed of artificial satellites and the consequences of these data for space travel.
Epicyclic motion of the planets.

The planetarium is not recommended in the curriculum.
The two curricula cited so far exemplify the two extreme conditions prevailing for the subject of astronomy in the very diversified school-system of West Germany. Astronomy is a major subject in one state and a subordinated selective sub-theme in another state. This latter fact, however, need not automatically exclude the use of the planetarium, or at least the desire to use it, for such schools, as will be shown later in this thesis.

As observation and experience show and as is visible from the printed programmes of many planetarium performances, the descriptive astronomy as well as the actual themes listed above, are the common stock of planetarium shows. It is therefore safe to assume that the planetarium could also find a legitimate place in the schools of Rheinland Pfalz.

This state, however, does not own a planetarium anywhere, neither in the schools, nor the universities, nor the municipalities. Rheinland Pfalz does not expressly recommend the use of the planetarium for teaching the topics listed. It is known, however, that some schools of this state do undertake excursions to distant planetariums. *)

After having investigated the content and circumference of two typical curricula, and after having studied the behavioural objectives set for the relevant school subject of astronomy, we can now proceed to explain the meaning of educational value for the media involved in teaching astronomy.

*) Information obtained in telephone interviews with school headmasters, (Survey II/5).
6. Educational Value of a Medium:

Educational value in a medium can be described as its **effectiveness** in the fulfillment of the demands made by the curriculum in the cognitive as well as in the affective domain.

The better a given educational medium can help to achieve the set goals of an educational programme (such as astronomy), the more highly its educational value can be rated.

In the following paragraph an investigation will be made, in the above sense, as to whether the planetarium actually does rank at the top of the educational media available for teaching the many subjects of a school course in astronomy, such as the proponents of the planetarium claim.

The planetarium's potentials and functions, with regard to curriculum demands, in the light of other media choices open to the teacher, will be investigated.
Part B: THE PLANETARIUM'S INTRINSIC EDUCATIONAL VALUE

1. Introduction:

The Planetarium's Potentials and Functions determine its Intrinsic Value

In fact, as observation and experience show, and as the printed programmes of planetarium performances and published literature on the planetarium's demonstration capabilities reveal, the above list of astronomical topics taught in the two states falls into the very domain of the planetarium's time-proven activities; while the additional themes of astrophysics, galaxies and cosmology mentioned as part 2 of the list under review and not outlined here in full detail can partly be treated in the planetarium.

2. Limitation:

In the following treatise the planetarium's functions are compared to alternative media. While it is necessary for this purpose to outline the organizational contours of media application, it cannot be the object of this paragraph to deliver the full lesson contents for the astronomical subjects under discussion. This would be beyond the scope of this thesis. This treatise is hence limited to a description and discussion of media functions.

3. Evidence:

Evidence for the statements made on the potentials and functions of the media described and discussed in this study is derived only from the known construction of the media. Manufacturers' catalogues and handbooks deliver these data. No comparative experiments have been undertaken to substantiate the statements made, nor was this thought essential as the scope of the functions of the media involved are known by the users and do not seem to be questioned anywhere. The author has familiarized himself with the construction and functions of the media under discussion.

4. Media Choice for Teaching Astronomy:

The use of the planetarium for teaching the school discipline of astronomy is not the rule but the exception, as later surveys will show. In the absence of a planetarium, but also complementary to its
functions, schools use the following instruments in addition to conventional blackboard teaching:

Books and periodicals about the subject of astronomy, slides and films (e.g. on an eclipse), star globe, solar clock (manufactured by the students), rotatable star charts, solar height meters, a theodolite, a sextant, a school telescope, pantographs, lenses and prisms, perhaps a small heliostat, and a camera.

In the following paragraphs the available school curricula on astronomy will be discussed with their practical implementation by the use of various media. As far as the use of the planetarium is concerned, groups of related subjects are combined for one planetarium lecture-demonstration in order to make maximum use of scarce planetarium time. In case of a school-owned planetarium, ideally a classroom planetarium, more frequent and more intensive use would be made of the planetarium demonstration facilities.

4.1 The Implementation of the Astronomy Course:

Synopsis and History of the Science of Astronomy:

This is partly a historical discourse mentioning the ancient civilisations, the Greek mythology and conception of the universe, the philosophies of Anaximander, Pythagoras, Eratosthenes, Plato, Ptolemy and many others. Secondly, the achievement and views of the astronomers of the later ages will be treated, e.g. Copernicus, Brahe, Kepler, Galileo and Newton. Finally the space age and modern advances in the field of astronomy will be discussed and the synopsis of the science of astronomy may be presented as has been done in chapter I of this thesis.

Slides and pictures illustrating the various historical conceptions of the universe will be helpful to understanding. A star globe and star charts are indispensable in the explanation of the starry sky. The star globe as a model of the universe is seen from outside, and the rotatable star chart must be held above the head to provide a natural view. Both media are instructive models but appeal to the intellectual agility of the student to make the transition from the model to reality in which man is earthbound
inside the seemingly spherical universe. (This mentally made transition poses at least initial problems to many a student.)

A visit to the planetarium will actually allow the interaction and the relationship of the various branches of astronomy to be shown in the simulated universe and will also allow the description of the various interpretations given to the celestial phenomena throughout history.

Geocentric and Heliocentric Universe (2.3.1):

This subject can be easily combined with the above. A programme "Introduction to Astronomy" will cover both and is a very common subject in the calendar of events of any planetarium. The experiments performed in the framework of this thesis (II/10) have used such an introductory lecture-demonstration intended for newcomers to the science of astronomy.

The lesson on the above two subjects of the curriculum calls for a multimedia presentation. Speech will be the predominant tool for the historical section and will be supported by the simpler media with the added difficulty that the whole class can't see very much on one small star globe.

The section on the synopsis of astronomy could be continued in the same fashion but can be brought to life by a lecture-demonstration in the planetarium.

Based on observation and experience, planetarium teachers, astronomers, planetarium visitors and school teachers believe that the more lively planetarium lecture-demonstration will make the lecture easier to understand and more interesting, though the results of various theses written on teaching in the planetarium indicate that certain astronomical subjects are better taught outside the planetarium in the more conventional fashion (according to the survey on planetarium literature (II/3).)

In the planetarium all students experience the spectacle at the same time and do not have to wait their turn for a view of the star globe. This is but one advantage of the large spherical
star field projection in the controlled environment of the planetarium.

Blackboard teaching of the subject can be supplemented by using star charts and the star globe which are geocentric in construction. Textbooks will provide suitable drawings. Ptolemy and Copernicus, the proponents of the two conceptions, and their spiritual impact on their epochs can be repeated from the first lesson.

The planetarium sky can be explained as a natural model of the geocentric conception, as is in effect repeated over and over again in nearly every new planetarium lecture-demonstration. The geocentric earth projector with its shadow contours superimposed on the planetarium star field will assist in forming a clear conception of the geocentric universe. The planetarium is the only man-made tool to simulate the astronomical universe, and its demonstrations of this conception are easier to understand than flat drawings, as has been discussed elsewhere. The heliocentric projector will render this conception comprehensible, but could be used in an ordinary classroom as well, as the spherical planetarium dome is of no importance to this demonstration. Space-age planetarium projectors, however, can simulate the whole sky in a heliocentric configuration. (Spitz "STS", Zeiss Jena "Space Master".)
The following group of themes is particularly important as the base of descriptive astronomy.

**Celestial Equator and Pole (2.1.3), Hour Angle and Declination (2.1.5), Right Ascension (2.2.4), Ecliptic (2.2.3);**

(Celestial Coordinates and Celestial Triangle);

All subjects dealing with the celestial coordinates and reference points can fruitfully be combined in one lecture-demonstration in the planetarium. This will facilitate teaching and learning of all the later themes in the curriculum as it places their information in a defined three-dimensional system.

Star charts are useful at this stage as they mostly have the coordinate system printed on them, but their correct use and interpretation has first to be learned. This is best done in the planetarium for the sake of correct correlation of chart information with a simulation of reality. Scenes in the planetarium can be repeated at will to engrave a difficult subject in the memory of the audience for better retainment. The star chart will in the above way attain the characteristic of being a supplement to the planetarium rather than of being an alternative to planetarium teaching. This could be the ideal case as learning might be facilitated by the use of several media.

Printed Armillary Spheres showing the celestial grid in curved lines as a representation of three-dimensional space are a necessity, as they allow the student to learn the various meanings and purposes of these lines and the corresponding terminology by heart in his own time independently of the speed in the progress of the lecture in school. However, for many students, such flat drawings do not unfold into a three-dimensional image, as many a teacher will have experienced: A number of students do have a natural deficiency in spatial conception. It can be quite confusing to see the absolute spherical coordinates and the earthbound observer's reference grid combined in one single drawing.

The ancient Greek teachers had discovered this and promptly invented the Armillary Sphere, the early predecessor of the
planetarium, as described in chapter I. A star globe and a real Armillary Sphere therefore seem to be a necessity allowing the three-dimensional model of the universe to be seen from the outside and thus enabling the significance of space coordinates and reference points to be understood.

But we are living on the inside of the sphere that the universe seems to form, and it therefore appears to us to be natural to try to view the universal reference grid from our geocentric position. It is possible to facilitate this by constructing a large Faraday-cage-type Armillary Sphere, to erect it on a mountain top with a free view in all directions, to take a central position inside this sphere and to focus the eye on infinity along the bars of the Armillary cage, thus projecting this grid on the starfield on a clear night. This might be a promising solution to the problem of deficiencies in spatial conception.

The projection planetarium can achieve the same effect much better inasmuch as no problem of focus is involved and as all points and lines can be shown individually or in combination with any of the others or all others, as the lecture may demand. This can be done independently of the starfield or superimposed upon it. The azimuth-altitude system of star positions can be spherically demonstrated in combination with the horizon - and equatorial system.

Sitting inside the artificial model of the universe in the planetarium simulates nature for the observer and enables him to retain his natural geocentric view of the universe. No mental translations, so difficult to achieve for many students, have to be performed and the lecture can proceed uninterrupted. Different colours given to the circles further facilitate learning. This short description may also demonstrate the advantages that the planetarium offers to lectures in spherical geometry.

The ecliptic (2.2.3) studied from our geocentric view is the grand circle formed by the sun in its annual course as projected against the field of fixed stars. It can be explained to the students by an excursion to a point of good observation during a clear night with several planets visible and possibly the moon
as well. The ecliptic as an imaginary great circle runs very near to the positions of these celestial bodies. This can be explained to the students. A line normal to the tips of the sickle of the young moon in the night sky will extend on both sides into the ecliptic. The positions of the full moon recorded over a year will also result in the ecliptic. The positions of the moon recorded daily during one full moon period will also give the approximate position of the ecliptic. The moon’s position is determined by its angular distances from several known stars. A 1cm section on a ruler viewed at a distance of 57.3 cm will give an angular measure of 1°.

There are more observational methods, even more time-consuming, for the determination of the ecliptic. All of these are good practical exercises for the students, giving them training in practical observation and evaluation. However, climatic hazards, organizational problems and the question of time may prove to be frustrating handicaps, though more than one type of celestial observation could be organized into one practical excursion. The planetarium is free from such restraints, and sun and moon, (the latter including its periodical phases), can be guided over the ecliptic on the planetarium sky to mark its course. In fact, all these outside observations can be simulated in the planetarium.

In teaching the subject of the spherical coordinates for the measurement of the positions and motions of celestial bodies, the planetarium seems the best medium by virtue of its construction and inherent functions.

Stars on the Sphere (2.1.1):

In teaching this topic, the star chart as well as the star globe are indispensable and additional individual pictures of star constellations will facilitate learning a number of constellations by heart. There are more than a hundred defined constellations derived from various cultures in history and more can be added from historical research. The more distinctive ones (Great Bear, Orion, etc.) should be known by heart. A star chart of the northern sky with North in its centre and the celestial equator
forming the rim will, with some imagination, allow the relevant positions of the stellar configurations to be memorized. Imagination is required in order to achieve the transition from the inverted view into reality.

The star globe may be the better teaching tool for this subject by virtue of its spherical shape as a model of the universe, but its inherent handicap of being viewed from the outside may only prove another difficulty to some students as has been described previously.

Practical night sky observation will supplement classroom teaching. An evening excursion to a place of unobscured visibility will enliven the lecture by practical star observation and will also give the opportunity for exercises in star positioning with the aid of a theodolite or a sextant.

If climatic or organizational circumstances should not permit such an excursion, than a visit to the planetarium can be substituted. The planetarium offers the advantage that images of star configurations can be superimposed on the artificial star field. Simulating the starry sky with correctly positioned star images in their natural though accelerated motion is the very domain of the planetarium performance. As especially in the larger planetariums the illusion of being out in the open under a clear sky is a perfect one, and, as the alternative demonstration models discussed above are imperfect in their construction and function, it follows that the subject of "Stars and stellar configurations as celestial objects on a sphere" is best taught in the planetarium, on the artificial sphere, viewed from the observer's natural geocentrical position. Additionally, the visit to the school planetarium can be arranged more comfortably than an open air night-time excursion. By the help of the luminous arrow pointer the teacher can indicate positions and constellations simultaneously for the whole class.

It may, however, also be remembered that B.A. Smith (op. cit.) in his thesis had come to the conclusion that - among other themes - constellations were learned better in the classroom than in the planetarium. R.S. Bondurant (op. cit.) came to the opposite conclu-
sion and T.V. Smith (op.cit.) similarly concluded that the planetarium was superior for teaching constellations in comparison to classroom teaching. Even if a teacher did know the above research results, he would be able to be his own judge in his medium preference, although it would be difficult for anyone to deny the advantages offered by the planetarium's potentials and functions in teaching the above subject.

View of the Sky at Various Geographical Latitudes (2.1.4), Changing Nocturnal View of the Sky (2.1.2), Apparent Diurnal Motion of the Sky (2.1):

The above three themes are interrelated inasmuch as either the observer's position on earth is moved or the apparent motion of the sky provides a different view of the star field.

The suitable tools for demonstrating the phenomena contained in these subjects are again the rotational star chart and the star globe. The latter may be the more appropriate tool as it is relatively easy to move an observer along any celestial meridian and to demonstrate its changing field of vision by a small funnel made from paper. Rotating the globe will provide a demonstration of the diurnal motion and hence the changing nocturnal view of the sky in one night using the same paper funnel. This is a substitute type of observation. One of the above practical star observations will provide the natural experience of the changing nocturnal view of the sky.

The handicap inherent in the two simpler tools mentioned above and the problem connected with excursions may again prove to be a disadvantage while a planetarium lecture-demonstration will provide ideal conditions. A rotation of the star projector around its principal axes will deliver a perfect simulation of the desired events while the teacher delivers his lecture and discusses the topics under study with his class.
While star chart and star globe will be necessary to understand the lesson on time and will be helpful to some degree in supporting the blackboard lecture or book reading, the factor of time will set a limit to excursions as the subject cannot be covered in one single lesson under the free sky. But, as a constellation moves by 30° a month (360° in one year), its course can be followed and mapped at least over some shorter period of time. This observation and recording will help to understand sidereal time with a certain constellation rising about 1° (3min.56,56 sec.) earlier every day while the wrist-watch shows the conventional solar time (synodic time).

Replacing or supplementing the excursion by a planetarium lecture demonstration will provide a perfect simulation under accelerated time. The rotatable geocentric earth projector will superimpose its coordinates on the star field and a shadow lay-out of the earth's land masses. Projecting the hour circles will facilitate the explanation of the sidereal time. The difference in sidereal and synodic periods of the earth's rotation can be demonstrated in the planetarium as the observer first refers to the sun and then to a star. As the earth has moved on its orbit by approximately 1°, the sun is not yet in its original position relative to the star. The above lecture does not complete the subject of time. Time zones have to be explained either by simpler means or in the planetarium.

The possibility of a complex combination of the various planetarium projection devices renders the planetarium particularly effective in both teaching and learning a difficult theme. The interaction of the geocentric earth projector, the star field and the hour angles should make time zones more easily understood.
The Planets (3.2.1), Motion of the Planets (2.3), Spatial Position of Planets (2.3.2), Kepler's Laws (2.3.3), Newton's Law of Gravitation (2.3.3), Astronomical Unit (2.3.4), Comets (3.3.1), Interplanetary Matter (3.3.2):
The above are interrelated themes and could therefore be treated as one group. Star charts of various periods over the year, the star globe and a mechanical tellurium, e.g. a heliocentric planetary system with mechanically moving orbits, and the blackboard lecture are the conventional means for teaching these topics. The tellurium simulates the positions of the planets, and shows their orbits and spatial positions and their relative sizes. A set of special mechanical pantographs is suitable for students' exercises in drawing the orbits of the planets on graph paper. This will deepen the understanding of the subject.

The mathematical work involved must be explained on the blackboard. The motion of the planets against the fixed star sky can be followed over a time by excursions to a good viewing place and will usually be combined with other practical astronomical observations. Much of the simpler practical observations can be left to the individual student to organize for himself, as it will be difficult to gather a whole class together at frequent intervals. Using a telescope or an ordinary pair of binoculars will allow observations of the moon and the moons of Jupiter in their orbits. Practical observation is of course very time-consuming and must be extended over several months.

The planetarium in contrast will perfectly simulate the motion of the planets against the fixed star sky in accelerated time and even the retrograde motion of Mars can be perfectly simulated.

A heliocentric planetary system projector can optically replace the mechanical tellurium, but has no noticeable advantage over the latter. On the contrary, the tellurium can be handled by the students. The planetarium teacher will hardly allow students to work with his projectors. The astronomical unit as a measure derived from the earth's orbit around the sun can effectively be demonstrated by either of the above means. Kepler's and Newton's laws need intensive mathematical treatment, but their practical
origin can effectively be demonstrated by either of the above means. Comets can best be shown by slides either projected on a screen in the classroom or on the planetarium sky. Photos in a textbook will serve as well. Actual orbital motion can, however, only be simulated in the planetarium against the artificial star field. The tellurium experiments can be witnessed only by small groups at a time. The planetarium lecture-demonstration can be experienced by the whole class simultaneously. The planetarium is more universal and more complete in its possibilities of simulation and demonstration in comparison with other media. Even meteor-showers and shooting stars can be simulated in the planetarium by special-effect projectors.

Limits of the Planetarium:

The following themes will lead us to the limits of planetarium lecture-demonstrations.

It must be remembered that the planetarium is not a research instrument for astrophysics or astrochemistry but a simulation device delivering a controlled model of the starry sky and a large range of celestial phenomena and events.
Trigonometric Determination of Distances (5.1.1), Brightness-based Determination of Distances (5.1.3), Starbrightness (5.1.3) and (5.1.2):

Both subjects involve blackboard lecturing and book reading. Practical exercises are done with a theodolite under the sky by the parallax method. Lab models can be constructed for the trigonometric measurements of distances. It will be explained that 50 pc* is the utmost distance that can be determined in the trigonometrical way and that photometric methods based on star brightness have to supplement the trigonometric methods.

As in the planetarium the star field can be moved at variable speeds at will and as its use makes one independent of climate, location and time, it offers a very suitable place for a geometrical exercise, especially as coordinates can subsequently be superimposed on the star field for verifying the results of the geometrical exercises.

The differences in star brightness and the meaning and importance of this phenomenon can also be explained in any planetarium of more advanced type, in which the stars are exactly grouped according to their order of magnitude. (Apparent brightness is the result of real brightness and distance.) The brightness can be determined coarsely by the visual method, photographically or photoelectrically. The latter method can be explained to students but practical exercises are not the rule at the high school level, as the complicated apparatus required is only found at the level of higher education and research. Mathematical calculations with pre-given data can be performed at the high school level. Photographs are preferably taken in nature as an exercise in practical astronomy.

The planetarium is a convenient place for demonstrations and exercises involved in teaching the above subject for the reasons outlined above. Outside excursions provide for natural conditions.

*) pc = Parsec, a unit of measure for inter-stellar distances = 3,26 light years.
The Moon (3.1):

The moon as the nearest of all heavenly bodies offers many possibilities for astronomical observations and studies. There are comparatively cheap moon globes available nowadays, since also the other side of the moon has been mapped. Photos, charts, students' own observations through a pair of binoculars, the tellurium, text books and blackboard teaching are the conventional media used in dealing with this subject. The moon's surface is seen much better in nature than in the planetarium. The planetarium can simulate the moon's orbit around the earth and their common course through space. Also the moon phases can be exactly simulated and explained as well as lunar eclipses. Real and apparent motions can be demonstrated. The planetarium offers the advantage over other media that the moon is seen in motion against the background of the starfield in accelerated time. The planetarium can not replace natural moon observation.

The Sun (4.1):

The study of the sun as the nearest of all fixed stars is the basis of all serious astrophysical study "by virtue of the mass of data that can be obtained from solar observation. Text books are needed with suitable photos of solar phenomena such as of the complete disc in white light, of sun-spot regions, granular disc structure, the hydrogen-alpha disc and prominence, flares, X-line image, and eclipses. These cover the visible phenomena and allow individual lectures of the origin and significance of these phenomena. Rotation can be studied by observation. Solar physics and solar chemistry can be introduced by constructing a simple spectroscope from available prisms and lenses, and the simplest form of a heliostat is a mirror held by hand or mounted on a small swivelling mount allowing tracking of the sun. The reflected solar light can be depicted by a lens as a white light disc, or it can be projected into the make-shift spectroscope for the study of the solar spectrum and the typical absorption lines. The solar disc can be projected through the school telescope onto white tracing paper for following growth and course of sun spots over some period of time.
Blackboard lectures will guide and supplement observations and experimentation, which should - according to the curriculum - also include limb-darkening studies by means of an ordinary photographic exposure meter or a lux meter, which may be available in the physics collection. Films are available and also slides, normally free of charge, from the central school film library.

The planetarium can simulate the sun's orbit and solar eclipses and thus supplement but not replace the above other forms of solar studies. Slides on special features of the sun can be projected either in the planetarium when discussing the mechanics of the sun or in the classroom.

Advanced Themes:

Part of the many themes of astrophysics contained in the more advanced section of the curricula could be treated in the planetarium in combination with the planetarium lecture-demonstrations already discussed, though in their majority these themes are suited to blackboard teaching and book learning. The planetarium cannot offer any particular advantages for these subjects as neither real sky observation nor its substitute, planetarium sky observation, is involved.

Other advanced astronomical themes in higher courses similarly find only a limited place in the planetarium proper. The Milky Way, some galaxies and nebulae can be shown and discussed in the planetarium, also the location of radio sources can be pointed out in the planetarium and such demonstrations need supplementation by slide projection (e.g. actual photographic slides of nebulae superimposed on the starfield). If planetarium facilities are readily available, e.g. a school-owned planetarium, and if in the ideal case this were a multi-media classroom planetarium, then all indoor activity would take place there. But if excursions to an outside planetarium have to be undertaken, then these themes might only be touched upon as the planetarium demonstration facilities cannot cover their full scope and depth.
With this in mind, the author has listed only the basic course in more detail, as it is the themes of the basic course which lend themselves best to planetarium demonstration.

Table 6 on the following page summarizes the comparison made of the various media involved.

As to point 9 of this table it must be mentioned that in the curricula for the school subject of astronomy published by the respective Ministries of Education of Baden-Württemberg and Berlin strong reservations are being made against the use of transparent star globes, as the views offered by these globes are considered as being confusing.
# TABLE 6

**SKY IMAGES**

**MEDIA USED IN BASIC ASTRONOMY COURSES**

<table>
<thead>
<tr>
<th>Nos.</th>
<th>Medium</th>
<th>Purpose</th>
<th>Limitations</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Star Chart</td>
<td>Star positions at specific times, and astrometric data.</td>
<td>Valid only for one observation point and certain specific times. Must be viewed from below. Flat image. Small size.</td>
</tr>
<tr>
<td>2.</td>
<td>Star Chart, rotatable</td>
<td>Star positions over one year and astrometric data.</td>
<td>Valid only for one observation point for one year. Must be viewed from below. Flat image. Small size.</td>
</tr>
<tr>
<td>4.</td>
<td>Tellurium</td>
<td>Movable mechanical heliocentric model of the solar system.</td>
<td>Planets' motion not demonstrated against the star field.</td>
</tr>
<tr>
<td>5.</td>
<td>Armillary Sphere</td>
<td>Celestial coordinates, ecliptic and reference points.</td>
<td>Single purpose instrument. Must mentally be transferred to the real sky.</td>
</tr>
<tr>
<td>6.</td>
<td>Pictures</td>
<td>Celestial coordinates, points and references.</td>
<td>Flat image difficult to translate into 3-dimensions and to visualize as being superimposed on the starfield. Small size.</td>
</tr>
<tr>
<td>7.</td>
<td>Pictures &amp; Slides</td>
<td>Celestial objects.</td>
<td>Clear but no motion, only small sections of the sky visible.</td>
</tr>
<tr>
<td>8.</td>
<td>Films</td>
<td>Celestial events.</td>
<td>Clear but only useable for specific isolated events, no full sky view possible.</td>
</tr>
<tr>
<td>9.</td>
<td>Transparent Star-Globes</td>
<td>Star positions and astrometric data.</td>
<td>Strongly advised against by the educational authorities.</td>
</tr>
<tr>
<td>10.</td>
<td>Projection Planetarium</td>
<td>Simulation of all celestial events.</td>
<td>None of the above limitations. Sky appears as in nature.</td>
</tr>
</tbody>
</table>

## SUMMARY

From a comparison of educational tools for teaching the school subject of astronomy, the planetarium emerges as the most universal medium. The scope of its functions is not reduced by the limitations inherent in other media.
4.2 The Curriculum of Rheinland-Pfalz:

The selection of special astronomical themes found in the physics curriculum of Rheinland-Pfalz is not capable of presentation without at least a basic introduction into general astronomy, including the solar system. Teachers will simply have to include such lectures in their programmes in order to set the scene for the other topics to be taught, even if the curriculum does not expressly instruct them to do so. The experience of a planetarium lecture-demonstration on basic astronomy may be the most convenient method of giving such an introduction to students by virtue of the universal simulation and demonstration facilities of the planetarium.

The themes mentioned in the short curriculum can all be treated in the planetarium inasmuch as the different celestial events forming the themes of the various subjects and the physical laws governing these events can be shown in action in the simulation of the original scene, while the mathematical treatment of these laws is routine classroom teaching. The simpler media mentioned above will prove useful, though in their more limited ways.

5. Summary and Evaluation:

Among the media used for teaching astronomy, the planetarium occupies a prominent place inasmuch as it is the largest of all the media and as it is the only one that really simulates the night sky. It renders the celestial phenomena and positional measurements of celestial objects particularly comprehensible in comparison to other media as it puts an observer in his natural geocentrical position and as it delivers a three-dimensional image in nearly perfect simulation of natural astronomical events. Also celestial points and lines of references can be projected in 3-dimensions. Its projections condense time and thus allow observations that would require long periods of time for completion under the natural sky. The use of the simple star chart and globe is also done in condensed time. The planetarium can widely replace the need for excursions under the natural sky, though not detailed star observation through the telescope. It makes one independent of time and climatic conditions, as does any other form of classroom teaching. It can take the observer to any place on earth and forwards or backwards in time.
The themes of basic astronomy and descriptive astronomy contained in the curriculum of school astronomy can, in their vast majority, be more instructively taught in the planetarium than by other media which all suffer from certain limitations in their application. The planetarium is the most universal teaching tool in the range of instrumentation presented and discussed in this thesis. The projection planetarium's limit for teaching astronomy is reached when teaching the more advanced themes of astrophysics and other higher themes that exclude the necessity of sky observation but demand predominantly blackboard lecturing, book reading, telescope observations, mathematical computation, and lab-experimentation, but the base for such themes can be laid in the planetarium. If their treatment is performed in the planetarium chamber, then this is done predominantly in the classroom function of this chamber.

Astronomy is taught by conventional classroom methods and limited experimentation plus planetarium lecture-demonstrations, and it follows from this treatise on media use that the combination of both in a multi-media classroom planetarium would facilitate teaching as it would avoid shifting a whole class of students from one place to another. For planetarium lecture-demonstrations need both pre- and post-experience activities in order to deepen understanding and to promote retention, as is claimed by certain planetarium research. (II/3)

A comparative summary of those media used for depicting the starry sky is given in Table No. 6.

Affective Domain:

While the survey of planetarium literature showed that much of the educational value of the planetarium is found or believed to be found in the affective domain, the study of the planetarium's functions in fulfillment of curriculum demands did not lead to any manifestations of the affective aspect of the planetarium experience. This aspect had thus to remain outside the scope of this study but much space will be given later in this thesis to this particular part of the planetarium's educational value. At this stage we can only summarize the expectations made on the planetarium regarding the affective aspect of planetarium teaching.
Expected Benefits of the Planetarium in the Affective Domain

While it is true that the material available for this programme does not cover the affective domain of planetarium teaching, it is possible to summarize some of the benefits which are expected from the planetarium in this domain, basing this on the other surveys and especially on the opinion polls performed and the author's experience and observations.

The planetarium is expected:

1) ... to form a cultural institute beneficial to the youth as an alternative to harmful forms of entertainment. (This very argument brought the Bangkok planetarium into being, as the author was able to witness on the spot.)

2) ... to be an attractive medium.

3) ... to stimulate an interest in science and to promote a love for learning.

4) ... to elevate the mind and to stimulate contemplation and thought beyond mere factual knowledge.

5) ... to fill a student with awe and respect for the wonders of the universe and the laws and the order that govern the universe. This should help in making him conscious of his own worth as a part of creation.

6) ... to provide a marvellous and fascinating experience, able to inspire with enthusiasm for the spectacle and its educational message.

7) ... to unite families in erudite entertainment.

8) ... to foster the religious concept of God's great creation.
9) ... to awaken or to strengthen in a student the roots of a spiritual life.

10) ... to confirm "scientific atheism".*

11) ... to "confirm the laws of Marxistic Dialectics".**

12) ... to achieve a peace of mind elevated above the frustrations of daily life.

Educationalists and many promoters of the planetarium idea place much emphasis on these - and probably many more - affective aspects of planetarium teaching as a second and complementary quality which is of educational value in addition to the many teaching potentials of the cognitive domain.

*) Lecture of the Director of the Moskwa Planetarium, see survey II/8.

**) Zeiss Jena publication 1977.
6. The Planetarium's Value for Non-Astronomical Subjects:

The country that invented the projection planetarium but has been hesitating for decades to install it at the school level cannot be expected to include in its school curricula hints on the use of the planetarium for disciplines other than astronomy, e.g. mathematics or environmental sciences. This is in contrast to the USA, where the more universal application of the school planetarium is common-place nowadays. Chapter I contains lists of subjects other than astronomy taught in the planetarium. This leads to the assumption that the planetarium is considered to be a valuable teaching tool also when used outside its true domain, as has also been confirmed by several surveys, f.i. II/5.

7. Conclusion of the Study on the Planetarium's Intrinsic Educational Value by Definition of its Potentials and Functions:

The author has attempted to show, in the two case studies unfolded above, which potentials and functions can be ascribed to the planetarium and how the planetarium's intrinsic educational value is defined by its efficient use. The planetarium seems therefore to be of value to the student, as its function is to render a difficult subject dramatic and easy to comprehend by simulating, at the highest degree of precision, the celestial events in as perfect an illusion as is technically possible.

Similarly the planetarium seems to be of value to the teacher as a teaching tool for facilitating the dissemination of knowledge in a difficult discipline. The planetarium delivers the model for a true-to-nature simulation of astronomical events with the added advantage of allowing a significant condensation of time. It includes projection possibilities for all themes of the basic course and for many themes of the higher course.

The complexities of sky mechanics, the spatial conceptions involved in studying and determining positions and motions in space, the many topics of descriptive astronomy, and the notion of the limitless universe can be taught more easily in the planetarium by virtue of its inherent technical potential.

Describing the planetarium's potential and function is an absolute manner of defining its value as a teaching tool.
The question of definition of value by function has been answered by this study, likewise the question of to whom the planetarium is of value. The above statements will be supplemented by the results of opinion polls conducted with all groups concerned with the planetarium. The planetarium's educational value will also be investigated experimentally in an attempt to determine the planetarium's value in a more absolute manner in both the cognitive and the affective domains. This will answer those questions on the planetarium's educational value that could not be treated in this study.

The results of this part refute the operational hypothesis in its relevant first half, and in this the results of this study support the general hypothesis in that part saying that planetariums are believed to be educationally valuable teaching tools in terms of their capability to facilitate the attainment of teaching objectives as laid down in the school curricula for astronomy.

As we have convinced ourselves of the planetarium's inherent potential and function as an expression of its intrinsic educational value, it remains to be seen in the next part of this programme whether or not media research delivers any form of justification for the planetarium's application as an educational tool, i.e. for its existence and use.

8. Implications:

As this study had to be limited to an investigation of the cognitive aspect of planetarium teaching and learning, it follows that the same questions which have guided this investigation of the cognitive domain have to be asked again for the affective domain of teaching and learning in the planetarium and, for this reason, general planetarium visitors as well as students taking courses in the planetarium were tested for their attitudes in this respect, as will be demonstrated in later survey reports.

9. Outlook:

At the end of the investigation on planetarium research literature (II/3 A) it was demanded that "it should be attempted to define what one may rightfully expect of the planetarium and then to test whether or not expectations are met."
With this part of the survey we come back full circle to this recommendation. Within the limitation made for this survey, which concentrates only on the intrinsic value of the planetarium, what one may expect of the planetarium in terms of the requirements of the curriculum has been defined. How the planetarium can meet these requirements has been explained.

In the later survey II/10 an attempt has been made to deliver proof of the planetarium's efficiency in the cognitive and in the affective domain by conducting practical experimentation in the planetarium, as has been mentioned before.
Part C: THE USE OF THE PLANETARIUM AS AN EDUCATIONAL TOOL IN THE LIGHT OF MEDIA RESEARCH

1. Introduction:

The planetarium belongs to the group of visual media, and much research has been undertaken in order to investigate the advantage or disadvantage of the use of modern visual media in education and to define for these tools a proper place - if any - in the teaching-learning process, if their use can be justified.

It is not clear whether or not the justification for the use of the planetarium can be derived from the broad range of media research as no relevant studies seem to be available. This is seen from the many titles of publications on the planetarium, collected by the author and listed at the end, pp. 465 - 536 , the titles treated in II/3 exempted.

2. Theme and Purpose:

The theme of this section is a study of the results of educational research, especially media research, with the purpose of investigating what - if any - educational value is attributed to teaching media and could be transferred to the planetarium.

3. Methodology and Procedure:

This study is based on an evaluation of literature which will be discussed in the light of the results of other surveys of this thesis.

4. Limitation:

In order to keep the total work in manageable proportions, much reliance is made on secondary literature such as treated in an earlier paper by the author, entitled "The Teacher and his Media" (1977).

5. Findings and Discussions:

Media research does not take for granted that the educational tools devised or adopted by philosophers and teachers are helpful in attaining the set goals of education such as is implied by the introduction given to the first part of this study under the title "Goals of Education" on page 107.
Indeed, the results of much current educational research cast doubt on the positive assumptions and expectations that brought modern media into the schools. Before going into detailed considerations of the possible merits of media, their position in the wider scope of school system research is summarized as the justification for their existence may already be questioned at that level.

5.1 School System Research

In West Germany it is the school systems which compete with one another in order to define how educational goals can best be achieved, and even the goals themselves are subject to attempts of new definitions. Professor Rolff, Dortmund\(^3\), postulates that school achievement needs clarification. What is the goal? Training of a) "the problem solving attitude", b) "memory", c) "more factual knowledge", d) "increase in the ability to exercise criticism", e) "more knowledge in the conventional style of writing", f) "the development of a more personal style of writing", g) "all at the same time and - if so - than less pronounced individually".

"DER SPIEGEL" complains that educational research directed at evaluating the educational worth of the competing school systems has created nothing but confusion and that results of research on the "Gesamtschule" (Comprehensive School), rather than determining the pedagogical rank of this school type, exposed the political position of either the researcher or of the authority who ordered the research.

In evaluating this situation it seems obvious to the author that discussions conducted at this level do not reach down to the lower orders of educational research and do not directly touch the questions of media application. It is, however, conceivable that in the quest for better educational achievements - which are needed for political argumentation - each school of thought may readily grasp the possibility of employing promising media for promoting their goals on the grounds of a predominantly political motivation.

---

3) DER SPIEGEL, Investigation of the Schools Systems in West Germany "Gesamtschulen in der Bundesrepublik" (III) 17/34, 1980, page 76.
It is here that the deeper issue lies. Conservatives fear that the comprehensive school will eventually do away with the more eliterian "Gymnasiums" (Grammar Schools) and create a society more open to radical changes in the socio-economic system, i.e. in the direction of socialism.

Decisions of media installation and media use are hence predictable for which - in the heat of the moment - the presently available knowledge, convictions and expectations may suffice for their justification. In the few case studies conducted by the author in the framework of an earlier paper "The Teacher and his Media" (op.cit.), he came across a relevant example where "political" money had been made available for the installation of an expensive language lab.

British School System Research asks similar questions and wants to know "if it is important to the child which type of school it attends and if so which conditions in the school are the decisive ones". Rutter and his co-authors conclude that consistency in the persuance of clearly defined educational objectives, school discipline and orderliness, in short "the climate and general ethics" in a school are more important for achievement in school than the questions of whether the schools are small or large, old or modern, poorly or richly equipped with media. 3500 school children of 12 similar London secondary schools were tested over the long period of 8 years. The broadness of the survey lends weight to its findings.

This British survey has visible repercussions on German educational research and West German educationalists. Prof. Hartmut von Henting sees in it "a great help in the diagnosing and overcoming of mistakes". The study may deliver suitable material to the promoters of an "inner reform of the schools in West Germany".


5) See "DER SPIEGEL", op.cit.
In evaluating the results of the British research and its likely re-
percussions on the school reforms under study or in progress in West
Germany attention is focussed - in the sense of our study - on the
media question. For one of the results of Rutter's work is the re-
alisation that the extent to which a school is equipped with teaching
media has no measurable influence on the achievement of educational
goals but that other pedagogical factors account for the degree and
quality of that achievement.

The question arising from this result is whether or not it will have
an influence on the philosophy of media installation and media use in
West Germany. To derive any encouragement from Rutter's work for the
more widespread use of sophisticated media seems, in any case to be
impossible.

Educational research on the planetarium itself is not known to teachers
in West Germany, as will be seen in a later survey conducted with the
schools in West Germany (Survey III/5), but the above cited more general
British research is being translated at the moment for distribution
among the school masters in West Germany according to the survey con-
ducted by "DER SPIEGEL". It remains to be seen what effect this may
have on media choice and media use.

School System Reform in the USA

The "Back to Basics" Movement

The above description of the apparent British trend to put more trust
into the inner values of basic pedagogical arts than into outside
appearances and gadgetery leads one to consider the influences that
may be exerted on the educational system in West Germany by similar
educational ideas and ideals originating in the USA.

"Back to Basics" is the name that an educational movement in the USA
gave itself, and the name is an indication for the course they steer
in their attempt to reform the educational theories and instructional
methods generally prevailing in the USA School System now.

In contrast to the more liberal educational approach with a more open
classroom and emphasis on creativity, there seem to be tendencies in
development in the USA to curtail the liberal trend in favour of a
strictly regimented curriculum basing this on a recently completed 3 million Dollar study sponsored by the US Office of Education\textsuperscript{6}).

The movement calls itself "Back-to-Basics". Since 1968, schools in a hundred cities investigated a wide range of curricula, and the researchers finally had chosen 9,200 third-graders to test the results, which ultimately showed that only two very formal programmes had significantly improved pupil's performance.

The "Distar" Experiment:
A system called "Distar" was the most successful in the overall project intended to improve school attainment of children from low-income class families. Teacher's imagination and creativity, in short the liberal approach, were not much in demand in this programme. Instead a drill-like performance in which the teacher read a text word by word before the children who in turn chanted rote responses was the teaching method applied.

Disadvantaged third-graders subjected to "Distar" benefited from the system. But it is said that the children's further progress through higher grades will have to be studied before any recommendations for an eventual educational policy change could seriously be attempted. It is possible that the method works best at primary level since at higher grades clear comprehension may be more required than rote learning.

Formal Methods - Formal Discipline:
The classical theory of "formal discipline" has been rejected by educational research, according to educationalist L.J.Cronbach\textsuperscript{7}), but "Distar" promotes its revival. This theory had postulated that memory, reasoning and concentration could be drilled in an abstract fashion. Cronbach's statement contradicts in fact the seemingly new evidence of success of the formal method brought forward by the "Distar" experiment. Cronbach quotes a number of research results in the field of educational psychology, which could be used for refuting the "Distar" claims of being an appropriate method.

\textsuperscript{6}) Newsweek, issue 4th July 1977, page 76.
The formal method, as exercised by the movement, has a strong tendency towards verbalism and is thus opposed towards the application of advanced teaching media. This is detrimental to the students' interests. Students today claim that they should be able to use modern media also in school, since they already encounter modern media at so many places in their daily lives outside school.

American planetarium professors have admitted that the "Back to Basics" movement has exerted an adverse influence on the installation of new planetariums and is likely to continue its unfavourable influence (see survey III/5).

It is not exactly known if this movement has had, as of yet, any significant influence on the school system in West Germany, but if so, it could accelerate the "Inner Reform" tendencies in the sense of British ideas and this could result into a more critical attitude towards media installation and media use to the possible detriment also to the planetarium idea.

5.1.2 Conclusion:

Competing school system movements in West Germany tend to be potentially favourable to the promotion of media installation and media use while educational ideas and ideals imported from outside may work in detriment to such tendencies.

Discussions on the topic of school reforms in West Germany are still in progress and final decisions promise to be of regional importance rather than of overall importance.

5.1.3 Implication:

The proponents of the planetarium idea in the school system of West Germany will have to focus a watchful eye on trends and developments in the school system reforms under way at present lest new educational ideas or revived old ones might deliver the argumentation apt to overrule theirs.

*) Footnote: It has had apparently no influence on the teachers level according to survey III/5, table 23, question 6, page 388.
5.2 Media Research

Specialized media research on the educational value of the planetarium has been discussed in survey II/3. As there seem to be no relevant research publications available anywhere else but in the USA, according to extensive search undertaken by the author, survey II/3 had to be limited to work available from there.

Most of the available publications in the field have one common feature in design:

In nearly every study a test group in the planetarium is compared to a control group in a classroom. Results and conclusions differ from thesis to thesis so that no valid generalisations could be drawn from the very specialized work done so far.

An attempt has therefore been made to search for a justification of the planetarium's existence and use in the field of the wider scope of school media research.

Before entering into relevant studies, it is thought expedient to set the scene by defining the planetarium's place in the range of visual media. For this purpose table 6A has been prepared. It is copied from an earlier paper of the author "The Teacher and His Media", 1977. Media are also classified and their role in education is briefly defined.

Table 6A contains a list of all visual media hardware used in the school and groups them into:

- objects that can be seen as well as touched and handled;
- representations (of objects) like models, pictures, etc;
- production equipment like the blackboard which is a tool to produce information;
- the remote blackboard and electronic image creation computers which range under the same group as the blackboard;
reproduction equipment which is used to create an image of an object, e.g. slide-projectors, opaque projectors, micro-projectors, and film projectors;

the planetarium which is also a production equipment in the sense that it incorporates its own software for producing a spectacle.

A classification of media is possible according to the stimuli corresponding to each medium. Realia correspond to the sense of touch, audible media to the sense of hearing, and visual media to the sense of vision.

The Role of Media in Education

Erickson and Curl (8) list different roles of media, and though not each individual medium may play each of the roles, others in contrast may fulfill several roles:

"Extend human experience - Provide meaningful information - Stimulate interest - Guide student's response - Overcome physical limitations - Stimulate problem solving - Provide diagnostic and remedial tools".

One could add "facilitate the dissemination of knowledge - aid the teacher in fulfilling his functions - allow teaching of otherwise unconveyable information".

<table>
<thead>
<tr>
<th>GROUP</th>
<th>HARDWARE</th>
<th>SOFTWARE</th>
</tr>
</thead>
<tbody>
<tr>
<td>I. OBJECTS and REPRESENTATIONS and PRODUCTION EQUIPMENT</td>
<td>Real Objects Models Blackboard Charts (also animated) Maps Pictures Photographs Books</td>
<td>self-sufficient</td>
</tr>
<tr>
<td>II. REPRODUCTION EQUIPMENT</td>
<td>SLIDE PROJECTORS Miniature Projectors for slides &amp; film strips 24 x 36 mm = standard size Miniature Projectors for object sizes smaller than standard size Diascopes for slides 6 x 6 cm up to 9 x 12 cm Overhead Projectors, average object size 25 x 25 cm Large Diascope for x-ray diapositives 32 cm x 32 cm</td>
<td>transparencies</td>
</tr>
<tr>
<td>III. REPRODUCTION EQUIPMENT</td>
<td>OPAQUE PROJECTORS Episcopes - single lamp, object size 19 x 16 cm maximum objective f = 400 mm Episcopes - double lamp type, obj. size 30 x 30 cm maximum objective f = 800 mm Episcopes - quadruple lamp type, object size 30 x 30 cm maximum objective f = 1300 mm</td>
<td>opaque objects</td>
</tr>
<tr>
<td>IV. REPRODUCTION EQUIPMENT</td>
<td>EPIDIASCOPES combined opaque- and dia-(slide) projectors, episcopes functions, object field sizes and objective focal lengths as above, diaspsections, the dia-objectives are either fixed for slides up to 9 x 12 cm, or exchangeable against a miniature slide objective with picture stage for slides or filmstrips 24 x 36 mm. With the four lamp type large epidiascope only dia-objectives for large slides up to 9 x 12 cm are being built, epo-objectives and object sizes are as in the pure episcop. Max. dia. objective f = 800 mm</td>
<td>transparencies &amp; opaque objects</td>
</tr>
<tr>
<td>V. REPRODUCTION EQUIPMENT</td>
<td>MICROPROJECTORS: Microprojection attachment, low power objective for miniature slide projectors Small simple Microprojector low power objective, bulb 6 V 5 Amp. Medium size combined Microprojection apparatus and Microscope. Microscope, with one condenser, projection mirror or projection prism in top of the eyepiece, or screen. Separate or built-in incandescent lamp up to 100 W or new metal-halide lamp (up to medium power objective). Microprojector large size with up to 7 objectives. Microprojection-Video-Camera-Microscopes Combination with TV monitor and TV receivers, black &amp; white and colour, suitable for all microscopical methods without limitations.</td>
<td>microscopic objects: slides</td>
</tr>
<tr>
<td>VI. REPRODUCTION EQUIPMENT</td>
<td>FILM PROJECTORS 8 mm, super 8 mm, 16 mm, 35 mm, 70 mm, TODD-AC, cinerama - 3 x 35 mm or 3 x 70 mm, panorama, hemispherical 35 mm and 70 mm, rear screen projectors various formats, 8 mm cassette projectors.</td>
<td>hard copies</td>
</tr>
<tr>
<td>VII. REPRODUCTION</td>
<td>TELEVISION Auditorium-TV-Projectors, TV- Receivers, closed circuit TV, VCR.</td>
<td>hard copies &amp; electronic signals</td>
</tr>
<tr>
<td>VIII. PRODUCTION EQUIPMENT</td>
<td>TELEVISION</td>
<td>electronic signals</td>
</tr>
<tr>
<td>IX. PRODUCTION EQUIPMENT</td>
<td>PLANETARIUMS</td>
<td>inherent software akin to slide projection</td>
</tr>
</tbody>
</table>
5.2.1 School Media Research in West Germany

In the introduction to the "Deutscher Lehrmittelberater 1972"
* it is stated that in West German schools during 1971 teaching
was organised" into the following didactic categories and per-
centage distribution:

- Verbal methods = 68%
- Experiments = 14%
- Audiovisual methods = 18%

Teaching at teachers' training colleges was conducted verbally
to the extent of 78%.

According to G. Havelberg\(^\text{(9)}\), who summarizes media research in
West Germany, media are used in the schools of West Germany pre-
dominantly for illustrative or decorative purposes. Media in
the hands of the students is a goal still to be reached. Verbal-
ism is the dominant teaching method in the schools of West
Germany, which may, as Havelberg quotes, lead to conformistic
thinking and the development of conformistic judgement on the
part of the students. An undesired development, evidently. The
necessary promotion of intrinsic motivation, of personal talents
and abilities in a pluralistic society should lead to curriculum
reforms incorporating a new orientation of media-didactic
principles, giving more importance to an increased use of media.

Media are to promote independent thinking and a more intensive
personal experience of the content of learning. Media are to
sharpen comprehension of the essentials, to train the mind in
abstract processes of reasoning and in the ability of deducing
the general principles from the concrete subject matter, thus
allowing the transfer to other domains.

\(^{(9)}\) Havelberg, Gerhard, "Medien als unterrichts-technologische Innovation",
in "PRAXIS GEOGRAPHIE", 2. April 1980

*) "Deutscher Lehrmittel Berater", Verlag DLV, Druck Westermann
Media of observational character are intended to deliver concrete models of reality without necessarily giving relevant verbal explanations or classifications. This holds true for films and pictures (but logically only for silent films as sound film demonstration today is, of course, always accompanied by a narrative).

The use of media should stimulate the student to mental explorations in realising, comparing and classifying, and in discovering the elementary and transferrable characteristics in the structure of an object under study. The student will be lead through the process of classifying, abstract thinking, and transfer. The acquisition of transferrable knowledge and the ability to perform such transfer promises to be the result of a judicious use of observational media.

The elementary quality in a medium must be its ability to match with the learning objectives of a given subject. Its congruence with the curricula demands must be assured.

Teachers will have to carefully plan which medium to use at which stage of teaching a certain subject. Teaching should be media-orientated in order to promote learning-motivation and the process of thinking, learning, transfer and exercises.

Improvising with media, in the implementation of goals defined by educational politics, ought to be replaced by judicious media planning - and application.

These are in short Havelberg's postulations and summaries which he bases on 30 different research reports, theses and books in the field of media research and general educational research, the current trends and tendencies prevailing in West Germany.

*) Footnote: Insertion in brackets by the author.
Engelhard\(^{(10)}\) complains in a recent article that in teaching geography in the schools of West Germany a media mono-culture rules using nearly exclusively the setbooks and the atlas. He welcomes more recent tendencies to enlarge on the scope of teaching media. He states that a media mono-culture cannot advance the attainment of the educational objectives of the school discipline of geography to eventually enable a student to achieve an independent orientation in his environment and the world as a whole, to develop a sense of social responsibility for forming the conditions for a social life in the community to which he belongs. Skills and abilities are to be promoted which will enable the student to acquire knowledge. Engelhard postulates that only the offer of a rich variety in media choice combined with an active part in media selection and media use on the part of the students would allow the attainment of the educational objectives mentioned above.

Engelhard regrets that educational research (in West Germany) had in the past neglected the theme of media didactics. He quotes, however, more recent relevant research which gives emphasis to the definition of such media requirements as will be helpful in promoting the learning process of differently talented students, e.g. media variety.

Engelhard has evaluated 7 titles of research publications for his theme and presents the current position of educational and media research in West Germany.

Ginzel\(^{(11)}\), a third author on the same subject, advocates the multi-media approach in the teaching/learning process in the schools of West Germany. "The more diversified the sensory stimulus, the more differentiated will be the learning process".

\(^{(10)}\) Engelhard, Karl, "Medien im Lernprozess", ibid.

\(^{(11)}\) Ginzel, Hannes, "Medienverband-Begriff und Zielsetzung", ibid.
The multi-media approach fosters the learning process and advances the development of individual talents. These are the conclusions drawn by Ginzel from the results of 7 different research papers.

Ginzel finds support also in the work of Vester\(^{(12)}\). Frederic Vester lists several main types of learners and therefore recommends a multi-media approach and the application of a variety of media in order to do justice to the individual differences in learning attitudes and learning habits. They may learn best at different rates or at different times of the day. Some need repetition, some are "visual" learners, some "audio", some learn best in groups, some on their own, etc. The (unattainable) ideal would be an individualistic approach appropriate to each specific learner in each specific learning situation. But no perfect system can be devised which would be suitable for all learners.

Multi-Media Preference:

Medium variety, the application of various media within the given framework of one teaching/learning unit, seems to be the ruling consensus of media research in West Germany.

The Planetarium's Multi-Media Role:

Does the planetarium fulfill this role? The planetarium is a teaching tool in the first place, and an underused one, as will be seen later in this thesis. Its use should not be overlooked, if multi-media application in teaching is the aim. As to media variety in a given teaching situation the modern multi-media classroom planetarium will by its inherent capacities provide a multi-media function, but most planetariums involved in this thesis are of the conventional type, having only special effects projectors, slides and films to offer in addition to the projected starfield.

\(^{(12)}\) Vester, Frederic, "Denken, Lernen, Vergessen", Deutsche Verlagsanstalt Stuttgart, 1975, pages 49/50 and 149
All but one West German planetariums are of that type.

The surveys conducted with planetarium visitors (II/6), and with students tested in the planetarium (II/10), produced as a result that the overwhelming majority preferred the planetarium as a place for learning astronomy. Participants in the survey were not divided according to their specific learning habits, but it seems possible that the spectacle impresses an audience to such degree that justice to the greatest number results in teaching an educational subject there. Visitors did not find the performance to be monotonous, as will be seen in later reports.

The educational authorities of Baden Württemberg and Berlin as well as those of Nordrhein-Westfalen, who have recommended the planetarium as a tool to be used for the attainment of the educational objectives laid down in the school curriculum of astronomy do obviously believe in the planetarium's potentials as a suitable medium for serving that purpose.

Conclusion:

Results of media research in West Germany obviously do not only favour the application of modern educational media but advocate the application of media variety for the best attainment of teaching goals. Findings seem to be transferrable to the planetarium. Educational value is diagnosed for teaching media.

Implication:

The results of general media research in West Germany do not stand in the way of a more widespread use of the planetarium and must hence be definitely excluded from being a possible cause for the underuse of the planetarium in education.
5.2.2 School Media Research in East Germany and in the East Block Countries

The author can again draw on the work of others, which seems anyway to be the only course open for this section of programme II/4, if the overall work is not to grow out of reasonable proportions.

Küster (13) summarizes in his thesis the present position of media research in the above geo-political area: "In many research works performed in the socialists countries it has been established that the application of modern media has promoted the better attainment in learning, if the application of the relevant media had been methodical and well performed".

It may suffice for our purpose to only cite this quotation to illuminate the situation. Küster's work points in the same direction as those of his colleagues in West Germany: only a true multi-media approach will be beneficial in the teaching/learning situation of schools.

5.2.3 School Media Research in the USA

A short summary may suffice to illuminate the situation:

Media Comparison:

Media research in the USA has compared the various media and weighed them against each other. As a result, it seems to produce, according to sources quoted by Romiszowski (14), the statement that there is "no significant difference" created by applying any specific one of them for the attainment of teaching goals. This seems, in short, to be the overall tenor of much of the educational research in the USA.


There seems to be no need to pursue the matter further in this thesis and to explore the reasons that have caused the different results produced by German and American research of the same academical discipline in comparable school systems. The fact is that relevant research undertaken in the USA does not seem to be known to teachers in West Germany and hence has had no influence on their opinions and attitudes, according to survey III/5.

Table 23 on page 389 represents part of the questionnaire used in the survey conducted with schools in West Germany. Question 6 in this table informed about the above-mentioned results of USA media research.

While 51 out of the 194 (26.29%) participants in the question confirmed that their own media experiences were similar to those of the USA observations, only 5 out of 180 (2.78%) teachers saw in this a reason to dispense with the use of the planetarium as an educational tool.

Outcome of Research:

The negative findings of USA research could not prevent the installation of about 1000 planetariums in the USA with a growth tendency being observable. Positive research results in West Germany could not visibly influence the installation of school planetariums. This may be different in East Germany, where more school planetariums exist, and where a home industry (e.g. Zeiss) produce 2 types of school planetariums. There are, however, no exact data available from which this could be deduced with more certainty.
6. **Summary:**

Media research in West Germany is slow in effecting practical teaching but tendencies to follow recommendations for a more intensive media application in the schools are noticeable. Media research favours media variety in practical teaching, and its many arguments seem to be applicable in justifying the use of the planetarium as an educational tool. Media research in East Germany seems to result in similar recommendations. USA media research seems to produce a more pessimistic view of media application in the schools but does not seem to have had any repercussions on the schools in West Germany.

7. **Conclusion:**

The results of this part of programme II/4 refute the second half of the operational hypothesis which has governed this study. It was hypothesized that (educational) media research might not promote the planetarium idea. This implies support for the general hypothesis as to the educational value of the planetarium.

8. **Implication:**

Any interested party intending to install a school planetarium will find supporting educational argumentation in the results of current media research in West Germany.

The following report II/5 opens the row of opinion poll surveys on the planetarium's educational value.
"TEACHERS MAY NOT BE CONVINCED OF THE PLANETARIUM'S EDUCATIONAL VALUE AND MAY NOT EXHIBIT ANY DEMAND FOR THIS EDUCATIONAL TOOL, WHICH WOULD ACCOUNT FOR THE UNDERUSE OF THE PLANETARIUM IN EDUCATION"

Pilot Survey and Main Survey Conducted with Schools in West Germany

TEACHERS' INTEREST IN THE PLANETARIUM AS AN EXPRESSION OF ATTRIBUTING EDUCATIONAL VALUE TO THIS MEDIUM AND AS AN INDICATION OF DEMAND FOR THE PLANETARIUM.

1. Introduction:

The schools in West Germany are the main target group of the research. Before conducting an enquiry with this population on a larger scale and with a more representative sample size, a pilot survey was performed in order to test the feasibility of such a larger scale survey.

It was considered to be important to learn several facts and figures from teachers concerned with the subject of astronomy in the schools prior to starting the actual full scale research on the planetarium as a school teaching medium. This pilot project was also undertaken in order to justify the efforts which needed to be invested and in order to define the possible scope of the research with this important target group. It was also intended to obtain from this group necessary encouragement in the form of the teachers' cooperation to embark on the formidable task of treating the neglected subject of the research problem. Last but not least, the author intended to gain some experience in dealing with the target group of the research.

2. Theme and Purpose:

An earlier survey had been conducted in order to define the schools as the target group. The theme of this survey is "The teachers' position regarding the subject of astronomy and its relevant media, especially the Planetarium". The purpose of the research is to establish the teacher's knowledge, intentions and actions, his
opinions, conceptions, and wishes concerning the subject of astronomy and the planetarium for teaching this subject in the schools. How do the teachers value the planetarium in terms of their reflections and emotional expressions as visible from their answers to a questionnaire presented to them? Do teachers value and use the planetarium or are they at least ready to use it?

The answers are to support or to refute, at the school level, that part of the general hypothesis saying that planetariums are believed to be of educational value and that there exists a demand for them.

The preceding pilot enquiry had the same theme and purpose and, though conducted on a smaller scale, provided the necessary insight and information for conducting this larger survey.

This survey is guided by the operational hypothesis printed at the heading.

3. Population:

Acting on the experience gained in the preceding pilot surveys, it was decided to concentrate on the high schools in West Germany, especially on the particular group of high schools which devote a large section of their curriculum to the natural sciences. A few comprehensive schools were included. These schools contain under one roof primary, intermediate and frequently also secondary schools. These schools operate on course systems and their branches share the same facilities independent of the level of teaching.

Experience gained in interviews, conversations, correspondence and telephone interviews inside and outside the framework of the preceding pilot enquiry indicated to the author that the above group of schools would be the appropriate target to concentrate on.
Their curricula frequently include astronomy as an independent subject or as a strong branch of other disciplines such as physics or geography. Furthermore, science is taught there at a rather intensive level and adjacent disciplines that might be interested in using a planetarium are more strongly represented in this group of schools. There are also indications that their budgets or means of providing money for more sophisticated equipment more readily allow the installation of a planetarium than it is the case with other types of schools.

Suitable addresses were found in a general school directory and a suitable sample size was randomly selected from this directory.

4. Methodology:

While the limited scope of the pilot enquiry allowed for personal interviews and telephone interviews as well as correspondence and mailed questionnaires, the larger survey with the schools in West Germany was carried out exclusively by questionnaires sent through the mail. Each questionnaire was accompanied by a covering letter explaining the purpose of the research and inviting participation. *) An illustration was included depicting 3 different types of school planetariums; a small and a medium size conventional projection planetarium, and a modern projection planetarium of the classroom type with uni-directional seating and multi-media facilities. A self-addressed stamped envelope was included in each delivery.

Experience gained in the pilot enquiry conducted with the schools and in the general initial pilot survey had indicated that teachers' patience in dealing with a complex subject matter could not be exhausted by presenting them with several questionnaires, each one dealing with a different sub-theme in much detail. It was therefore decided to cover the large field of the planetarium's use and under-use in education in one single comprehensive questionnaire containing a well-mixed set of questions dealing with each sub-theme such as

*) See appendix on page 544.
evaluation, demand, and underuse. The circumference of the questionnaire was so arranged that it could be completed in approximately 25 minutes. *

The questionnaire used for the pilot survey was less comprehensive. ** This questionnaire contained initially some 34 points (later reduced to about 30) intended to provide a broad spectrum of information on level, scope, means and methods used in the schools for teaching the discipline of astronomy. Experience gained during some personal interviews with teachers and from evaluating the first dozen or so questionnaires showed that the essential information to be acquired from the schools could just as well be obtained by using a more streamlined set of questions. Those points that dealt with the teacher's evaluation of the planetarium as a teaching tool and his interest in the planetarium were retained in the second shorter questionnaire. The remaining group of relevant questions selected from the earlier larger questionnaire were collected under the Leitmotiv of "TEACHERS' INTEREST IN THE PLANETARIUM AS AN EDUCATIONAL TOOL", which incorporates the notion of teachers' evaluation of the planetarium as an educational medium. The method of questioning was partly direct and partly indirect in character. Experience gained during the preceding programmes helped in finding and formulating suitable questions.

The covering letter that went with both the questionnaires and the circumference of the questions asked were geared to arise interest in the programme. Many of the teachers readily answered the questions and gave additional comments. 36 schools were approached in the pilot survey, 32 replied, 3 with regret, and 29 replied to the questions posed.

Table no. 30 displays the relevant action of the pilot survey and the results of this programme. Table no.31 provides a cross reference for testing the consistency of the answers given, which is an indication of the reliability and validity of the test instrument. - These two tables are in the appendix pp. 539 - 540.

*) See large comprehensive questionnaire of the school main survey, in the appendix pp. 546 - 551.

**) See large questionnaire of the school pilot survey in the appendix pp. 541 - 43.
5. Rationale of the Questions of the Main Survey:

As teachers could not be bothered with several sets of questionnaires, the questions had to be phrased in such a way that the answers could serve several purposes simultaneously. Many questions are therefore asked indirectly and are aimed at learning the teacher's interest in the planetarium with the intention of translating this interest in terms of his attribution of educational value and demand, and even explaining the obvious underuse of the planetarium. Only one of the questions asks directly about the educational value of the planetarium and only one other question asks the teacher to compare the planetarium with the conventional media known to him.

Had it been possible to ask the teachers some more direct questions, as had been done in the surveys conducted with planetarium directors, planetarium visitors, astronomers and others, a finer total pattern of answers might have resulted. On the other hand, as the pilot survey had already revealed, a useful range of opinions evolves from the survey, and it had been ascertained in several personal interviews and discussions during the pilot survey that the questions and answers do in fact reflect a very comprehensive image of the teachers position regarding the subject of astronomy and the planetarium as a tool of teaching astronomy.

It has been attempted to ensure the validity and reliability of the test instruments (the questionnaires) in both surveys by establishing for each of the main tables a corresponding table of cross references. Similarly, the results of the pilot survey are to some degree a measure of the reliability of the results of the main survey as they show a similar tendency in the pattern of answers.

The test instrument possesses content validity and face validity inasmuch as it adequately covers the subjects to be studied by straightforward questions.

The system of cross references ascertains consistency in the answers which is considered to be an indication for the reliability of all the answers, even as only the more salient points are included in the test of consistency. (See table 8 for the main survey and table 31 for the pilot survey.)
Type of Survey and Limitations:

A descriptive survey, aimed at learning facts and opinions, has been conducted. The type of variables accounting for the creation of these opinions had to be left out of consideration as such a deeper explanatory survey would have gone beyond the theme under investigation and would also have been outside of the working capacity of the author, who had to keep his work within manageable proportions. The results of the survey allow, however, the interpretation of the teachers' position regarding the research theme under study.

Scores:

In calculating scores and providing rank orders for the questions investigated, an attempt has been made to provide some kind of a measure for the relative importance given to the various questions by the teachers interviewed, though the pure figures obtained do call for some qualification as not all questions are of equal weight.

There is also a compensation provided for teachers' unequal participation in the various questions by introducing the system of "relative percentage scores" as a basis for the determination of rank orders. The relevant explanations are given under paragraph 8 on page 164.

Additionally, the system of scores and the resulting total score with its relationship to the maximum possible score are intended to give an instrument of quantification, though a rather crude one, for expressing group achievement on as close to an absolute standard as seems possible. In order to compensate for this coarseness in the test instrument a discussion of the questions involved is offered.
6. Procedure of the Main Survey:

450 schools were addressed. 220 replies were received, 201 of the questionnaires were useable for the survey. The action was followed up by written and telephone reminders to determine the reason for the many abstentions. Several schools apologized, saying that they could not take on extra work involved in dealing with the questionnaire. Others did not participate as they needed special permission from their superior authorities. In this context, a mild reproach was received from the Ministry of Education in Berlin for having conducted a school survey without previous permission. It seems safe to assume that the necessity of obtaining permission accounts for the greater part of the approximately 70 abstentions from Berlin and about 40 more in the Düsseldorf-Bonn area. There are indications that many of the remaining abstentions may have the same origin. Some schools evidently did not bother. Those who did reply were either not subject to any restrictions or simply ignored them. At an intelligent guess the abstentions may be divided into: 150 no permission, 50 no time, 30 not interested, which leaves a participation of 44.67% of the total and of 67% when discounting those without permission.

The questionnaires were received by the schools' headmasters and given to the specialized teachers for reply. From the pattern of the replies received it seems that the sample size is fairly representative of the total. Replies were hand-counted. Additional comments given by some of the teachers for certain questions have been evaluated when discussing the respective question.

One table summarizes the results of this survey and one additional table provides cross references for some of the more salient questions with a treatment of some likely inconsistencies in the answers.
7. Findings:

Reference is made to table no. 7, which summarizes the results of the school main survey.

The first group of questions sets the scene by dealing with the school's treatment of the subject of astronomy and the teacher's knowledge about the planetarium. The first point condenses the first 3 questions of the large original questionnaire to be found in the appendix pp. 546 - 551.

The next group of questions deals with the teachers' interest in using the planetarium and their readiness to acquire one.

With the following group of questions it is intended to clarify the extra efforts that teachers are ready to invest in teaching astronomy, their judgement of the planetarium's value in comparison to more conventional media, and whether they rate the number of planetariums in West Germany as adequate or not.

8. The Relative Percentage Score System:

In order to enable the following table to be more readily understandable, the scoring system devised and used is described below.

Absolute (abs.) score figures are obtained by rating each question in its positive meaning as follows: "yes" = 3, "undecided" = 2, "no" = 1. In a 5-column table, the figures count from 5 to 1, as 2 more categories have been introduced. Negatively phrased questions are rated inversely to the above. The number of votes in each cell of a table is multiplied by the respective factor above. The total of one row of cells is the total absolute score figure for that question.¹)

This system is fully adequate for determining rank order successions for the questions in a table in all cases of equal N-number participation in all questions of the table.

In cases of an unequal N-number participation, a more refined system has to be introduced, which the author likes to call "the relative percentage score system". In this system, the absolute score for a given row and a given N-number is converted into the percentage of the maximum possible score. This is always the highest cell factor, i.e. 3 for a 3-column table and 5 for a 5-column table, multiplied by the respective N-number;

\[
\text{e.g. } \quad N = 200 \text{ in a 3-column scale} \\
\text{Maximum possible score } = 200 \times 3 = 600 \\
\text{Actual score, say } = 500 \\
\text{The relative percentage score } = 83.33\%
\]

Arranging rank orders according to relative percentage scores provides for a just system in a questionnaire with irregular participation figures for individual questions.

For both questions 13 and 16 four answers can be chosen, and scoring has to be adjusted to the triple-choice system of the other question in the table. This is achieved by allotting the multiplication factor 3 x to sub-questions a) and d) in question 13, and the multiplication factor 1 x to sub-question b), while sub-question c) receives the factor 2 x. In question 16 the first sub-question receives the factor 1 x, the second one the factor 2 x, and the last two are grouped together under the factor 2 x. Full explanations for this procedure are contained in the discussion of these points.
### TABLE 7

**SURVEY WITH SCHOOLS IN WEST GERMANY**

**THE EDUCATIONAL VALUE OF THE PLANETARIUM**

"Teachers' Interest in the Planetarium as an Educational Tool and Teachers' Demand for the Planetarium"

<table>
<thead>
<tr>
<th>No.</th>
<th>Question</th>
<th>N</th>
<th>Rank Order</th>
<th>% Score (abs)</th>
<th>Yes</th>
<th>Undecided</th>
<th>No</th>
</tr>
</thead>
<tbody>
<tr>
<td>1)</td>
<td>Does the school teach Astronomy at any level?</td>
<td>198</td>
<td>3</td>
<td>96.46 / 573</td>
<td>181</td>
<td>13</td>
<td>4</td>
</tr>
<tr>
<td>2)</td>
<td>Does your school possess</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>a) astronomical charts?</td>
<td>184</td>
<td>16</td>
<td>67.02 / 370</td>
<td>88</td>
<td>10</td>
<td>86</td>
</tr>
<tr>
<td></td>
<td>b) slides about astronomy?</td>
<td>175</td>
<td>18</td>
<td>65.14 / 342</td>
<td>79</td>
<td>9</td>
<td>87</td>
</tr>
<tr>
<td></td>
<td>c) star globes?</td>
<td>174</td>
<td>22</td>
<td>57.47 / 300</td>
<td>62</td>
<td>2</td>
<td>110</td>
</tr>
<tr>
<td></td>
<td>d) films about astronomy?</td>
<td>161</td>
<td>24</td>
<td>45.75 / 221</td>
<td>27</td>
<td>6</td>
<td>128</td>
</tr>
<tr>
<td></td>
<td>e) a telescope?</td>
<td>138</td>
<td>15</td>
<td>69.56 / 288</td>
<td>73</td>
<td>4</td>
<td>61</td>
</tr>
<tr>
<td></td>
<td>f) other astronomical apparatus?</td>
<td>82</td>
<td>19</td>
<td>65.04 / 160</td>
<td>38</td>
<td>2</td>
<td>42</td>
</tr>
<tr>
<td>3)</td>
<td>Is the large projection planetarium known to</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>a) the teachers?</td>
<td>195</td>
<td>11</td>
<td>80.85 / 473</td>
<td>129</td>
<td>20</td>
<td>46</td>
</tr>
<tr>
<td></td>
<td>b) the pupils?</td>
<td>187</td>
<td>17</td>
<td>65.95 / 370</td>
<td>69</td>
<td>45</td>
<td>73</td>
</tr>
<tr>
<td>4)</td>
<td>Do you know that the planetarium not only serves the</td>
<td>201</td>
<td>6</td>
<td>88.56 / 534</td>
<td>178</td>
<td>16</td>
<td>7</td>
</tr>
<tr>
<td></td>
<td>science of astronomy but also allows aspects of other</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>disciplines to be taught with advantage (mathematics, physics,</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>geography, mythology, etc.)?</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5)</td>
<td>Have planetarium performances ever been visited by</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>a) the teachers?</td>
<td>197</td>
<td>10</td>
<td>81.55 / 482</td>
<td>132</td>
<td>21</td>
<td>44</td>
</tr>
<tr>
<td></td>
<td>b) the pupils?</td>
<td>200</td>
<td>12</td>
<td>79.33 / 476</td>
<td>128</td>
<td>20</td>
<td>52</td>
</tr>
<tr>
<td>6)</td>
<td>Do you believe that a small planetarium would be an</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>attractive medium at your school?</td>
<td>200</td>
<td>9</td>
<td>81.66 / 490</td>
<td>117</td>
<td>56</td>
<td>27</td>
</tr>
<tr>
<td>7)</td>
<td>Would you instead of asking for a small planetarium for your own</td>
<td>195</td>
<td>8</td>
<td>85.86 / 492</td>
<td>72</td>
<td>43</td>
<td>80</td>
</tr>
<tr>
<td></td>
<td>school, promote the acquisition of a medium size planetarium for a</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>group of schools?</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>8)</td>
<td>If the purchase price of a planetarium were to be of</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>agreeable order, would you consider buying one?</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>a) would you earmark the necessary funds?</td>
<td>132</td>
<td>21</td>
<td>58.08 / 230</td>
<td>24</td>
<td>50</td>
<td>58</td>
</tr>
<tr>
<td></td>
<td>b) would you apply for the necessary funds?</td>
<td>169</td>
<td>13</td>
<td>75.54 / 383</td>
<td>80</td>
<td>54</td>
<td>35</td>
</tr>
<tr>
<td></td>
<td>c) would you try to collect the necessary funds by public</td>
<td>146</td>
<td>23</td>
<td>55.02 / 241</td>
<td>24</td>
<td>47</td>
<td>75</td>
</tr>
<tr>
<td></td>
<td>performances in the school, donations from parents, donations from</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>industry and trade?</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>9)</td>
<td>Would you like to use a planetarium if it were situated near to your</td>
<td>199</td>
<td>5</td>
<td>91.79 / 548</td>
<td>154</td>
<td>41</td>
<td>4</td>
</tr>
</tbody>
</table>
Would it be too much trouble and fuss for you to visit a more distant planetarium with your pupils?  

Does your school entertain a voluntary students group of hobby astronomers?  

Would you promote the establishment of such a hobby group provided planetarium and/or telescope were to be available to you?  

In case you really do know the planetarium, please be good enough to answer the following questions:  
Do you believe that the planetarium as a teaching medium compared to the classical methods: blackboard & chalk, globe & maps is  
a) superior?  
b) inferior?  
c) of equal value?  
d) a good supplement?  

Do you agree that there are doubts concerning the educational value of the planetarium?  

Are you in your own teaching fully satisfied with using only blackboard, globe, charts & pictures in treating astronomical subjects?  
If this is so, would this be a reason for you to dispense with  
a) using a planetarium?  
b) buying a planetarium?  

In West Germany there exist 6 large planetariums and 8 school planetariums, additionally 4 school planetariums installed at nautical colleges. These figures mean 1 planetarium for 166,666 pupils of intermediate and high schools (special schools excepted).  
Do you rate this number of planetariums as too many?  
sufficient?  
too low?  
much too low?
9. Discussion and Evaluation:

As has been said above under paragraph 3, "Methodology", the various questions differ in weight which tends to make the test instrument coarse as far as quantification is concerned. No attempt has been made to provide a system of weighting the various questions and to use this for giving bonuses in the calculation of the scores for the more important questions, as this method could have developed rather arbitrarily. The rank order calculated for the various questions in the survey is consequently no absolute measure for their relative importance. A question may, for instance, point to a certain uncontrollable short-coming, and thus have no chance in obtaining a high positive response. The following discussion will therefore try to investigate the significance which each question bears for the survey and how it is interrelated with the other questions.

9.1 Knowledge and Media:

Teaching Astronomy

Question 1 had already been asked in preceding pilot survey and served the purpose of clarifying whether or not the whole survey was meaningful. For if there were no astronomy being taught at all in the schools there would be little sense in starting an investigation into teaching media used for this subject. However, the prediction made from the results of the pilot survey has been confirmed by the results of the main school survey in which the vast majority of the schools interviewed had confirmed that astronomy is being taught. It can hence be safely assumed that all these schools have a potential demand for the planetarium as an educational tool.

9.2 Media available:

In spite of the fact that all schools do teach astronomy at some level, the answers given for question 2 reveal that charts, slides, star globes, films and any other teaching apparatus are owned by less than half of them. The number of telescopes available in the sample size interviewed is high. 73 schools out of 138 do have a telescope, a rather expensive tool compared to the more simple media. Some of the schools own transparent luminous star globes, but none of them seems to use this globe for
projection. One school possesses a small projection planetarium, which had not been known to the author and has promptly been entered into the census contained in the first chapter of this thesis. The count shows that there is a potential scope for a planetarium either as a supplement or as a substitute for other media not available in schools at the present time. It is astonishing to note the high number of schools that do not possess even the simplest teaching media for astronomy, not even those that could be made by the pupils, like star maps, and still - as a later question shows - nearly all the schools are interested in owning a planetarium or to participate in the ownership of such a facility.

9.3 Knowing the Planetarium:
------------------------
The large projection planetarium seems to be fairly well-known among teachers, as 2/3 of them have indicated in the questionnaire. The teachers have also stated that about 1/3 of the pupils know the planetarium. There is an obvious discrepancy in the following figures for which no exact explanation has been found. Only 69 schools out of 187 stated that their pupils know the planetarium but 128 schools state that their pupils had visited the planetarium. In the author's conception those pupils that have "visited" a planetarium also "know" the planetarium, but evidently the author was not able to convey the same conception to the teachers interviewed. It is therefore easily possible that teachers have interpreted the verb "know" very restrictively. But what actually counts is the fact that the pupils of 128 schools out of 200 have visited a planetarium performance at least once. Thus a large proportion of teachers and pupils have seen and hence do know the planetarium. As an individual count reveals, only 31 teachers out of the total of 201 do not know either the large or the small planetarium.

The above questions have clarified the basic point that astronomy is being taught in the schools, that basic material and even telescopes and certain apparatus are in part available to some schools, that the planetarium is known to teachers also in its wider fields of application. The prerequisites for investigating teachers' interest in the planetarium and their evaluation of this educational tool have been established.
Interlinked with one another are the 3 questions asking for the planetarium's attractiveness for a school, teachers' readiness to buy one or their readiness to participate in the purchase of a medium size one for a group of schools. These are the questions 6, 7, and 8.

9.6 Wanting a Planetarium:

More than half of the 200 schools would consider the planetarium as an attractive teaching medium for their school. About 1/4 were "undecided" and only a few "disagreed". Questions 6 and 7 must be viewed together. Most teachers have chosen either a small planetarium for their own school or participation in a medium size one for a group of schools. Some teachers marked both questions in the affirmative. Most of those undecided about having an individual planetarium for their own school went into the group of those favouring a central planetarium for a group of schools. From the study of the figures obtained it follows that there is demand for planetariums. The vast majority of the schools would be either interested in having a small planetarium or in participating in a medium size planetarium together with several other schools, i.e. 148 (=74,00%) in all.

9.8 Readiness to Buy a Planetarium:

Question 6 and 7 can apparently be considered as "academic" questions, treating wish or conception rather than reality. For when it comes to the actual point of buying a planetarium it is observed that many teachers shy away from treating this question. The number of respondents to the 3 sub-questions sank from 200 to 169 participants and even down to 132 when asked if they would earmark their own funds for the acquisition. However, about half the schools were ready to apply for the necessary funds, that is considerably less than those interested in having or participating in a planetarium. Only a few would spend their own budget for buying a planetarium, i.e. a little over 10% of the total sample size have expressed this readiness and an equal number expressed their readiness to earn the necessary funds by either soliciting for funds or working for the money. A good proportion were 'undecided'.
9.13 Value and Interest:

9.14 Rating for the Planetarium and Doubt in its Value:

Question 13 shows how highly teachers rate the planetarium in comparison to classical media. Only one teacher has stated that he thinks the planetarium "inferior" to the conventional media. None of those in the smaller sample size of the pilot survey thought so. The vast majority of the teachers think it "a good supplement" or even "superior", but when asked if there were any doubts concerning the educational value of the planetarium, question 14, the enthusiasm was less pronounced. More than 1/4 were undecided, 10% of the respondents "agreed". Still, the majority does not doubt the educational value of the planetarium. The two questions, 13 and 14, dealing directly with teacher's evaluation of the planetarium have met with a very positive result for this educational tool. (Rank order places 2 and 8 respectively.)

9.9 Using the Planetarium:

9.10 These 2 questions deal with teachers' interest in using a planetarium and this expression of interest is interpreted as an expression of a positive judgement of the planetarium's educational value and potential demand. A little more than 3/4 of the teachers who replied to question no. 9 would be interested in using a planetarium if it were situated near to their school. Only a very small section of about 2% is not interested. But only a few more than 1/4 of the teachers interviewed would not mind the trouble and fuss involved in taking their pupils to a more distant planetarium, as question 10 shows. About 1/4 in each group was "undecided".

An intelligent guess, based on the results of question 13 where teachers have so positively compared the planetarium to the conventional media, would allow the interpretation that the majority of 1/4 undecided about using a nearby planetarium may eventually decide in favour of going there. No such guess can be made for the undecided group which is unsure of whether or not to take the trouble to go to a more distant planetarium, as distance is an impeding factor.
9.13 The Educational Value:

This question is introduced with a limitation in so far as it is addressed only to those teachers who "do know the planetarium". Consequently not all schools in the total sample size participated in answering this question. The questionnaire should perhaps have been structured differently for this particular question. Since 4 choices of answer are given by the 4 subquestions, the "undecided" and the "no" columns could have been omitted so as not to let answers overlap. As an alternative, teachers should have been warned to mark only in the "yes" column. As neither was done, answers overlap. For this reason only the marks to be found in the "yes" column are carried over from the individual questionnaires into the table no. 7.

The teacher's judgement about the educational value of the planetarium in terms of a comparison with the conventional media can safely be assumed to be widely based on intuition or imagination or some passive experience as a guest in a planetarium. Only two of the opinions expressed originated from schools that owned a planetarium, but even they have not substantiated their judgement experimentally in any way. They possess, however, a sufficient degree of experience in the cognitive as well as in the affective domain to pass their judgment with some weight. One of the school planetarium directors describes the institution as being "far superior" to any conventional media.

Those ministries of education in West Germany who are encouraging the use of planetariums in the schools might be disappointed to see that while 148 schools wish to have a planetarium, only 128 are ready to do something for the actual acquisition.

In defence of the teachers it must be said that in the main survey only 35 (=17,67%) out of 198 said that they had ever received any information or advertising material about school planetariums. In addition, in another survey described in chapter III of this thesis, 85 (=58,21%) out of 146 teachers stated that they had never considered the acquisition of a planetarium. The question of allotting or asking for money, which is always scarce in schools, is one that requires more contemplation than is involved
in just reading a questionnaire and looking at 3 attached pictures of school planetariums. This consideration makes the relatively high number of those undecided easier to explain.

No actual price for a school planetarium was given to the teachers in order to avoid time-consuming calculations which would have entailed the danger of a low participation. It could be argued that the question prejudiced the answer. Teachers, however, are a critical population and are not easily manipulated, and many have indeed answered in the negative or have declared themselves undecided. The question is highly informative as it divides the sample into 2 groups, one claiming to be interested in the planetarium but not ready to "fight" for the necessary funds, and one interested and ready to do something about financing their wishes.

9.15 Attitude towards the Planetarium:
----------------------------------

The wish and the readiness of schools to either own or to participate in owning a planetarium should be contrasted with the teachers' attitude towards their media used for teaching astronomy. Question 15 tries to determine this attitude by asking whether or not teachers are fully satisfied with using only the conventional media. Participation is very high; all schools but 2 replied to this exposing question. The questionnaire was inquisitive enough to ask the "satisfied" teachers whether or not their being content with the conventional media prevented them from using a planetarium and eventually from buying a planetarium. Most of them confirmed their interest in using planetariums, and only 24 were outspoken against buying a planetarium. Many remained doubtful and 39 of the teachers confirmed their readiness to buy a planetarium. The figure of those participating in the 2 sub-questions is a little higher than the "satisfied" and "undecided" group added together. Apparently some out of the group who were not satisfied with classical media exclusively had answered these questions.
Extraordinary actions taken in teaching a subject can, broadly speaking, be considered as an indication of an extraordinary interest in the subject. Schools were asked whether they entertained voluntary student groups of hobby astronomers or whether they would be ready to establish such groups provided they had a planetarium and/or telescope. Only a few schools do have such groups but 2/3 would be ready to install such groups, which shows that the vast majority of the teachers are ready to do more than their ordinary teaching duty if they were given the necessary means to occupy special groups outside normal school hours. About 1/4 were in doubt and, since only a very few were against the idea of forming such extraordinary groups, an intelligent guess may allow the prediction that the majority of those in doubt would eventually join the section that expressed their readiness to form such groups. On the other hand, it may very well be argued that, once the enthusiasm for the new subject had cooled off, everything might more or less return to normal.

"Do teachers rate the number of planetariums in West Germany that are open to schools as "too many" - "sufficient" - "too low" - or "much too low"?"

The questionnaire informed teachers about the number of planetariums in West Germany and that this meant that for each planetarium there are 166.666* intermediate and high school pupils; pupils of elementary schools and all special schools being exempted. This figure had to be given to teachers in order to provide them with a basis for their judgement. It could not be expected that teachers had this figure available anywhere.

*) At the time of conducting this survey, not all planetariums open to the schools were known to the author. The actual ratio is 150.694 pupils to 1 planetarium. See page 350.
As to the structure of this particular section of the questionnaire, the same applies as for question 13 above. The author has omitted to either bar the "undecided" and "no" columns in a suitable manner or to warn teachers to mark only the cells in the "yes" column. To avoid confusion to the reader the author has therefore transferred from the individual questionnaires only the marks found in the "yes" column. The four sub-questions were allotted the following multiplication factors for the calculation of the score: "too many" = 1, "sufficient" = 2, "too low" and "much too low" = 3.

The last question concerning the number of planetariums is intended to involve the teacher in a little more than just judging a statistical figure. He is to qualify this figure, and the phraseology used is intentionally provocative: saying "too low" or "much too low" instead of "insufficient" invites at least the intimation of a regret, the revealing of an attitude. No one objected to this, whereas many teachers have criticised the phraseology of other questions. Only a very few thought that planetariums are sufficient in number. Looking at the very many marks given for "too low" and "much too low" in conjunction with teachers' readiness to undertake extra work and with their wish to have a planetarium allows the interpretation that they regret the low or much too low number of planetariums, and that there must be a potential demand for planetariums.

The main strength of this particular question lies, admittedly, elsewhere in the overall research work of this thesis, but besides the attempt at demonstrating regret on the part of teachers for the apparent low number of planetariums, the question contributes much towards the justification for later phases of this research. Knowing that teachers do consider the number of planetariums as being insufficient lends a special dimension to the survey, contributes to its meaning and importance, and widely determines the character and the methodology of later phases of this work.
10. Inconsistencies:

The pattern that has developed from the answers given does not form a strictly coherent entity, a monolithic block of solid statements. It must in all fairness be said that one could not expect the teachers to deliver a perfectly balanced piece of work based on diligent scrutiny and deep pondering. Some of the answers in several questionnaires apparently follow the intuitional urges felt at the spur of the moment when reading a particular question. There is always a marginal number of votes found to be out of line when comparing questions that are interlinked by their nature. But a hard core of answers which are in a logical sequence across the questionnaire is numerically strong enough to allow conclusions to be drawn with a sufficient degree of certainty. By making due allowances for the less orderly respondents, such as have been presented in the discussions above, the general tendencies can fairly well be established on the grounds of the total number of answers received. The validity of this has been supported by the results of a number of case studies taking the form of personal interviews with teachers during the preceding pilot survey.

Table number 8 presents a cross reference of the more salient points with answers being counted individually from the 201 questionnaires. This is intended as a test for the validity and reliability of the answers received. See next page.
TABLE 8

SURVEY WITH SCHOOLS IN WEST GERMANY

THE EDUCATIONAL VALUE OF THE PLANETARIUM

"Teacher’s Interest in the Planetarium as an Educational Tool and
Teachers’ Demand for the Planetarium"

CROSS REFERENCES TO TEST CONSISTENCY OF THE ANSWERS IN PROGRAMME II / 5

<table>
<thead>
<tr>
<th>Questions</th>
<th>14</th>
<th>8a</th>
<th>8b</th>
<th>8c</th>
<th>9</th>
<th>15</th>
<th>3</th>
<th>4</th>
<th>13</th>
</tr>
</thead>
<tbody>
<tr>
<td>Group Characteristics and N Figures Teachers:</td>
<td>Doubt the educational value</td>
<td>Ear-mark funds</td>
<td>Apply for funds</td>
<td>Are ready to collect funds</td>
<td>Want to use nearby planetarium</td>
<td>Are satisfied with classical media</td>
<td>Know the planetarium</td>
<td>Know the various functions of the planetarium</td>
<td>Rate the planetarium highly</td>
</tr>
<tr>
<td>6/7</td>
<td>N=191</td>
<td>N=132</td>
<td>N=169</td>
<td>N=146</td>
<td>N=199</td>
<td>N=199</td>
<td>N=200</td>
<td>N=201</td>
<td>N=160</td>
</tr>
<tr>
<td>.. Want a planetarium</td>
<td>yes=20</td>
<td>yes=24</td>
<td>yes=80</td>
<td>yes=24</td>
<td>yes=154</td>
<td>yes=55</td>
<td>yes=169</td>
<td>yes=178</td>
<td>yes=148</td>
</tr>
<tr>
<td>N=200</td>
<td>=10.47%</td>
<td>=18.18%</td>
<td>=47.38%</td>
<td>=16.44%</td>
<td>=77.39%</td>
<td>=27.64%</td>
<td>=84.50%</td>
<td>=88.56%</td>
<td>=92.5%</td>
</tr>
<tr>
<td>yes=148 x)</td>
<td>=74.00%</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Summary

148 schools, about 3/4 of those interviewed, clearly want a planetarium, and 37 more are in doubt. The number of those teachers that give the planetarium high marks ("superior", "a good supplement") is very high and in absolute numbers equal to those that want the planetarium. But only about half of the total participants (numbers overlap slightly) are ready to actively seek funds for a planetarium — perhaps more could not have been expected from the teachers being so suddenly confronted with the idea of having a planetarium. The numbers of those teachers who claim to know the various possible functions of the planetarium is higher by 9 than the number of those who claim to know the planetarium at all — a small discrepancy without explanation.

Both numbers are, however, higher than the numbers of those who want a planetarium and are hence not inconsistent with this latter number. The number of those "fully satisfied with classical media" (55) is only a little higher than the number of those not wanting a planetarium (15), plus those being "undecided" (37) = (52). 20 teachers doubt its educational value. This number is not inconsistent with any of the others.

Also the number of those interested in using a nearby planetarium (if it did exist) is above that of those wanting a planetarium and hence not inconsistent with this number. The main inconsistency lies between the wanting and the funding of a planetarium. The other inconsistencies are more marginal and leave a strong core of logically coherent answers.

x) Footnote: according to an individual count, which compensates for overlapping, only 15 schools voted clearly against the idea of owning or co-owning a planetarium. 5 of them are situated in the neighbourhood of a large planetarium, which leaves only 10 schools being genuinely against having a planetarium. 37 schools were "undecided", either about both planetarium types under discussion, or undecided about one of them while clearly refusing the other.

xx) By the same method it was established that a total of 169 teachers do know either the large or the small planetarium, or both of them.
11. Conclusions and Implications:

All scores have been added together including the scores of those questions that are of a more preparatory character. The actual total score amounts to 10.561, the maximum possible score would have been 14.013 which results in an attained percentage of 75.36%. Within the limitations made, the figures allow the interpretation that the planetarium is well in favour with teachers, which points to the prevalence of a demand for planetariums. It has been established that necessary prerequisites for using the planetarium as an educational tool are prevalent, that there is an interest in the use of this tool, and that a higher educational value is attributed to the planetarium than to classical media. Even the teachers' readiness to take unusual steps in utilizing this medium has been strongly expressed, but reservations have been noticeable when it came to the question of financing the wish to have a planetarium.

The results of the survey refute the operational hypothesis which guided this survey.

The results of the 2 surveys support the respective part of the main hypothesis saying that planetariums are believed to be educationally valuable teaching tools.

This is so in the eyes of the vast majority of the teachers interviewed in the present survey as measured by their replies to the questions put to them. The results of this survey likewise support the hypothesis that there seems to exist a demand for planetariums.

Still, so very few planetariums are in use, (see the additional survey in chapter III of this thesis), that this implies that there must be strong factors actively preventing a more widespread use of the planetarium as an educational tool. Chapter III of this thesis is devoted to an investigation of such factors.

Two tables supplement and illustrate this record of the main survey conducted with the schools in West Germany. Two further tables which summarize the findings of the school pilot survey are included in the appendix pp. 539 - 540.

*) The maximum possible total score has been attained by multiplying the N-number for each question by 3, the highest cell factor, and by subsequently adding the results.
Outlook:

The question posed in survey II/4 on how the value of the planetarium is rated by those concerned with it has been positively answered by the vast majority of a representative sample of school teachers in West Germany.

It seems to derive that teachers' opinions about the planetarium and their attitude towards this medium cannot be counted as a possible reason for the underuse of the planetarium. But results are not that clearly cut as the diminishing vote regarding the question of finance indicated. The results of this survey will therefore be thoroughly questioned in chapter III on the underuse of the planetarium.

The next survey will test the planetarium visitors in order to learn their opinions and attitudes regarding the planetarium as an institution for learning and for erudite entertainment.
"PLANETARIUM VISITORS MAY BE CRITICAL OF THE PLANETARIUM AS AN EDUCATIONAL TOOL AND THUS BECOME A FACTOR IMPEDING THE MORE WIDESPREAD USE OF THE PLANETARIUM"

A) Personal Interviews Conducted with Planetarium Visitors on an International Level - A Preparatory Pilot Survey

1. Introduction:
When conducting the personal interviews with planetarium teachers on the international scene (II/8), the opportunity was seized to interview a number of planetarium visitors on the spot. This was to prepare for the larger survey with planetarium visitors in West Germany.

2. Theme and Purpose:
The theme of this report is an investigation conducted with planetarium visitors as to their opinions and attitudes regarding the planetarium's educational value. The purpose of this survey is to investigate tendencies on the visitors' level for refuting or supporting the operational hypothesis guiding this survey, and to see in this way whether or not tendencies exist to support that part of the general hypothesis saying that planetariums are believed to be educationally valuable teaching tools.

3. Methodology:
Personal interviews were used exclusively in this survey. A descriptive survey has been conducted. The interviews were informal in character and allowed for indirect and multiple questioning. Scores for negative questions are calculated in an inverted manner, so that the resulting figures combine with those obtained for the positive questions in such a fashion that their succession is an expression of a measure in the positive meaning.

4. Procedure:
On visiting a number of planetariums, the author randomly selected a number of visitors after the performance and engaged them in informal conversations about the planetarium performance they had just experienced. Notes were taken and subsequently evaluated. For the
interviews in the 2 school planetariums in Kuwait the help of an
interpreter was employed. Individual sample sizes were very small
and are therefore not representative.

The interviews took place with visitors of the following planetariums:

1.) Kuwait I 2.) Kuwait II 3.) Stuttgart
4.) Cleveland 5.) Los Angeles 6.) Nürnberg
7.) Vienna 8.) Bangkok 9.) Boston
10.) San Diego 11.) Reutlingen *

5. Rationale of the Questions:
The questions are mostly direct in character; only question 25 is in-
direct. Positive and negative questions were randomly mixed and ques-
tions were phrased each time anew, so as to be easily understood by
each age group involved, whilst the core of each question was kept
constant. The questions do adequately cover the topic under investiga-
tion and have therefore content validity.

Content validity of the test instrument is limited in the cognitive
domain as only form but not content of learning is covered. (This has
been improved in the main survey.) In the affective domain impression
and reaction are covered and the subjects agreed to the questions' con-
tent as reflecting their feelings. Reliability is ensured by the fact that
essentially similar results were obtained in 11 different attempts.
Time available for the interviews did not allow for a finer test
instrument with 5 columns.

6. Limitation:
The unrepresentative sample sizes in the population and a certain
coarseness in the test instrument render results more tentative than
absolute.

7. Population:
The population participating in this survey consisted of a total
sample size of N = 70 randomly selected from chance visitors to the
11 planetariums listed under paragraph 4. The participants were
mostly of school age with some 20 grown-ups including several

* A short description of these planetariums is printed in the appendix
to programme II/6, pages 552 - 554.
teachers. Some groups participated in school courses, others visited public performances. The Thai visitors had their planetarium experience some time back, the others were interviewed immediately after the performance.

8. Findings:

Reference is made to the following table no. 9 summarizing the results of the surveys.

A) **The Cognitive Domain**

13 questions were posed, 7 of them dealt with learning in the planetarium and 6 of them dealt with the experience of the planetarium performance.

B) **The Affective Domain**

13 questions were posed, 7 of them were related to learning and 6 of them dealt with the experience of the planetarium performance. It was thus attempted to treat both domains with equal weight.
TABLE 9
PERSONAL INTERVIEWS WITH PLANETARIUM VISITORS

"The Educational Value of the Planetarium"

N = 70

A) The Cognitive Domain

<table>
<thead>
<tr>
<th>Educational Value was defined as:</th>
<th>Rank Order</th>
<th>Score</th>
<th>Agree</th>
<th>Undecided</th>
<th>Disagree</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Instructive</td>
<td>6</td>
<td>201</td>
<td>64</td>
<td>3</td>
<td>3</td>
</tr>
<tr>
<td>2. Topsy-turvy</td>
<td>10</td>
<td>195</td>
<td>6</td>
<td>3</td>
<td>61</td>
</tr>
<tr>
<td>3. Informative</td>
<td>5</td>
<td>203</td>
<td>65</td>
<td>3</td>
<td>2</td>
</tr>
<tr>
<td>4. Too fast</td>
<td>8</td>
<td>198</td>
<td>5</td>
<td>2</td>
<td>63</td>
</tr>
<tr>
<td>5. Easy to grasp</td>
<td>13</td>
<td>183</td>
<td>53</td>
<td>7</td>
<td>10</td>
</tr>
<tr>
<td>6. Showing new things</td>
<td>1</td>
<td>208</td>
<td>68</td>
<td>2</td>
<td>0</td>
</tr>
<tr>
<td>7. Too technical</td>
<td>9</td>
<td>196</td>
<td>6</td>
<td>2</td>
<td>62</td>
</tr>
<tr>
<td>8. Dramatic in performance</td>
<td>2</td>
<td>208</td>
<td>68</td>
<td>2</td>
<td>0</td>
</tr>
<tr>
<td>9. An enriching experience</td>
<td>4</td>
<td>204</td>
<td>64</td>
<td>6</td>
<td>0</td>
</tr>
<tr>
<td>10. All of it too difficult to understand</td>
<td>3</td>
<td>208</td>
<td>0</td>
<td>2</td>
<td>68</td>
</tr>
<tr>
<td>11. Most of it too difficult</td>
<td>7</td>
<td>200</td>
<td>3</td>
<td>4</td>
<td>63</td>
</tr>
<tr>
<td>12. Some of it very difficult</td>
<td>12</td>
<td>192</td>
<td>7</td>
<td>4</td>
<td>59</td>
</tr>
<tr>
<td>13. It is not better than any other place to learn</td>
<td>11</td>
<td>194</td>
<td>6</td>
<td>4</td>
<td>60</td>
</tr>
</tbody>
</table>

Possible Maximum Score: 2730 Actual Total Score: 2590
Possible Maximum Mean: 39 Actual Mean: 37.0% (=94.87%)
### B) The Affective Domain

<table>
<thead>
<tr>
<th>Attitude was determined by expressions of feelings:</th>
<th>Rank Order</th>
<th>Score</th>
<th>Agree</th>
<th>Undecided</th>
<th>Disagree</th>
</tr>
</thead>
<tbody>
<tr>
<td>14. Interesting</td>
<td>5</td>
<td>207</td>
<td>68</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>15. Boring</td>
<td>3</td>
<td>208</td>
<td>0</td>
<td>2</td>
<td>68</td>
</tr>
<tr>
<td>16. Fascinating</td>
<td>9</td>
<td>203</td>
<td>64</td>
<td>5</td>
<td>1</td>
</tr>
<tr>
<td>17. Average</td>
<td>12</td>
<td>199</td>
<td>4</td>
<td>3</td>
<td>63</td>
</tr>
<tr>
<td>18. Frightening</td>
<td>1</td>
<td>209</td>
<td>0</td>
<td>1</td>
<td>69</td>
</tr>
<tr>
<td>19. Awe-inspiring</td>
<td>13</td>
<td>197</td>
<td>61</td>
<td>5</td>
<td>4</td>
</tr>
<tr>
<td>20. Confusing</td>
<td>6</td>
<td>206</td>
<td>2</td>
<td>0</td>
<td>68</td>
</tr>
<tr>
<td>21. Entertaining</td>
<td>4</td>
<td>208</td>
<td>68</td>
<td>2</td>
<td>0</td>
</tr>
<tr>
<td>22. Monotonous</td>
<td>7</td>
<td>205</td>
<td>2</td>
<td>1</td>
<td>67</td>
</tr>
<tr>
<td>23. Sorry I went there</td>
<td>2</td>
<td>209</td>
<td>0</td>
<td>1</td>
<td>69</td>
</tr>
<tr>
<td>24. Like to go again</td>
<td>11</td>
<td>200</td>
<td>61</td>
<td>8</td>
<td>1</td>
</tr>
<tr>
<td>25. Bring my friends and family</td>
<td>8</td>
<td>204</td>
<td>64</td>
<td>6</td>
<td>0</td>
</tr>
<tr>
<td>26. Liked to tease my neighbours in the dark</td>
<td>9</td>
<td>204</td>
<td>2</td>
<td>2</td>
<td>66</td>
</tr>
</tbody>
</table>

Possible Maximum Score: 2730 Actual Total Score: 2659
Possible Maximum Mean: 39 Actual Mean: 37.98 (=97.38%)

### Summary

Planetarium visitors were personally interviewed as to their opinion about the planetarium's educational value. The interviews were conducted in the form of informal conversations changing in tone for adjustment to the respective age groups but retaining in each case the core element of each question. Most of the subjects were school children; about 20 of the participants were grown-ups, including several teachers.

The tables A and B represent the accumulated experience of 11 different case studies from 11 different planetariums.

Visitors' opinions and attitudes were found highly in favour of the planetarium.
9. Discussion and Evaluation:

A) The Cognitive Domain

Learning:

The lecture demonstration was found to be "Instructive" (1) by the visitors in the sense of an effective teaching method and was found "Informative" (3) in the sense of the richness of facts conveyed by the planetarium lecture-demonstration. Still, those that found the planetarium lesson "Easy to grasp" (5) produced the lowest score figure of all in the 2 tables. The question attained the score figure 183. The same number in agreement must be the same who were found to have "agreed" that "Most of it (is) too difficult (to understand)" (11) or "Some of it (is) very difficult (to understand)" (12).

As a "--- better place to learn --" (13), the planetarium does not rank highest with visitors. Other points seem to be more important, as is visible from the score-column in table 9.

The span between the highest and lowest score figures for the planetarium teaching/learning situation in the cognitive domain amounts to 208 (10) - 183 (5) = 25, which shows that opinions about the teaching/learning aspect of the planetarium were diversified, which may be ascribed to the completely incoherent structure of the population stemming from so many different planetariums. The vast majority judged question 6, 8 and 10 highest in expressing the planetarium's educational value.

The Performance:

"Topsy-turvy" (2) was understood as being an effect of disturbing the natural sense of equilibrium by simulating the vastness of space and the movement of heavenly bodies. This was indeed experienced by a few visitors, but the sensation, if it lasts only for moments - as when roll, pitch and yaw of space vehicles are demonstrated - is usually felt rather as being entertaining than as being disturbing. A fast-moving projector was always described as creating a "topsy turvy" sensation.
"Too fast" (4) was experienced in a triple sense, either the narrative or the movements or both went too fast for normal comprehension, but only a few complained about this particular point, which is completely within the control of the lecturer.*

"Showing new things" (6) and "An enriching experience" (9) meant to be able to see the hitherto unseen demonstrated by a technical method never witnessed before. Both questions met with much acclaim, and this is confirmed by score figures of 208 and 204 for these questions.

"Too technical" (7) meant that the combined effects of too many gadgets interplaying or superimposed upon each other distracted from the actual educational message they were intended to convey. A few visitors "agreed". Again, the control is in the hands of the operator.

"Dramatic in Performance" (8) describes the theatrical demonstration of celestial events in real motion, most of the motions being condensed in time. This question also met with the highest score in confirmation (208).

The span between the highest and the lowest score for the planetarium performance as a means of conveying an educational message amounts to 208 (6) + (8) + (9) - 195 (2) = 13. Not only is the span between highest and lowest scores much less than the one calculated for the teaching/learning aspect of the planetarium performance, but there is also a shift in scores visible towards the high side. Opinions on performance were more uniform. On the other hand, it cannot be said with any certainty that all questions are of equal weight and equal discriminatory power. Figures have to be read with this limitation in mind.

* Footnote: Manufacturers of planetariums agree that the advantages of even the best and most sophisticated equipment can only be realized through the skills of the talented operator, as is shown in a later survey with manufacturers.
Previous surveys indicated that much of the planetarium's educational value may be found in the affective domain. It has therefore been attempted to test the visitors' reaction towards the planetarium in the affective domain.

The experience gained in this pilot project allowed for the construction of a better test instrument used in the main survey and the experiments of survey II/10.

B) The Affective Domain

Learning:

The lecture demonstration was found to be "Entertaining" (21) due to the unusual display of events. It was found to be "Interesting" (14) by the visitors as the events demonstrated continued to attract their attention throughout the performance. Many visitors even found the lecture demonstration "Fascinating" (16) as it really captured their mind. In contrast, the planetarium performance appeared only to a few as being "Average" (17), i.e. as a routine event with nothing much remarkable about it.

"Confusing" (20) was understood to be disorderly in information, and "Monotonous" (22) described an ongoing equilibrium in the performance without any accents or highlights. "Boring" (15), of course, described a performance that tended to tire the audience by its dormitive dullness. There was found very little agreement to the three latter points.

The span between highest and lowest scores of the questions dealing with the affective side of learning amounts to 208 (15) - 199 (17) = 9 only, which indicates a more pronounced uniformity in attitude towards planetarium learning than was visible in the opinions expressed concerning the cognitive side of planetarium learning.

The Performance:

A strong majority went to the extent of agreeing to have been spell-bound by the "Awe-inspiring" (19) performance. This points to the prevalence of the "mystic effect" as defined by
"Frightening" (18) in the sense of inducing fear had not been an agreeable term to any visitor.

"Sorry I went there" (23) was not felt by anyone of the international population of this survey, though a few were "undecided" about it.

"Like to go again" (24) described the opposite attitude. "Bring my friends and family" (25) was a subtle indirect question to which only those were expected to agree who had developed a strong liking for the planetarium. The weakness of these questions is that it was omitted to ascertain if the respondent was on good terms with friends and family, or had any such relations at all.

"Liked to tease my neighbours in the dark" (26) is the question demanding a confession, and only a few were ready to confess to such practices. In a later survey with other visitors the question is asked indirectly, i.e. if people felt disturbed by others in the dark chamber, and this method of questioning proved more revealing as will be seen.

The span between the highest and lowest scores was 209 (18) + (23) - 197 (19) = 12 which is nearly the same span as was obtained for the investigation of performance in the cognitive domain, but there is no shift in scores visible towards the higher side.

10. Summary and Evaluation:

A survey with a rather dispersed population resulted in the observation of diversified opinions about the teaching/learning aspect of the planetarium, but in a much more uniform judgement about the educational value of the planetarium performance as a means of conveying an educational message. Attitude towards the planetarium teaching/learning aspect was found to be rather uniform, so was the attitude towards the planetarium performance.

1) Ridky 1973, op.cit.

*) Footnote: The "Mystic Effect" seems an interesting phenomenon in the planetarium being worthy of a closer investigation. The author can, however, only point to its existence where it seems to appear and cannot engage himself with an extra survey on its influence, as this may be slightly outside the scope of this thesis.
Scores were very high in the cognitive as well as in the affective domain (95.02% + 97.38%), which shows that the planetarium is popular with the subjects tested.

Results of this survey point towards a tendency to refute the operational hypothesis and in this show a tendency to support that part of the general hypothesis saying that planetariums are believed to be educationally valuable teaching tools, as has been measured with the test instrument applied for this survey.

Due to the limited and hence unrepresentative sample sizes in the population tested, the conclusion drawn from the results of this survey is only tentative and is therefore presented in a correspondingly guarded formulation. No valid generalisations can be made from it. The sample is not homogeneous and the survey is only a collection of uniformly conducted small-size case studies.

While the survey conducted with this international audience can - within the limitation made - be seen as being illuminating in each limited case and can also be seen - on a larger scale - as tentatively pointing towards the planetarium's popularity as an institution for learning and erudite entertainment, that survey was in essence more preparatory in character for the following survey conducted in West Germany. This survey is described in the following part B of this investigation with planetarium visitors.

11. Limitation in the Evaluation of Results:

Scores obtained in this pilot project are higher than the scores obtained in the main survey conducted with planetarium visitors in West Germany.

This is ascribed to two recognizable causes:

The test instrument is not the same. The one used in the pilot project is simpler and less controversial in questioning in comparison to the questionnaire used in the main survey. The tests in the pilot project were conducted verbally and the disadvantage of receiving "pleasing" (i.e. positive) answers could perhaps not be sufficiently controlled.
B) A Survey Conducted with Planetarium Visitors in West Germany

THE MAIN SURVEY

1. Introduction:

General planetarium visitors seem to belong to the a priori unbiased section of those groups concerned with the planetarium, alone by virtue of the fact that they do not form a particular party or otherwise socially definable entity other than sharing a casual interest in a random planetarium performance. Exceptions must only be made for members of astronomical societies who may have a vested interest in the planetarium. Participation of such groups could not be traced.

The interviews conducted with planetarium visitors face-to-face in a number of planetariums in various countries - and the present part of this programme - the survey with planetarium visitors in West Germany - rank very highly in importance as they deal with the very people for whom the planetarium has been created.

2. Theme and Purpose:

The theme of this part is a survey conducted with 243 planetarium visitors in West Germany. The purpose of this survey is to seek support or refute on the planetarium visitors' level for that part of the general hypothesis saying that planetariums are believed to be educationally valuable teaching tools. An operational hypothesis, printed as the heading of part A) has been devised for this purpose and it is put to the test also by this part of the survey.

Confirmation is sought in a general way as well as in specific points of planetarium learning as presented by the results of survey II/4.

3. Methodology:

The survey was conducted by using questionnaires. A descriptive survey has been conducted leaving unexplored the possible variables that probably have contributed to the answers given. Questionnaires were chosen, as it was impossible for the author to conduct personal interviews in several planetariums with a sufficiently large sample size. While 13 questions were discussed in both the cognitive and affective domain, in the personal interviews conducted with planeta-
rium visitors in the framework of programme A, the number was reduced to only 10 in the written questionnaire of the present survey. The limitation seemed necessary so as not to overstrain the patience of the participants. The set of questions chosen seems to have content validity since they are based on previous experience with planetarium audiences, literature read, cover form and content of learning by the planetarium show and since the advice of planetarium teachers was sought. The tests showed reliability by producing similar results with various audiences, and by showing internal and external consistency (par. 7). Later experiments have reconfirmed validity and reliability of the affective test. *Questions were randomly mixed and care was taken that each half of them were phrased positively and negatively.

4. Procedure:

In conducting this survey the planetariums in West Germany were requested to support the first research programme ever to be carried out in West Germany for establishing the educational value of the planetarium and the degree of its use or underuse. Unfortunately not all planetariums replied. 2 did not react at all in spite of several reminders. The large planetariums had to be reminded several times; one of them refused to distribute the questionnaires designed for the planetarium visitors on the grounds that in their view the questions posed were not sufficiently representative.

The planetariums in the possession of naval colleges could likewise not participate in a visitors survey as they are not open to the general public. As institutes they are used only for very limited purposes, such as purely descriptive astronomy and astronomical navigation. 3 of the smaller planetariums were found to be most cooperative.

The planetarium directors were asked to distribute a questionnaire containing 20 questions, 10 in the cognitive and 10 in the affective domain, after any of their usual public performances, or if possible school performances. Participants were also asked whether they had visited the planetarium once or several times before and whether they would be interested in seeing a suitable film and some slides in addition to the pure planetarium performance. Additionally, participants were asked for their opinion as to what could be improved in the planetarium. This question served for an indirect expression of criticism.

*) See survey II/10 "Experiments in the Planetarium"
Participation was very vivid, though not every subject answered all the questions posed. The questionnaire began with a short address to the "Dear Planetarium Visitor", inviting him to participate in a systematic investigation of the educational value of the planetarium, and it was stated that the visitors' opinion was of particular value in this investigation. The best participation was noted in the small planetariums where nearly all the questionnaires distributed had been filled in and returned.

The planetarium lecturers distributed the questionnaires after the performance and recollected them on the spot.

**Limitation:**

This survey could not be limited to school pupils, though many of the participants were pupils. The results therefore are not directly related to the schools' use of the planetarium, but reflect the opinions and attitudes of a representative cross-section through the planetarium's clientele in West Germany.

5. **Population:**

A total population of \( N = 243 \) participated in the survey. They were casual planetarium visitors who went there for erudite entertainment; more than half of the participants were youths, many of them going to school. The various groups were randomly selected as they came to the planetarium and therefore seem to be representative. Individual groups were larger than in the pilot survey and also form one ethnic and language entity which adds towards the representativeness of the total and hence towards the validity of the tests performed.

6. **Rationale of the Questions:**

Positive and negative questions are randomly mixed in the questionnaire which is divided into one half for the cognitive and one half for the affective domain. The questions in the cognitive domain are direct in form and straightforward in content. They deal with learning in the planetarium in general terms and also mention some themes of typical planetarium demonstrations. As the conversations with planetarium visitors revealed, a comparison with the familiar
conventional classroom learning situation facilitates their evaluation of the planetarium learning situation. Some questions are therefore of comparative character. A five column Lickert scale has been used to allow for shades in expression. Scores were calculated in rising order for positive questions and in falling order for negative questions. As participation was irregular, scores are expressed in both absolute figures and percentages of the maximum possible score for each question and participating N-number. Rank orders are calculated according to the relative percentage scores for each domain separately. Questions are not weighted in any qualitative form, and the rank order places they obtained signify the strength of the immediate meaning a question had for the participants.

The questions of the affective domain are partly direct and partly indirect. 6 questions are of an emotional character and 4 of a factual character. They are designed to measure the planetarium visitors' attitude towards this medium and towards the performance experienced.

The same set of attitude questions is used again to test the attitude of pupils who were lectured in the planetarium in the framework of 5 experiments carried out in 2 German planetariums. See programme II/10.

7. Findings:

Reference is made to the following table displaying questions and answers, rank orders and scores in absolute figures as well as in terms of percentages relative to participation. Questions 2, 3, 5, 7 and 10 deal with learning specific themes and the answers reveal internal consistency: Questions 3 and 5 are of equal difficulty and produce equal agreement (90.53%). Questions 7 and 10 are more difficult in rising order and thus produce diminishing scores (86.58% and 76.48%). Question 2 seems most difficult and scores lowest (73.50%). These answers are externally consistent with the findings of survey II/4. Establishing consistency lends reliability to the test.

*) Question number 3 is borderline and could also be considered to be of an emotional character.
Survey held with Planetarium Visitors in West Germany

"EDUCATIONAL VALUE OF THE PLANETARIUM"

A) Cognitive Domain

B) Affective Domain

<table>
<thead>
<tr>
<th>Opinions Expressed</th>
<th>N</th>
<th>Rank Order</th>
<th>% Score abs.</th>
<th>Strongly agree</th>
<th>Undecided</th>
<th>Strongly disagree</th>
</tr>
</thead>
<tbody>
<tr>
<td>(A) 1) The Planetarium is a highly instructive institution.</td>
<td>242</td>
<td>1</td>
<td>90.83</td>
<td>1099</td>
<td>143</td>
<td>89</td>
</tr>
<tr>
<td>2) Astronomy involves mathematics, it is hence better studied on the blackboard in the classroom.</td>
<td>234</td>
<td>9</td>
<td>73.50</td>
<td>860</td>
<td>9</td>
<td>21</td>
</tr>
<tr>
<td>3) Three-dimensional demonstrations, spatial conceptions, are better understood in the Planetarium than on the blackboard (in the classroom).</td>
<td>243</td>
<td>3</td>
<td>90.53</td>
<td>1100</td>
<td>143</td>
<td>86</td>
</tr>
<tr>
<td>4) What I don’t otherwise understand even the Planetarium show cannot make clearer to me.</td>
<td>234</td>
<td>7</td>
<td>77.69</td>
<td>909</td>
<td>2</td>
<td>11</td>
</tr>
<tr>
<td>5) Star configurations and their respective positions in the sky are best learnt in the Planetarium, better than by slides or pictures.</td>
<td>243</td>
<td>2</td>
<td>90.53</td>
<td>1100</td>
<td>145</td>
<td>84</td>
</tr>
<tr>
<td>6) Everything moves much too fast, I am really confused by all these impressions.</td>
<td>239</td>
<td>10</td>
<td>72.55</td>
<td>867</td>
<td>9</td>
<td>26</td>
</tr>
<tr>
<td>7) The total network of the celestial co-ordinates becomes more comprehensible in the Planetarium than from books or the blackboard in the classroom.</td>
<td>234</td>
<td>4</td>
<td>86.58</td>
<td>1013</td>
<td>111</td>
<td>94</td>
</tr>
<tr>
<td>8) Everything is very difficult to understand.</td>
<td>238</td>
<td>6</td>
<td>78.92</td>
<td>940</td>
<td>3</td>
<td>13</td>
</tr>
<tr>
<td>9) The great sky projection enables everything to be easily remembered.</td>
<td>241</td>
<td>5</td>
<td>81.91</td>
<td>987</td>
<td>77</td>
<td>119</td>
</tr>
<tr>
<td>10) With complicated themes like sky mechanics, laws of the motions of the stars, galaxies and their position in space, and problems of space travel, none of them is made clearer by the Planetarium than by charts, globes and blackboard.</td>
<td>233</td>
<td>8</td>
<td>76.48</td>
<td>891</td>
<td>6</td>
<td>18</td>
</tr>
</tbody>
</table>

(B) 11) I like to learn astronomy in the Planetarium rather than in the classroom. | 238 | 2 | 87.65 | 1043 | 133 | 73 | 24 | 6 | 2 |
| 12) I find the Planetarium demonstration too monotonous. Only stars. Boring! | 240 | 3 | 87.58 | 1051 | 0 | 6 | 21 | 89 | 124 |
| 13) The Planetarium made me more interested in astronomy. | 240 | 6 | 79.92 | 959 | 61 | 104 | 56 | 17 | 2 |
| 14) A Planetarium demonstration is an elevating and marvellous experience. | 240 | 8 | 76.67 | 920 | 54 | 116 | 49 | 17 | 5 |
| 15) Actually I am sorry I went there. | 238 | 1 | 92.94 | 1106 | 3 | 1 | 8 | 53 | 173 |
| 16) There is too much nonsense going on in the dark chamber. | 240 | 9 | 73.25 | 879 | 6 | 13 | 45 | 78 | 98 |
| 17) I should like to take my friends and relatives. | 240 | 7 | 77.42 | 929 | 61 | 114 | 46 | 11 | 8 |
| 18) The Planetarium does not equal reality sufficiently. | 239 | 4 | 84.02 | 1004 | 0 | 11 | 25 | 130 | 73 |
| 19) At night I can see everything just as well outside. | 240 | 5 | 82.17 | 986 | 6 | 5 | 30 | 111 | 88 |
| 20) Every visitor must be inspired with enthusiasm by the Planetarium. | 230 | 10 | 69.91 | 804 | 48 | 62 | 87 | 22 | 11 |

Summary

Two hundred and forty-three randomly selected Planetarium visitors tested in various planetariums display a strongly positive opinion about the Planetarium's educational value in the cognitive domain and a very strong attitude in the affective domain.

<table>
<thead>
<tr>
<th>Additional Information</th>
<th>Yes</th>
<th>No</th>
<th>Undecided</th>
</tr>
</thead>
<tbody>
<tr>
<td>1) Have you visited a Planetarium before?</td>
<td>190</td>
<td>42</td>
<td>7</td>
</tr>
<tr>
<td>2) Have you visited a Planetarium more than once?</td>
<td>150</td>
<td>81</td>
<td>7</td>
</tr>
<tr>
<td>3) Would you like to see some supplementary films or slides in addition to the star show?</td>
<td>208</td>
<td>20</td>
<td>12</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th></th>
<th>(A)</th>
<th>(B)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Actual Total Score:</td>
<td>9,766</td>
<td>9,681</td>
</tr>
<tr>
<td>Possible Maximum Score:</td>
<td>12,150</td>
<td>12,150</td>
</tr>
<tr>
<td>Actual Mean:</td>
<td>41.01 = 82.02%</td>
<td>40.66 = 81.31%</td>
</tr>
<tr>
<td>Maximum Mean:</td>
<td>50.00</td>
<td>50.00</td>
</tr>
<tr>
<td>M N:</td>
<td>238.1</td>
<td>238.1</td>
</tr>
</tbody>
</table>
The planetarium visitors were invited to write any additional comments on the rear page of the questionnaire. It was attempted in this way to really obtain a full view of the spectrum of opinions extending beyond the scope of the pre-given questions.

The General Comments:

The following additional comments were received from planetarium visitors:

1.) Very bad seating arrangement. Seats cause a stiff-neck problem when looking up to the artificial sky for such a long time.  

2.) The lecture goes too fast. Too many points are crammed into one lecture.  

3.) The planetarium is fine, there is nothing that could be improved.  

4.) The planetarium chamber should be larger.  

5.) There are not enough planetariums available. The public does not know enough about them.  

6.) Information material should be distributed for better understanding and better retainment of the subject presented.  

7.) The planetarium programmes should cover a larger range of subjects.  

8.) The music is good.  

9.) More constellations should be shown and explained.  

10.) The lecture was bad.  

11.) The lecture was too impersonal and mechanical.
12.) The lecture was good. 3 x

13.) Technical equipment should be improved. 2 x

14.) The large projector obscures vision from many places in the auditorium. (Remark comes from a large planetarium.) 2 x

15.) Air-conditioning is needed. 2 x

16.) Bad acoustics. 1 x

17.) Difficult to see projected slides from every place. Slides should be projected more into the centre. 1 x

18.) Lecture is too long. 1 x

19.) Lecture is too short. 1 x

20.) A short interruption would be good. 2 x

21.) Discipline is very good. 1 x

22.) I like the planetarium because it is good for all levels of the population. 1 x

23.) The planetarium is an outstanding invention. It stimulates an interest in astronomy. The planetarium should be used even more intensively. 1 x

Total N of free comments = 79

79 visitors, i.e. 32.51%, followed the invitation to give free comments.
8. Discussion and Evaluation:

A. The Cognitive Domain:

8.1 The Purpose of the Planetarium.
This is the only question among the set of 20 giving, in a very concise form, a general description of the planetarium. It met with the strongest support.

8.2 Classroom or Planetarium?
A few participants obviously shied away from this question and did not answer. The negative phraseology and the necessity of inverting the pre-given answers in order to come to a positive result may have posed an additional problem to some of the respondents.
The very bold statement, which implies that the visitors had gone to the wrong place, obviously confused a few and made them mark the "undecided" cell and, of the remaining section that had voted in "agreement" or "strong agreement" to the statement, it is not known how many may have misinterpreted the relationship between the negatively phrased question and the scale provided for answers. Relatively more youths than adults objected to the statement, whereas they provided the larger fraction in the "undecided" cell.

8.3 Spatial Conceptions are better understood where?
The results show that planetarium visitors are well aware and conscious of this particular advantage of the planetarium.
Questions 3 and 4 can be linked with question 11, which deals with the preference of the planetarium visitor for either teaching situation, planetarium or classroom. This question also compares the planetarium to the classroom teaching situation. The positive phraseology and the specificity of the question served as a compensation for those who did not want to deal with the former question. All participants responded. The question deals with one of the most obvious advantages that the planetarium offers in comparison to the blackboard - classroom situation.
8.4 The Planetarium's Teaching Effect.
This is again a provocative question phrased in the negative form, which apparently was not liked by all participants as 9 abstained from voting. The question is aimed at whether the expectancy of the public of a better understanding of an unusually difficult subject was met or not. More than 1/4 of the participants were not satisfied or remained in doubt as to the teaching effect of the planetarium. The difficulty of the question becomes obvious not only from the number of abstentions but also from the relatively high number of those who were "undecided".

8.5 Star Configurations are best learned where?
The visitors were asked whether they agreed that star configurations and their respective positions in the sky were best learned in the planetarium and if they considered this method as being better than learning with the aid of slides or pictures only. All subjects responded, from which it can be derived that they all must have experienced a relevant demonstration in the planetarium and that they all had, more or less frequently and more or less intensively, seen slides or pictures of star constellations and may have tried to memorize them and mentally to project them onto the actual sky. The vast majority is found in "agreement" with learning constellations in the planetarium.

8.6 Confusion created in the Planetarium?
This question deals rather with the handling of the planetarium equipment and the presentation of a specific lecture than with the planetarium as an institution. As in point 4, the statement made is unspecific and does not relate to a particular event or information. Though the participation was high with only 4 abstentions, a strong shift towards the centre is noticable.

Though there is a strong fraction in doubt or even convinced that they had not learned much in the planetarium due to the speed of presentation and due to the multitude of impressions received, we see from the answers received for questions 11 and 15 in the affective domain that the planetarium is well-liked as a place of instruction.
8.7 The Celestial Network is best learned where?
Point 7 is one of the strongest arguments brought forward in favour of planetarium teaching by the promoters of the planetarium idea. It is claimed that it is easier for the student to learn about astronomical reference lines in the planetarium than in the classroom. In the planetarium the student sits inside the dome and sees the lines of the zodiac, latitude, right ascensions and declination, the spherical (nautical) triangle, etc., directly projected onto the hemispherical starry sky. He does not have to try to visualize these concepts from 2-dimensional presentations. It is safe to assume that a large fraction of the visitors interviewed have experienced both learning situations and thus felt competent to comment. The large majority have confirmed this point.

8.8 Is Teaching in the Planetarium difficult to follow?
Question 8 is supplementary to question 4. Whereas question 4 limits non-understanding to particular subjects that are not comprehended by other means and also not comprehended in the planetarium, question 8 refers to the complete planetarium experience. Are the expectations of the planetarium visitors of learning something in the planetarium met, or are visitors disappointed by the planetarium? A strong fraction is "undecided" about this point, namely 42 (17.65%), the majority of them being youths. Also in the section of those in "agreement" with this point, or "strong agreement", only one adult is found in each of these groups, i.e. 14 youths find it difficult to learn something in the planetarium. Section II/10 of this thesis is devoted to an investigation of the planetarium's teaching effectiveness by conducting tests in the planetarium exclusively with youths.

8.9 The Learning Advantages of the Great Sky Projection.
This statement is in some contrast to statement 8. Participation is slightly higher. The undecided fraction is nearly equal in both questions but the fraction voting negatively is significantly lower in question 9. No one "strongly disagreed", only 6 "disagreed". It implies that everything is well understood and, above this, that everything is easily remembered. The large sky projection is made responsible for this double effect. The vast majority of the planetarium visitors "agrees" to this statement.
8.10 Complicated Astronomical Themes are best learned where?
The question is a difficult one by virtue of the wealth of astronomical subjects it covers. Also the number of those "undecided" is relatively high, namely 41, but a good majority are of the opinion that even difficult subjects, such as quoted in question 10, are better learned in the planetarium than by conventional means.

Later in this thesis it is attempted to establish the value of the planetarium as an educational tool experimentally. However, no attempt is made to compare the planetarium to the classroom in this programme of experimentation. This is explained in detail later in Programme II/10. In this survey, the visitors were invited to compare the two media in 4 of the above 10 questions in the cognitive domain. All 10 questions in the cognitive domain deal with learning, and also question 5 invites a comparison between the planetarium and more conventional means of learning star constellations without expressly mentioning the school classroom. Question 4 involves general learning in comparison to the planetarium without pointing to any particular source or place of this general learning. It is noted that preference is given to the planetarium.

B. The Affective Domain:

The core of the test in the affective domain is the 6 emotional questions contained in the questionnaire-type test instrument. These questions are phrased so as to express successively a rising order of emotional strength. It was expected that the evolving rank order of the responses would develop inversely proportional to this preset order of expressions, which is essentially what took place. There was a slight deviation in as much as question 17 came out one place before question 14, while a reverse order had been expected, according to the weight given to each question. Figure no. 1 presents a graphical display of the test results. See page no. 209.

The same instrument is used in the 5 tests conducted with West German pupils in 2 planetariums. See section II/10. Results are slightly different in these tests, as had been expected. It seemed normal for pupils to rank the question of where to learn astronomy
above any of the other considerations in the list, and thus it was expected that question 11 would be found at rank order place 1, where it actually landed. Results of the tests conducted with pupils will be compared to all those for the non-homogeneous groups of general visitors. (See survey II/10.)

8.11 Preference for the Planetarium.

The planetarium visitor was invited to compare the two learning situations, planetarium and classroom. The question was asked after the planetarium performance. The question was not answered by the full number of participants in the survey but it met with a very strong affirmative response as table no. 9 shows.

Of those not participating in the vote, 4 could be identified as adults to whom the question may not directly apply. Other adults, in contrast, have placed themselves in the role of pupils and participated.

Question 11 should be seen in conjunction with question 15. Did those "undecided" and those that had voted in favour of the classroom regret having gone to the planetarium? None of those "undecided" regretted having gone to the planetarium. The majority objected strongly to the insinuation. One of those in "disagreement" with statement 11 did not vote in row 15 and another one declared his agreement with statement 15, i.e. he was sorry that he had gone to the planetarium. He left the place disappointed. A third one was "undecided" on both issues and explained that the planetarium performance had been too long and that the room was too small for his taste.

The two in "strong disagreement" with point 11 did not regret at all having gone to the planetarium, they strongly objected to question 15. One of them complained that the lecture had gone "too fast" and recommended that the lecturer should "talk a little bit more slowly". The two are youths.

8.12 Boring Monotony.

This question had a very high participation, only 3 abstained from voting.

The planetarium shows after which the test was performed were randomly selected and in no case were they special events offering special attractions of whatsoever sort to the public.
A few of the performances had some additional slides in support of the pure planetarium show, but most of the planetarium performances were conventional astronomical demonstrations. Question 12 attained rank order place 3.

As a supplement to question 12, people were asked, within the additional questions outside of the 20 main questions, whether or not they would like to see a suitable film or more slides to supplement the star spectacle in the planetarium. They were also asked whether they had seen a planetarium performance once or several times before. The majority of the participants had been in the planetarium several times before and many had been there once before, only a few were newcomers. Nearly every participant voted in favour of additional films or additional slides. Combining the answers received for question 12 and the additional supplementary question leads to the conclusion that the wish for additional films or additional slides did not have disappointment with the pure astronomical show as a basis, but must rather have been caused by the desire of widening and supplementing the planetarium experience. Viewing questions 14, 15 and 17 in this context gives additional emphasis to the conclusion drawn.

8.13 Increased Interest in Astronomy.

This is a most interesting question, since the planetarium had been created in order to satisfy an existing appetite for astronomical information on part of the general public and students. It has also been argued many times that the planetarium has the capacity of creating an interest in this dignified science. While question 1 in general and question 11 in particular dealt with the first purpose of the planetarium, question 13, directly and in a straightforward manner, invites the visitors to fix their standpoint towards the second purpose of the planetarium. When reading the answers it must be taken into consideration that only a few newcomers are among the participants in the test. All the others have had previous planetarium experiences. 2/3 of the visitors confirmed statement 13, but the fraction in simple "agreement" was stronger than the fraction in "strong agreement". Still, it seems from various telephone conversations conducted with West German planetarium directors that they are highly satisfied with this result.
8.14 **An Elevating and Marvellous Experience.**

This question appeals predominantly to the aesthetic side of the planetarium's performance and the wording was chosen accordingly.

Only 1 vote each in the "disagree" and "strongly disagree" cells stems from large planetariums, the rest come from small planetariums. Roughly 2/3 of the votes in the "undecided" cell come from small planetariums and only 1/3 from the large planetariums although, in the group of the very enthusiastic which voted for "strong agreement", the large planetariums do slightly better than the small planetariums. From this comparison it can be seen that the planetarium performance seems to be experienced with a stronger aesthetic component in the large planetariums than in the smaller planetariums. This may be due to the larger size dome, the much higher number of stars, the more dramatic star presentation and the greater versatility of the equipment, even at a loss of contact with the lecturer. Point 14 attained place 16 in the rank order.

8.15 **Regretting the Visit to the Planetarium.**

This statement met with a vivid protest. Question 15 keeps rank order place 1, and it can be concluded that by far the vast majority of planetarium visitors had no regrets at having gone there. It must be noted that various planetariums, both large and small, had participated in the survey and that the planetarium shows were randomly selected. The result seems, therefore, to be representative.

8.16 **Distracting Disturbances in the Planetarium.**

Several planetarium professors had complained about this very point and some of the culprits had admitted such practices in the personal interviews during the pilot survey. The anonymity of the dark planetarium chamber may be felt by some of the younger students to be a very tempting opportunity for playing pranks. The point, however, seems to be a minor one as it attained rank order place 9.
8.17 Bringing Friends and Family to the Planetarium.
Did the visitors like the planetarium performance and the planetarium institution to the extent that they felt induced to bring their friends and relatives?
Participation in the question was quite strong, only 3 refrained from voting. In point 17 the indirect method of questioning is used and about 3/4 of the participants express in this way that they like the planetarium and the planetarium performance.

8.18 The Planetarium as a Model of the Real Sky.
Does the general public accept the illusion of reality which the planetarium offers? This question becomes critical when small planetariums are involved, and the majority of the respondents have participated in this test after visiting a small planetarium. Still, the vast majority accepts the planetarium as an illusion of reality and thus confirms the principle technical feature of the planetarium.

8.19 A Study of the Real Sky is preferable to the Planetarium Simulation.
Questions 19 and 18 belong closely together. Both met with very similar responses and participation was nearly the same. Altogether more than 85% disagreed with the statement and the comments given to this statement point to "unfavourable meteorological conditions" and to the unfavourable scenery of a big town". The planetarium is preferred.

8.20 A General Enthusiasm for the Planetarium.
This is a rather audacious statement, not only asking the participant to confirm his like or dislike but to acknowledge his outspoken enthusiasm, not only for himself but at the same time for the whole audience.
Not very many people felt able to comment for others, nor did they feel able to join in a statement of enthusiasm. Question 20 had the lowest participation.
In the brackets of "strong disagreement" and "disagreement" the juvenile visitors are very highly represented and even in the "undecided" cell their representation is disproportionally high. Seeking the distribution of the negative voices between large and small planetariums, one finds only 1 vote in "strong disagreement" in one of the large planetariums and 6 in "disagreement". The result meets with expectations; the larger planetariums with their greater versatility, greater dome, much higher number of stars and higher number of events that can be displayed, and maybe also with their better quality of the overall starfield tend to stimulate a higher degree of positive attitude reactions in the visiting public. The smaller planetariums seem to be a little less favoured in this particular respect.

C. The General Comments:

The main complaint received about the planetarium deals with the seating arrangement. A flat-floor conventional planetarium with a dome several meters above the audience enforces an unnatural viewing position. (This has been the problem in many planetariums around the world ever since planetariums exist. It seems that the hyposphere inclined dome planetarium with mono-directional seating and the resulting much better vision for the audience has overcome this problem.)

The second point troubling the public is the method of lecturing. Only 1 respondent was not satisfied with the amount of learning offered, several found the demonstration too fast and the material offered too voluminous. Participation in the test was very vivid and gave the impression that the public welcomed the opportunity of having their say about their planetarium experience and their feelings towards the planetarium.

9. Summary and Evaluation:

The attitudes of planetarium visitors in West Germany were tested with 10 questions in both the cognitive and affective domains. The questions in the cognitive domain involved the idea of learning in the planetarium in general and in addition some specific themes of planetarium demonstrations were mentioned. Visitors were asked to compare the planetarium to other media teaching situations.
This was done for two reasons: (1) To many people it seems to be easier to express their preference for a certain thing by comparing it to an alternative choice. This seems to facilitate the articulation of their feelings and convictions. It was therefore expected that this form of questioning would provide for a broader spectrum of opinions and would result in a high N-number of participation. This latter expectation is marred by the low participation in the complicated and overloaded question 10, while holding true for the rest of the relevant questions.

(2) It was expected that the general planetarium visitors would confirm on grounds of their personal experiences some essential points of planetarium learning, as were established in the framework of survey II/4. (3) This goal has, in fact, been amply achieved. Teachers could not be asked these questions in the preceding survey with the schools (II/5) as teachers have no planetarium teaching experience; reliance is therefore made on the planetarium visitors' judgements.

The majority (2 &11) prefer the planetarium to the classroom, even as it was asserted that the large amount of mathematics involved in the study of astronomy would render the classroom a better place to learn.

94.24% of the visitors prefer the planetarium for topics requiring spatial conception, and 87.61% of the visitors favour the planetarium for studying the topics of celestial coordinates and reference points. 94.24% learn star configurations rather in the planetarium than by mere slides or pictures and 72.10% of the visitors prefer the planetarium to other media for learning the more complicated themes of astronomy. 86.55% of the visitors sum up their planetarium experience in expressing their general preference of the planetarium to the classroom (question 11).

In the affective domain a test instrument has been constructed which provides for a fine grid for measuring attitudes. Figure no. 1 illustrates graphically how the value of the relative percentage scores decreases more or less proportionally to the questions' gain in emotional strength as indicated by rising rank order numbers which signify falling rank order positions as the scale is counted downwards from 1 to 10. A very strong attitude in favour of the planetarium was measured.
In the affective domain one additional question compared the planetarium to the classroom teaching situation, but all other questions dealt with the scale of feelings that the planetarium and the planetarium performance induced in the visitors.

Small and large planetariums were involved. Adult and younger visitors were tested. The younger visitors proved to be partly more critical, partly less sure about their convictions and impressions. The general public's attitude towards the planetarium is a very favourable one.

**Educational Value:**

When seeking a definition for educational value for the planetarium by the relevant study II/4, the question was asked as to how the planetarium's value is rated in the opinion of those concerned with it.

This question has been positively answered by the planetarium visitors, tentatively by a smaller sample from the international scene, and in more definite terms by a larger representative sample of the scene in West Germany.

The visitors' opinions are in favour of the planetarium and will definitely not impede its more widespread use. The visitors' opinion must consequently be eliminated as being a possible cause for the underuse of the planetarium.

10. **Conclusion:**

The mean of the opinion test in the cognitive domain amounts to 41.01 (=82.03%) and to 40.59 (=81.18%) in the attitude test of the affective domain, the latter describing a "very strong attitude" towards the planetarium according to a scale of definition explained later in this thesis in section II/10 "Tests in the Planetarium". Applying the same scale to the opinion test in the cognitive domain, a "very strong" favourable opinion about the educational efficiency (value) of the planetarium is found.

Planetarium visitors have confirmed the findings of survey II/4 with regard to the planetarium's intrinsic value in teaching specific astronomical themes.
Planetarium visitors prefer the planetarium as an instrument of learning in their majority and show a favourable attitude towards the planetarium. Planetarium visitors value the planetarium highly in both the cognitive and the affective domain in terms of the 20 questions posed. Visitors have also exhibited criticism on isolated features or functions or the individual performances.

The results of this survey widely refute the operational hypothesis that guided this investigation and widely support that part of the general hypothesis saying planetariums are believed to be educationally valuable teaching tools in terms of the test instrument applied.

11. Implication:

Justification for the Planetarium's Existence and Use:

As the planetarium is accepted by its audiences of general visitors, which include a high number of students, as being a valuable place for learning and erudite entertainment, its existence and its use seem fully justified on these grounds alone. This justification is independent of whether or not media research may produce different conclusions (see survey II/3/4). Moreover, the methods of media research could be questioned if its results were so much opposed to reality. It is difficult to conceive why any negative findings of research on the value of media use should not have manifested themselves in any measurable observations of any negative reactions of the public like staying away from the planetarium. This, however, could only be noted where the performances are continually dull and uninspiring. (Cases known to the author cannot be quoted for ethical reasons.) Otherwise, the planetariums in West Germany (and elsewhere) are much in demand. The long daily queue in front of the Stuttgart planetarium is only one example of many. German media research seems in conformity with planetarium reality, whereas USA media research casts doubt on its value.

In the light of the above, the question of why so few planetariums are in existence in West Germany becomes more intriguing as one strong factor, "the public's preferences", is eliminated as being a possible cause for the underuse of the planetarium.
12. **Outlook:**

Visitors' opinions do not articulate themselves in any organized form audible to decision makers in the budget funding agencies. Visitors' opinions will have to be measured (as in the framework of this thesis, f.i.) by some interested party and to be brought to the knowledge of decision makers, if more planetariums are the goal.

While it is true that visitors' opinions about the planetarium's educational and cultural value will certainly not be an impeding factor for the more widespread use of the planetarium, these positive opinions will remain a dormant and inactive force until mobilized by some interested party. It cannot be expected that the visitors themselves will become active and organized, as they do not form a socially definable body of any sort.

Later in this thesis it will be investigated how strong a fraction of the society can be counted as planetarium visitors and only then shall we see how strong and how weighty the potential lobby of planetarium visitors could be. (See survey III/4)

For our present purpose it suffices to have measured the opinions and attitudes of a representative sample of planetarium visitors in order to test the hypothesis with regard to the educational value of the planetarium as is being believed in by general planetarium visitors.

In the following survey II/7, astronomers in West Germany are interviewed for their opinions and their assessment of the planetarium's educational value.
SURVEY WITH PLANETARIUM VISITORS IN WEST GERMANY

Attitude Test — Affective Domain

6 Emotional Questions

Summary

This figure is related to table number 9. It demonstrates graphically the diminishing value of the relative percentage score as being dependent on an increase in the questions' emotional strength, indicated by falling rank order places. A negative correlation between these two variables is represented by the resulting regression line.
"GERMAN ASTRONOMERS MAY BE CRITICAL OF THE PLANETARIUM AS HAVING MUCH EDUCATIONAL POTENTIAL AND AS BEING REALLY AN EDUCATIONALLY VALUABLE TEACHING TOOL"

A Survey Conducted with West German Astronomers

1. Introduction:

In addition to the data derived from the opinions and attitudes collected and evaluated from other groups in the course of the investigations made on the planetarium, for completeness' sake the voices of the astronomers must be taken into consideration. It is their domain that is concerned when investigating the educational potential and value of the very tool intended for the dissemination of the facts and figures, theses and hypotheses of the science of astronomy.

2. Theme and Purpose:

The theme of this report is an investigation of the opinions and attitudes held by astronomers with regard to the educational potential and value of the planetarium. The purpose of the survey conducted with these astronomers was to seek support or refute for that part of the general hypothesis which says that planetariums are educationally valuable teaching tools. Also confirmation for survey II/4 is sought.

3. Methodology:

The relevant part of the general hypothesis has been operationalized by constructing the operational hypothesis printed at the head of this report. The survey conducted was guided by this operational hypothesis, which was put to the test by means of a questionnaire containing each 16 questions in both the cognitive and affective domains. Question no. 16 in the cognitive field, dealing with the number of planetariums available in West Germany, was also intended to serve survey no. III/1 of this thesis. An additional 17th question is included in each field which serves survey no. II/2 in this thesis. A descriptive survey has been conducted delivering the data for the analyses intended.
The questionnaires were designed in the form of Lickert scale tables with 5 columns. All questions were direct in character and most of them were phrased positively. In this the usual rules of questionnaire design with an equal mixture of questions phrased partly positively and partly negatively have been intentionally violated. It was feared that the highly educated and highly critical population of this survey could have felt themselves to have been manipulated by a questionnaire of strongly polarized questions and thus be induced to refrain from participation.

Conditions prevailing in the USA have been used for providing a meaningful comparison, basing in this on the separate survey conducted with a population of professors in the USA.

4. Population:

Table no. 29 on page 537 supplies a review of the size of the astronomical community in West Germany. There is a total of approximately 300 astronomers working in 20 different universities and other research institutions. 60 of them were approached with the questionnaire and 53 responded. 51 of the questionnaires returned were usable for evaluation, i.e. 85%; 2 respondents excused themselves.

Eminent professors of prominent institutes of international repute, such as the various Max-Planck-Institutes of Astronomy, and of old established universities have participated in the survey. Astronomers seem a priori unbiased towards the planetarium as their interests in instruments lies elsewhere, in the domain of telescopes etc.

5. Procedure:

60 names and addresses in West Germany were randomly selected from astronomical journals, describing the publications of the population selected or their participation in scientific conferences. Letters were sent inviting their participation in the first survey of this kind ever conducted in West Germany. The questionnaires were sent with these letters of introduction, and each lot was accompanied by a self-addressed stamped envelope for the reply.

1) See Oppenheim, A.N. "Questionnaire Design and Attitude Measurement". OU setbook 1966, page 133.
6. **Rationale of the Questions:**

The questions posed contain the stock of argumentation that the author had found in the relevant literature and that formed the gist of so many conversations and interviews conducted in the framework of the other programmes. In formulating the questions of the affective domain the author based on his own observation and experience with planetarium audiences and on advice given by planetarium teachers and descriptions of planetarium performances. Questions were not weighted according to any system of relative importance.

Form and content of planetarium teaching/learning are covered and comparison to other media is invited. Student's possible emotional reactions were envisaged in the affective domain. It was attempted in this way to ensure **validity**. Reliability of the test instrument is assumed, as it is difficult to conceive different answers from this critical academic sample if the same questionnaire were to be presented a second time. Par. 9 discusses consistency as a test for reliability.

7. **Limitation:**

A limitation has to be made in accepting the answers given: none of the respondents teaches in a planetarium, and none of them claims to have ever taught in a planetarium. The planetarium experience is therefore a passive one for all respondents. The judgements passed are in no case based on experimentation and none of the respondents makes reference to any literature. Answers given were thus entirely based on intuition and also on observation and experience according to whatever amount of passive experience was available to the respondent. Nevertheless, all respondents do know the planetarium and its potentials and felt competent to treat the subject, but they showed reservations where planetarium teaching experience was required.

8. **Findings:**

Reference is made to the 2 following tables which contain questions and answers in the usual manner followed in these texts.
### TABLE 10 A

**THE EDUCATIONAL VALUE OF THE PLANETARIUM**

Survey held with the Professors, Lecturers and Research Staff of Astronomical Institutes in West Germany

(A) **Cognitive Domain**

Questionnaire translated from the German Original

<table>
<thead>
<tr>
<th>No.</th>
<th>Questions Posed</th>
<th>Rank</th>
<th>Score</th>
<th>Strongly Agree</th>
<th>Agree</th>
<th>Undecided</th>
<th>Disagree</th>
<th>Strongly Disagree</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>The Planetarium simulates nature better than any other educational medium.</td>
<td>8</td>
<td>199</td>
<td>11</td>
<td>29</td>
<td>7</td>
<td>3</td>
<td>1</td>
</tr>
<tr>
<td>2</td>
<td>Planetarium Demonstrations are highly instructive.</td>
<td>2</td>
<td>216</td>
<td>16</td>
<td>31</td>
<td>4</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>3</td>
<td>Planetarium Demonstrations are too technical and hence of low educational value.</td>
<td>4</td>
<td>206</td>
<td>0</td>
<td>1</td>
<td>5</td>
<td>36</td>
<td>9</td>
</tr>
<tr>
<td>4</td>
<td>The dramatic presentation in the Planetarium simplifies the learning of difficult themes.</td>
<td>12</td>
<td>182</td>
<td>4</td>
<td>27</td>
<td>14</td>
<td>6</td>
<td>0</td>
</tr>
<tr>
<td>5</td>
<td>Constellations are best learned in the planetarium.</td>
<td>13</td>
<td>180</td>
<td>8</td>
<td>16</td>
<td>22</td>
<td>5</td>
<td>0</td>
</tr>
<tr>
<td>6</td>
<td>The Planetarium Demonstration will help to overcome difficulties in spatial conception.</td>
<td>5</td>
<td>204</td>
<td>11</td>
<td>31</td>
<td>7</td>
<td>2</td>
<td>0</td>
</tr>
<tr>
<td>7</td>
<td>Only the Planetarium can demonstrate the full starry spherical sky in realistic motion. Films could only show sections.</td>
<td>1</td>
<td>222</td>
<td>26</td>
<td>19</td>
<td>4</td>
<td>2</td>
<td>0</td>
</tr>
<tr>
<td>8</td>
<td>Space travel can be demonstrated particularly convincingly in the Planetarium.</td>
<td>15</td>
<td>168</td>
<td>6</td>
<td>17</td>
<td>15</td>
<td>12</td>
<td>1</td>
</tr>
<tr>
<td>9</td>
<td>Kepler’s Laws, the coordinate system, astrometric subjects, galaxies; all can be very effectively demonstrated in the Planetarium.</td>
<td>9</td>
<td>193</td>
<td>14</td>
<td>22</td>
<td>8</td>
<td>4</td>
<td>3</td>
</tr>
<tr>
<td>10</td>
<td>The Planetarium is distinctly superior to other teaching media like blackboards, charts and globes in the field of descriptive astronomy.</td>
<td>7</td>
<td>200</td>
<td>13</td>
<td>25</td>
<td>9</td>
<td>4</td>
<td>0</td>
</tr>
<tr>
<td>11</td>
<td>A well constructed Planetarium projector permits exact astrometric measurements for student’s exercises. This gives it a high didactic value.</td>
<td>16</td>
<td>153</td>
<td>1</td>
<td>16</td>
<td>20</td>
<td>10</td>
<td>4</td>
</tr>
<tr>
<td>12</td>
<td>It is expected that a lesson learnt in the Planetarium will be better retained than the same lesson learnt in the classroom.</td>
<td>10</td>
<td>189</td>
<td>5</td>
<td>29</td>
<td>14</td>
<td>3</td>
<td>0</td>
</tr>
<tr>
<td>13</td>
<td>The teaching effect of the Planetarium will be enhanced if it is equipped for multimedia functions.</td>
<td>11</td>
<td>185</td>
<td>1</td>
<td>33</td>
<td>14</td>
<td>3</td>
<td>0</td>
</tr>
<tr>
<td>14</td>
<td>The School Planetarium may also advantageously be utilized for other disciplines like Physics, Mathematics, Geography.</td>
<td>14</td>
<td>179</td>
<td>2</td>
<td>28</td>
<td>15</td>
<td>6</td>
<td>0</td>
</tr>
<tr>
<td>15</td>
<td>I like to recommend the Planetarium for use in schools.</td>
<td>6</td>
<td>201</td>
<td>12</td>
<td>28</td>
<td>7</td>
<td>4</td>
<td>0</td>
</tr>
<tr>
<td>16</td>
<td>There is not a sufficient number of Planetariums in use in West Germany.</td>
<td>3</td>
<td>214</td>
<td>19</td>
<td>24</td>
<td>7</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>17</td>
<td>The Planetarium is of no advantage for students of university level.</td>
<td>167</td>
<td>16</td>
<td>14</td>
<td>11</td>
<td>16</td>
<td>8</td>
<td></td>
</tr>
</tbody>
</table>

Questions 1 - 16: (Question 17 serves a different purpose and is therefore not counted here.)

- **Actual Total Score**: 3.091
- **Possible Maximum Score**: 4.080
- **Actual Mean**: 60.61 (75.75%)
- **Maximum Mean**: 80.00

Please name additional arguments in favour or against the educational value of the Planetarium in the cognitive domain.
Survey held with the Professors, Lecturers and Research Staff of Astronomical Institutes in West Germany

### (B) Affective Domain

<table>
<thead>
<tr>
<th>No.</th>
<th>Questions Posed</th>
<th>Rank Order</th>
<th>Score +5,4,3,2,1 -1,2,3,4,5</th>
<th>Strongly Agree</th>
<th>Agree</th>
<th>Undecided</th>
<th>Disagree</th>
<th>Strongly Disagree</th>
</tr>
</thead>
<tbody>
<tr>
<td>1)</td>
<td>The majority of pupils may tend to: .................................................................................................................................................................................................</td>
<td>1</td>
<td>102</td>
<td>228</td>
<td>26</td>
<td>23</td>
<td>2</td>
<td>0</td>
</tr>
<tr>
<td>2)</td>
<td>..............................................................................................................................................................................................................................</td>
<td>8</td>
<td>102</td>
<td>186</td>
<td>4</td>
<td>28</td>
<td>16</td>
<td>3</td>
</tr>
<tr>
<td>3)</td>
<td>..............................................................................................................................................................................................................................</td>
<td>6</td>
<td>102</td>
<td>193</td>
<td>6</td>
<td>29</td>
<td>15</td>
<td>1</td>
</tr>
<tr>
<td>4)</td>
<td>..............................................................................................................................................................................................................................</td>
<td>14</td>
<td>102</td>
<td>177</td>
<td>2</td>
<td>26</td>
<td>18</td>
<td>4</td>
</tr>
<tr>
<td>5)</td>
<td>..............................................................................................................................................................................................................................</td>
<td>7</td>
<td>102</td>
<td>189</td>
<td>3</td>
<td>33</td>
<td>12</td>
<td>3</td>
</tr>
<tr>
<td>6)</td>
<td>..............................................................................................................................................................................................................................</td>
<td>12</td>
<td>102</td>
<td>182</td>
<td>6</td>
<td>24</td>
<td>15</td>
<td>5</td>
</tr>
<tr>
<td>7)</td>
<td>..............................................................................................................................................................................................................................</td>
<td>11</td>
<td>102</td>
<td>183</td>
<td>0</td>
<td>4</td>
<td>16</td>
<td>28</td>
</tr>
<tr>
<td>8)</td>
<td>..............................................................................................................................................................................................................................</td>
<td>16</td>
<td>102</td>
<td>145</td>
<td>1</td>
<td>15</td>
<td>26</td>
<td>9</td>
</tr>
<tr>
<td>9)</td>
<td>..............................................................................................................................................................................................................................</td>
<td>13</td>
<td>102</td>
<td>178</td>
<td>2</td>
<td>28</td>
<td>14</td>
<td>7</td>
</tr>
<tr>
<td>10)</td>
<td>.............................................................................................................................................................................................................................</td>
<td>9</td>
<td>102</td>
<td>184</td>
<td>1</td>
<td>3</td>
<td>12</td>
<td>34</td>
</tr>
<tr>
<td>11)</td>
<td>.............................................................................................................................................................................................................................</td>
<td>10</td>
<td>102</td>
<td>184</td>
<td>0</td>
<td>5</td>
<td>11</td>
<td>34</td>
</tr>
<tr>
<td>12)</td>
<td>.............................................................................................................................................................................................................................</td>
<td>4</td>
<td>102</td>
<td>199</td>
<td>1</td>
<td>0</td>
<td>8</td>
<td>36</td>
</tr>
<tr>
<td>13)</td>
<td>.............................................................................................................................................................................................................................</td>
<td>15</td>
<td>102</td>
<td>166</td>
<td>1</td>
<td>23</td>
<td>17</td>
<td>8</td>
</tr>
<tr>
<td>14)</td>
<td>.............................................................................................................................................................................................................................</td>
<td>3</td>
<td>102</td>
<td>202</td>
<td>8</td>
<td>36</td>
<td>4</td>
<td>3</td>
</tr>
<tr>
<td>15)</td>
<td>.............................................................................................................................................................................................................................</td>
<td>2</td>
<td>102</td>
<td>207</td>
<td>12</td>
<td>30</td>
<td>9</td>
<td>0</td>
</tr>
<tr>
<td>16)</td>
<td>.............................................................................................................................................................................................................................</td>
<td>5</td>
<td>102</td>
<td>197</td>
<td>7</td>
<td>31</td>
<td>12</td>
<td>1</td>
</tr>
<tr>
<td>17)</td>
<td>For the university level of education the Planetarium is less attractive. .........................................................................................................................................................</td>
<td>151</td>
<td>102</td>
<td>189</td>
<td>3</td>
<td>33</td>
<td>12</td>
<td>3</td>
</tr>
</tbody>
</table>

Questions 1 – 16: (Question 17 serves a different purpose and is therefore not counted here.)

- Actual Total Score: 3,000
- Possible Maximum Score: 4,080
- Actual Mean: 58.82 (73.53%)
- Maximum Mean: 80.00

Open Question:

Please name additional arguments in favour or against the educational value of the Planetarium in the affective domain.

**Summary**

A sample size of N = 51 out of a population of 60 West German astronomers participated in a survey on the educational value of the Planetarium. Questions involving practical teaching experience drew the largest "undecided" votes, as astronomers in West Germany — as a rule — do not teach in Planetariums. Bearing this diminishing factor in mind, results support the hypothesis that the Planetarium is an educationally valuable teaching tool in terms of the questions posed.
9. Discussion and Evaluation:

Consistency

5 of the questions in table 10 A deal with the learning effect in the planetarium, 4 questions deal with teaching astronomical themes of the school curriculums already treated in survey II/4, 3 questions deal with the equipment's potentials, and 3 questions compare the planetarium to conventional media.

For the general visitors of survey II/6 planetarium learning was a clear-cut affair producing consistent answers in a logical sequence as one indication of reliability. Astronomers' behaviour is more complicated with less obvious consistency in their answers. A rather low percentage of the participants judges the teachability of the given astronomical themes as being positive, most are undecided and a very few object. The span amounts to (11) = 33.33% and (9) = 70.58%, i.e. 37.25%. A similar span holds true for the questions concerning the learning effect: (4) = 60.78% and (2) = 92.16%, i.e. 31.38%. This latter group of questions draws the positive agreement of a much larger percentage of the participants. Some internal consistency becomes visible in the affective domain, i.e. the answers to questions 9, 10 and 11. Some external consistency is visible in the cognitive domain when comparing the related questions of table 10A to those of table 9A (the visitors survey): i.e.(2)=92.16% and (1)=95.47%, (5)=92.15% and (5)=94.25%, (9)=70.58% and (10)=72.10% respectively. The other pairs of related questions in the 2 tables show a lower degree of positive correlation, i.e.(4)=60.78% and (3)=74% ;(6)=82.35% and(3)=94.23% , and(12)=76.47% and(9)=80.65%.

Later in these texts an attempt is made to account for the relatively low rate of agreement shown in the answers to the educational questions. As consistency in the answers is not very strongly pronounced, it is difficult to make it a strong factor in measuring reliability. The measuring instrument is not sufficiently diversified to probe into the sub-structure underlying the very differentiated pattern of answers supplied by the astronomers.
9.1 Cognitive Domain:

9.1.1 The first question states that the planetarium simulates nature better than any other teaching medium. Some respondents have corrected the sentence and replaced "nature" by "night sky", or added the adjective "extra-terrestrial" as qualifying "nature".

9.1.2 The next statement says that the planetarium fulfils its functions in a highly instructive way. Some astronomers, however, remarked that the degree of instructiveness of the performance depended on the quality of the teacher.

9.1.3 Planetarium demonstrations are of low educational value because they are too technical. The vast majority of the respondents did not accept this statement.

9.1.4 Point 4 says that the dramatic presentation of the subjects taught in the planetarium facilitates the learning of difficult themes. This statement sums up the experience of many planetarium teachers interviewed. Many are "undecided". Discussing this question would involve a study of the different types of learners and the different styles of teaching appealing to them. L.J. Cronbach, a recognized authority in the art of teaching, says "What is dramatically presented is well learned". (2)

9.1.5 Lectures on star constellations as seen by various peoples and various cultures belong to every planetarium programme, and this particular type of lecture is one of the public attractions of the planetarium. This is known from obser-

vation and experience and from studying printed programmes of planetarium performances. Statement 5 deals with this point and asserts that constellations are best learned in the planetarium. Not all astronomers agreed. One assistant professor asks: "Why should one learn constellations? They may be quite nice (to look at), but they will in no way promote understanding of astronomy!" This statement is difficult to accept. The identification of star constellations is one of the very early topics taught to all novices of astronomy, and the topic fills chapter after chapter of books of introduction to basic astronomy.

9.1.6 Point 6 deals with the advantages that the planetarium offers in teaching certain subjects which entail difficulties in spatial conceptions, a domain in which the planetarium is generally rated superior to other means of learning.

It requires a certain inborn talent in a student for him to be able to transform a flat drawing into a 3-dimensional concept. School books on astronomy, spherical trigonometry, and astronomical navigation contain quite a number of drawings intended to enable a student to understand the concept of a sphere with its coordinates, reference grids and such notions as an azimuth angle. In the study on the planetarium's intrinsic value (II/4) much attention has been given to this particular feature of the planetarium's potentials and functions.

J.M. Chamberlain writes in his article on planetariums in the USA (3) how the difficulties in drawing spherical configurations on a flat blackboard - in an attempt to make his students understand special themes of astronomy - converted him eventually into a confessed planetarium user.

In the planetarium the flat projection itself is - due to an optical illusion - experienced as 3-dimensional, as has been pointed out before. The vast majority agreed to point 6.

9.1.7 Point 7 has been mentioned to supplement point 1 in a more specific way. It asserts that only the planetarium will demonstrate the full starry spherical sky in realistic motion, in comparison to films that can show only sections of the sky. Still, 2 respondents "disagreed" and 4 were "undecided".

9.1.8 Point 8 of the cognitive table says that the planetarium can demonstrate space travel. This must be explained:

ZEISS have modernized their large planetarium projector in many notable ways; especially, it can be used for simulating space travel. When equipped with a 4th axis the projector can even show any possible course of a space vehicle. (4)

SPITZ have built their STP planetarium projector especially for simulating space travel effects, i.e. roll, pitch and yaw of a space ship, and the SPITZ STS projector has been built to take an audience 100 astronomical units away from the earth into space with a very realistic space travel simulation effect. As has been confirmed by the director of the first STS space theatre planetarium in a private correspondence, many people came to experience this very effect.

Only one large planetarium in Germany is equipped with the necessary functions to demonstrate space travel, so it is small wonder that many of the astronomers have no knowledge of this possibility, as is reflected by the large "undecided" section.

9.1.9 Point 9 sums up a few topics of more sophisticated themes found in planetarium programmes. Planetarium lecturers claim that their institutions are particularly suited to teach such themes advantageously, but some astronomers object.

9.1.10 Point 10 compares the planetarium in its particular domain, descriptive astronomy, to the classical media, like blackboard, charts, globes, and it is asserted that it is definitely superior as a teaching tool. Most of the astronomers agreed.

9.1.11 The next point was a difficult one for astronomers without planetarium teaching experience. The statement says that a particular didactic value of the planetarium was found in the fact that it allowed exact astrometrical measurements to be taken as part of a student's exercise.

In fact, not very many planetariums in Germany may be used in this way, with the exception of the 4 planetariums owned by the naval colleges.

Prof. Dr. Arthur Young of San Diego State College published several years ago a paper on "Quantitative measurements and demonstrations in the planetarium" (5). He described a series of lectures and exercises devised by him for the very purpose of taking measurements in the planetarium.

There exists a number of other articles on the same subject (6), but all of them appeared in the USA where the planetarium is a much more widespread teaching medium. The author knew that the question was a risky one to ask the West German astronomers and, knowing that experimentation would scarcely be available, the intention was to obtain nothing more than an opinion as to the planetarium's worth in one more critical domain. Results met with expectations. Only 17 (=33.33%) agreed.

9.1.12 The next point deals with the question of whether a planetarium demonstration provides for better retention on part of the pupil than ordinary classroom teaching. This is a claim frequently made by planetarium promoters. In the absence of any systematic investigation and - as a rule - not even experience, not more than an intuitive guess could be expected from the respondents. Still, the majority "agreed".

(5) Arthur Young "Quantitative measurements and demonstrations in the planetarium", San Diego College, Year?

(6) f.i. Caroline Bolognese, "Schools Planetarium Really a Laboratory", article in "TODAY'S POST", USA, June 14, 1977.
9.1.13 In point 13 the expectation is expressed that multimedia equipment installed in a planetarium would enhance the learning effect.

Among the first additional equipment installed in a planetarium was the sound system and a slide projector which introduced the development to today's automated system. It is known that the debate on the educational value of modern audiovisual media is still open. Numerous theses and dissertations written in the USA have come to the conclusion that modern audiovisual equipment does not enhance the learning effect, and neither deepens understanding nor promotes retention of the subject taught (7). See survey II/4.

All the planetariums in West Germany are of the conventional design with circular concentric seating arrangements. This means that slides or films are visible to only half the audience. Even assuming that this limitation is known to the astronomers, 2/3 of them "agreed" with the statement. (Erkrath, near Duesseldorf, West Germany, will by the middle of 1980 have the first unidirectional multi-media planetarium in West Germany.)

9.1.14 Statement 14 relates to other uses of the planetarium, saying that it could also be used with advantage for the disciplines of physics, mathematics, geography, etc. These supplementary uses of the planetarium are well-known in the planetarium world, and many school programmes, especially in the United States, give evidence of such additional uses of the planetarium. In Germany, where only a few planetariums are in use, they seem to be predominantly reserved for their original purpose of astronomy. Hence only 30 (=58.82%) "agreed."

9.1.15 Recommending the planetarium for school use indicates the astronomers' opinion of the educational value of the planetarium for the schools in the cognitive domain.

The study is summed up with the decisive question of whether or not the respondents could recommend the planetarium for school use. Nearly 80% of the respondents "agreed" to this.

9.1.16 The number of Planetariums in West Germany is not sufficient. 84.31% of the respondents "agreed," which in the given context can be interpreted as an expression of their regret and an indirect support for the installation of more planetariums in West Germany.

9.2 Additional comments made by the Astronomers in the Cognitive Domain

The following lists the respondents' comments given in the cognitive domain on the planetarium as an educational tool.

9.2.1 Only if the school already has an observatory, or an astronomical telescope, can the planetarium be recommended (as an additional piece of equipment).* The use of a telescope promotes the understanding of astrophysics better than a planetarium can. Recommendation made: "undecided".

9.2.2 A planetarium could be of advantage to familiarize an audience with the solar system and its planets. This also touches on other disciplines such as meteorology, planetary geology and extraterrestrial physics, and would be in direct relationship to space travel and the planetary exploration carried out by NASA and ESA, including studies of the earth from space. Recommendation made: "strongly agreed".

9.2.3 The planetarium does not replace nature. The planetarium should supplement conventional classroom teaching. Planetarium performances should not be overloaded with the displaying of special effects, as this prevents quiet understanding and realisation of subjects posed. Recommendation given: "agreement".

* Footnote: Insertion in brackets by the author
9.2.4 The planetarium is, without reservation, a beautiful institution - as long as one does not have to worry about the purchasing price and running costs. Recommendation given: "agreement".

9.2.5 As an alternative to the school planetarium, one should think of a school observatory. When thinking of using the planetarium for other disciplines, then the large public planetarium will do a better job. Recommendation made: "agreement".

9.2.6 The relationship between astronomy and daily life is best demonstrated in the planetarium. Recommendation made: "agreement".

9.2.7 The school planetarium requires, of necessity, that a special well trained teacher is available as a demonstrator. Recommendation made: "strongly agreed".

9.2.8 If the school wants to do something special for astronomy, it should think of buying a telescope and not an unreasonably expensive planetarium. By using a telescope (approx. DM 8,000.-- will buy a very reasonable one), astronomy would be learned more easily as active participation is required. Recommendation made: "disagreement".

9.2.9 Student exercises using a telescope under the free sky are recommendable. Recommendation made: "agreement".

9.2.10 I should be glad if my (university) * students could visit a planetarium. Recommendation made: "strongly agreed".

* Footnote: Insertion in brackets by the author
9.2.11 It does not pay to install a school planetarium for a single school when considering the high costs and the relative low frequency of use (for a single school). It would therefore be more sensible to install a central planetarium in larger cities. Recommendation made: "agreement".

9.2.12 Planetariums are expensive and sophisticated instruments. I believe that learning would be more enhanced by using a school telescope. Recommendation made: "undecided".

9.2.13 The alternatives determining the success of learning are not planetarium versus classroom teaching but large group versus small group. The small group has the learning advantage and it does not matter whether they are taught in a classroom, in the planetarium, under the free sky or in an observatory. Surely the planetarium can deepen understanding but only if basic knowledge has been acquired elsewhere. Recommendation made: "undecided".

9.2.14 The planetarium is an excellent teaching aid to demonstrate mechanical sky conditions and celestial events. This educational medium is of exceptionally high didactic value for the high school as well as at the university level. Recommendation made: "strongly agreed".

9.2.15 The planetarium is, for the promotion of astronomical knowledge in public education, undoubtedly of high value. The planetarium is less suitable for teaching astrophysics. It is more recommendable to teach this subject by using a small school telescope. A planetarium may be used to prepare for direct stellar observation, but it cannot replace direct observation. Each school should possess a telescope. Recommendation made: "agreement".
9.2.16 The planetarium is exceptionally suitable in overcoming difficulties in spatial conceptions. According to my own experience, this is of immense importance. Especially the conception of solar and moon eclipses suddenly became clear to me when I visited (as a high school student) a planetarium. Recommendation: "agreement".

9.2.17 The following comment comes from an astronomer who proves himself to be undecided on 10 different points in the cognitive domain and 11 points in the affective domain. He is, incidently, strongly in favour of the planetarium at the university level in the cognitive as well as in the affective domain, but cannot make up his mind about recommending it at the school level. His comments are summarized as follows:

The planetarium could be a very valuable and advantageous teaching medium (irreplaceable) in teaching many astronomical problems. My indecision in answering so many questions is based on my conviction that by far the majority of teachers and planetarium lecturers are didactically not qualified to present an attractive and informative demonstration that can be understood by all. I am very much in favour of the planetarium but I think it is indispensable that a solid training be given to teachers and planetarium lecturers. The planetarium shares this particular problem with all other teaching institutions like the general school, the university, etc. On the other hand, there is no reason why the planetarium should not be less attractive and interesting to university students. Recommendations made: "undecided".

9.2.18 Too much general investment in comparison to the educational messages which could possibly be taught there. For this reason not recommendable to the individual school but only for cities. Recommendation made: "disagreed".

The survey in the cognitive domain is summarized in table no. 10 A.

* Footnote: Insertion in brackets by the author
9.3 Telescope or Planetarium, a Discussion:

The telescope and its various accessories are the tools of the astronomer and it is, therefore, easy to understand that many astronomers recommend a telescope to a school rather than a planetarium. On the other hand, it must be realized that a teacher would face some difficulties in teaching a whole class of 25 pupils with one single telescope, let alone the organizational difficulties in getting these 25 pupils together on one particular evening as well as having a clear sky at the same time. A telescope is an excellent instrument for teaching small groups in well-selected very specific topics. Means permitting, a telescope should supplement a planetarium in teaching astronomy on school level but not vice versa; and in no case should a telescope be there instead of a planetarium, as the latter offers so many more possibilities of teaching and entertaining a whole class or several classes at the same time. See survey II/4.

The question is treated at the school level in a later survey. (See chapter III.)

9.4 Affective Domain:

The second set of questions dealt with opinions about the educational value of the planetarium in the affective domain. Here the task was a bit more difficult than treating the questions dealing with the planetarium in the cognitive domain. Of necessity, the questions appealed to the power of imagination as well as observation and experience, since the majority of the questions aim at an estimation of the average pupil's attitude towards the planetarium. The astronomers have, of course, a thorough knowledge of their field of science, a good conception of the school curriculum in astronomy, and most of them possess general teaching experience in lecture halls and in seminars at the universities, but they are not planetarium teachers. Since there are no exact experimental studies available today as a basis for answers in all of our opinion polls, we are fully satisfied in having the personal opinions of the astronomers, unsubstantiated experimentally. There is every reason to be grateful for the astronomers' participation in the research project and for having provided us with their conceptions of the pupil's attitude towards the planetarium.
9.4.1 **Question 1** says that the majority of the pupils would prefer a planetarium demonstration to conventional classroom teaching. A strong attitude statement to which 49 (=96.07%) of the astronomers agreed, with only 2 being undecided and none found in disagreement. What kind of teaching pupils do prefer is nowadays a legitimate question to ask any educationalist, and as a relevant test with students resulted in a similar majority, a very strong argument in favour of the planetarium has been confirmed by this survey.

9.4.2+4 **Question 2 and 4** belong together. Will pupils feel elevated and enriched by the planetarium experience? Will they be stimulated to contemplation and thought beyond the confines of mere factual knowledge? 32 (=62.27%) confirmed question 2, 4 of them strongly; and 28 (=54.90%) - 2 of them strongly - confirmed question 4. The inconsistency found in the answers given for two such very similar questions cannot be explained. Both questions deal with the educationally important notion that man does not only consist of intellect and knowledge but also of soul and feeling, and both elements have to be nourished. We are touching here an important aspect of educational philosophy. In the framework of our thesis, it may suffice to have pointed to a particular aspect of the planetarium where it seems to have the potential of an extraordinary educational value. The majority of the astronomers agreed with the meaning of the two points but the relatively high marks in the "undecided" bracket could be used as a basis for a discussion with astronomers on the ethical, even religious side of teaching their science. This would, of course, go far beyond the purpose of our study.

9.4.3 **Question 3** assumes that the planetarium stimulates students to a more intensive occupation with the subject matter offered in the planetarium. Motivation precedes learning, and any teaching tool that can enhance motivation thus proves its value. The majority"agrees"but many are"undecided."
9.4.5 It is said elsewhere that the planetarium has the potential of uniting families in erudite entertainment. Question 5 suggests therefore that pupils might be induced by the planetarium performance to bring their families to the next public show. Pupils would in this way indirectly express their affection for this teaching medium. The majority "agrees."

9.4.6 Question 6 proposes that students might be caused - by the dramatic planetarium performance - to concentrate better than in the conventional classroom teaching situation. If the planetarium can enhance concentration it will have proved its educational value in an important aspect. The majority "agrees."

9.4.7 Is the dark environment of the planetarium chamber not the ideal place for the bad child to play his pranks? Should he not therefore rather be taught in the classroom? This point may be valued as an indication of how much the fascination of the planetarium performance can keep an ordinary class of pupils interested and occupied. Only 4 respondents "agreed."

9.4.8 Question 8 asks "if the planetarium continually shows only stars and nothing else, is this not rather monotonous for the pupils?"

Apparently this point poses quite a problem for the astronomers. This question showed the strongest shift towards the centre: 26 (=51.19%) of the astronomers could not make up their minds about it. Many "agreed."

The result may be found to be puzzling. Many astronomers seem to fear that continual use of the planetarium might diminish its fascination and hence its teaching effect. If this particular diminishing effect were to be true, does continual classroom teaching on the same subject not also result in a similar diminishing learning effect? Does this not hold true for all teaching? One answer to the problem might be versatility in presentation.

One astronomer-teacher, who confirmed question 8, remarked that the planetarium performance should not be offered too often; it should always remain something out of the ordinary.
Another astronomer, who objected towards the statement, suggested that the highest learning effect would be attained by demonstrating a certain celestial phenomenon in a planetarium, subsequently treating the subject in the classroom, and then repeating the demonstration in the planetarium. He says that if only a certain percentage of the pupils gain something from a planetarium performance, the positive purpose of the planetarium would have already been fulfilled.

Another respondent pointed to the necessity of having a good teacher in the planetarium. Apparently this implies that even repeated planetarium demonstration would not be experienced as being monotonous if a good demonstrator were to run the show. In contrast, it should be noted that in another survey 88.75% of the planetarium visitors were not bored. (II/6)

9.4.9 Question 9 suggests a solution to the problem raised by question 8 in presuming that a multi-media planetarium demonstration would keep the students' interest more alive. A little more than one half of the astronomers "agreed", namely 30 (=58.82%). It can therefore be assumed that the alternative proposed by point 9 to the problem of monotony does not seem to be the best possible solution in the eyes of the astronomers. Whatever the ideal solution may be, if monotony is a problem, it is not apparent from the answers and comments received; but question 9 may at least point in the right direction. We must remember that the idea of a multi-media performance in the planetarium had 34 (=66.66%) supporters in the cognitive domain, which is significantly higher.

9.4.10 Question 10 deals with a common problem well-known to all teachers: the over-stimulation of our schoolchildren by so many audiovisual media, like colour TV, 3-dimensional films, discotheques and roaring singers. Does this over-stimulation not make the predominantly single-purpose planetarium seem to be a dull place to them? 35 (=68.62%) of the astronomers interviewed believe the appeal of the planetarium to be strong enough to overcome this difficulty.
9.4.11 Question 11 deals with the opposite expectancy. Does the planetarium performance overload and hence confuse with visual impressions? The majority of astronomers do not believe that there is a confusing overload of visual impressions in the planetarium.

9.4.12 Question 12 deals with the "temple atmosphere effect", an expression of the author, called "the mystic effect" by Ridky \(^8\). Does it induce timidness rather than enthusiasm in pupils? If the planetarium's atmosphere were actually to frighten an audience of pupils rather than enthuse it, the educational value of this institution would come into doubt. If, on the other hand, the planetarium's special atmosphere exerts a positive stimulus, it is a good argument for the planetarium's value in the affective domain. Most "disagreed".

9.4.13 Will pupils develop a pride in their planetarium? Pride is a strong factor in a pupil, and hence he will devote his interest to a place he cherishes. Pride in an educational institution will render it valuable to one who fosters this pride. This holds true for a theatre, an orchestra and a planetarium alike. Pride can thus be a stimulus making a pupil extraordinarily interested in the object of his pride. It is reasonable to expect that this would enhance the learning effect. The majority "agreed".

9.4.14 Point 14 states that the planetarium does create an interest in astronomy merely by virtue of its existence and reputation. This is another point of strong affective motivation. If an educational institution not only teaches a message well, but if it is also able to invite an interest in the message taught merely by the existence of its particular characteristics, its educational value gains a new dimension. The vast majority "agreed".

---

\(^8\) Ridky, R.W. *op.cit.*
9.4.15 **Question 15** supplements question 14 in stating that the planetarium has been a successful cultural institute and has attracted people. This is supposed to be a confirmation of the status of the planetarium as an institute serving the general public. The implication to be drawn from this statement is that if the public planetarium has been successful and has been attracting people, the school planetarium should be successful in a similar way. Question 15 scored second in rank order after question 1.

9.4.16 Point 16 deals with the influence that space travel has had on the planetarium. Has the planetarium received a new clientele, namely those who became interested in astronomy because of the thrilling news of space exploits? If this were to be so, then the planetarium has gained a new purpose, namely that of making the new science of space travel understandable to a greater audience. Themes of space travel are increasingly being taught in schools so that an available school planetarium gains in importance as a medium of instruction. Most "agreed."

9.5 Additional Comments made by the Astronomers in the Affective Domain:

Comments given in the affective domain were less numerous. The comments given are listed below together with the recommendation that was made for the school planetarium, Question 15 Table no.10B.

9.5.1 I believe that the planetarium will submit a false impression of modern astronomy, if not used as a supplement to a school observatory. Public planetariums certainly have a high value for adult education. At a high school one should try to surpass the very onesided, purely descriptive method of study, within the framework of the (general) teaching of science subjects. Recommendation made: "undecided."

9.5.2 Nature is God's work and the planetarium is Man's work, it can never be perfect. Recommendation made: "strongly agreed."
9.5.3 It will very much depend on the frequency of visits to the planetarium and on the originality of the topics offered, as to whether a student will find the planetarium monotonous. Recommendation made: "agreement".

9.5.4 Students will prefer the planetarium if they are not taken there too often. The planetarium will exert its stimulating effect only if the teacher succeeds in supporting this effect. Recommendation made: "strong agreement".

9.5.5 There is a danger involved in planetarium performances: the high aesthetics of the demonstration tend to prevent an insight into the content and methods of modern astronomical research. Recommendation made: "agreement".

9.5.6 Using a school planetarium necessitates the availability of a teacher who is well-trained in astronomy. Recommendation made: "strongly agreed".

9.5.7 The success of the planetarium demonstration depends on how the performance is conducted. Recommendation made: "agreement".

9.5.8 I still believe that actual observation of the stars under the free sky, such as is carried out in public observatories, is very valuable and this possibility should be utilized by teachers. The planetarium does not make this approach to astronomy and the cosmic experience that goes with it superfluous. Recommendation made: "disagreement".

9.5.9 I would rather go hiking on a winter night. Recommendation made: "disagreed".

Result: Cogn. Dom. 12 Agree; 4 Undecided; 2 Disagree; N = 18
Aff. Dom. 6 Agree; 1 Undecided; 2 Disagree; N = 9
10. Summary and Evaluation:

10.1 Cognitive Domain:

From the figures it can be seen that questions involving intensive teaching experience in the planetarium have resulted in a comparatively high number of "undecided" marks. Questions concerning the general educational value of the planetarium have found high marks on the positive side, and the question of whether or not the planetarium can be recommended for use in the school, has produced a high vote in favour of the school planetarium. The vast majority of a representative sample of the West German astronomers do recommend the planetarium for schools and are also of the opinion that there are not sufficient planetariums in use in West Germany. Many astronomers recommend the installation of a school observatory in order to let the students pursue active astronomy. Some do prefer an astronomical telescope to the planetarium. Question 7, 2 and 16 scored highest, question 11 scored lowest. The actual mean attained 75.75% of the possible maximum.

10.2 Affective Domain:

As in the cognitive domain, it is noticed that those questions involving actual teaching experience in the planetarium produced a significant shift towards the "undecided" column, but also in table no. 10 B the main weight is definitely on the positive side. Table no. 10 A and table no. 10 B correlate positively, although the total score and the mean for the affective domain are noticeably lower than for the cognitive domain. This could perhaps be expected from scientists to whom a rational approach is closer than an emotional approach. On the other hand, it cannot be said with any certainty that the measuring instrument is of equal validity and reliability in both domains, and any difference in results could just as well be ascribed to some uncertainty and imprecision inherent in the test instrument. Questions 1, 15 and 14 scored highest and question 16 lowest. The mean reads 73.53%.
10.3 The Astronomers' Position:

As astronomers in West Germany do not teach in planetariums and consequently do not have any active personal experience in the planetarium, the question may be raised of why astronomers should be important to a study on the planetarium's educational value. The answer is that astronomers, as a rule, do know the planetarium, its potentials and its functions, and thus they are competent in judging the value of a tool for teaching astronomy. None of the astronomers had declared himself as being incompetent to answer the questions.

Astronomers are indirectly concerned with the planetarium as they believe in its potentials and as they prefer "their dignified science to be taught to the general public by the planetarium teacher rather than by the daily 'Astrology Column' in the local paper or by science fiction on TV". *(Of course, there are also serious publications stemming directly from astronomical research being made known to the public through magazines and newspapers.)*

Astronomers are a very engaged group among the unbiased fraction of those concerned with the planetarium. If the scope of the questions treated with them plus their free comments given in the framework of this survey are compared to the findings of the study on the planetarium's intrinsic value (II/4), it is found that the astronomers' opinions do supplement the more absolute statements made on the planetarium's potentials and functions. Not all astronomers recommend the planetarium for routine teaching.

Secondly the opinions of the astronomers confirm in a positive manner the question of how the planetarium's value is rated by those concerned with it. This question was asked in survey II/4 in an attempt to define the educational value of the planetarium.

Thirdly, the astronomers have evaluated their opinions as to the planetarium's value in the cognitive domain by treating value in the affective domain, i.e. they have commented on the effect that the planetarium's functions exert on students' learning, attitude and interest. The result is highly positive, question 8 excepted.

*) Remark made by a prominent astronomer.
Astronomers have confirmed the planetarium's public success as a place of learning and of erudite entertainment and have, with their responses, delivered ample justification for the planetarium's existence and use. They have gone to the extent of recommending it for school use - with only a few reservations, e.g. telescope preference and frequency of use-and of stating that planetariums are not available in sufficient numbers in West Germany.

11. Conclusion:

The strong shift observed for both domains towards the "undecided" column, as accounted for above, has a diminishing influence on the score figures and hence tends to mask the astronomers' support for the planetarium. There are actually only a few negative voices, besides those given for question 8 in table 10 B. Bearing this in mind, the conclusion to be drawn can be formulated as follows:

The results of the survey refute the operational hypothesis and, in this, support that part of the general hypothesis saying that planetariums are believed to be educationally valueable teaching tools in terms of the 32 questions answered by astronomers in West Germany.

Educational potential is evidently understood by the astronomers as a notion of educational value.

12. Implication:

If asked for their advice, the overwhelming majority of the astronomers would recommend the installation of more planetariums. Astronomers have the potential of being a strong lobby for the more widespread installation of planetariums. They do not seem to have any personal vested interests, since their livelihood does not depend on the existence of planetariums.

The results of this survey eliminate one further factor from the range of possible reasons for the underuse of the planetarium, namely the astronomers' opinion about the educational value of the planetarium.

In the following survey II/8 the opinions of planetarium teachers and other promoters of the planetarium are investigated.
"PLANETARIUM DIRECTORS AND OTHER PROONENTS OF THE PLANETARIUM RATE THE PLANETARIUM HIGHLY AS A TEACHING TOOL"

PART A: AN ASSESSMENT OF REPORTS ON MEETINGS OF PLANETARIUM TEACHERS

1. Introduction:
This survey investigates the opinions of planetarium teachers and the opinions of other promoters of the planetarium on its potentials and functions as an expression of its intrinsic educational value. Their insight and experience qualifies them for participation in such a survey. As their livelihood depends on their institutions the directors of planetariums seem biased towards the planetarium, so are the other promoters of the planetarium. This introduces a limitation to the findings and influences content, style and circumference of this survey. This study covers 5 different surveys and is presented in parts A, B, C, D, and E.

2. Theme and Purpose:
The theme of this part of the survey is an assessment of reports of meetings of planetarium directors cum lecturers. The purpose of this study is to seek support from planetarium directors cum lecturers for that part of the general hypothesis saying that planetariums are believed to be educationally valuable teaching tools. It is expected that the findings will confirm some important results of survey II/4 on the intrinsic value of the planetarium. The question of validity and reliability does not arise as we are dealing with published material.

3. Methodology and Procedure:
The operational hypothesis printed as the heading is a prediction of the outcome of this study. This survey is descriptive in nature and is based on the official publications of reports on meetings held nationally by American planetarium directors cum lecturers and held internationally by the international planetarium community.
4. Population and Source of Evidence:

The population of this survey is formed by members of the international planetarium community who have delivered lectures at planetarium conferences. 21 of these lectures have been selected for citation.

5. Findings:

The full account of the findings is folded into the appendix pp.556-562. It follows a list summarizing the more salient arguments brought forward in the meetings.

List of Main Points of Argumentation in favour of the Planetarium extracted from Lectures delivered at Meetings of Planetarium Directors cum Lecturers.

1.1 Lectures on the coordinate systems, time and related subjects, topics that could be taught in the planetarium with a great saving in time. - Useful teaching aid. -

1.2 A medium of rare dramatic potential.

1.3 Reality given to the theory of celestial navigation - quite vivid presentations.

1.4 Presenting to the audience a complete picture of the universe.

1.5 Encouragement for the more widespread use of the planetarium in the schools.

1.6 Instrument capable of presenting an exceptionally wide range of programmes - educational opportunities which the planetarium provides should not be denied to fellow citizens.

2.1 Interest stimulated in the youngsters.

2.2 Much of the curriculum could be done very easily in the planetarium - the little children are fascinated.

2.3 Best approach to the problem of teaching navigation.
2.4 Ideal opportunity to show the behaviour of all celestial bodies.

2.5 Designed to instruct and inspire.

2.6 The youngest can benefit greatly.

3.1 Supplement and deepen the school curriculum - spread knowledge (including) scientific atheism.

3.2 Depict abstruse astronomical concepts for the laymen.

3.3 Study the starry sky under the most natural conditions.

3.4 The many cultural and educational tasks of the planetarium justify these government expenditures (for it).

3.5 Important teaching tool for the astronauts.

3.6 Programmes encourage planetarium visits by classes.

4.1 Capacity to teach the very young.

4.2 Place to gather knowledge and experience joy about the wonders of the cosmos.

5.1 Serious and responsible dramatisation of astronomical or related material - extraordinary educational value.

Most of the statements confirm general points in favour of the planetarium as established in survey II/4. Point 1.1 confirm the planetarium's potential in teaching specific topics of the school curriculum as discussed in survey II/4. Points 1.5, 2.1, 2.5, and 4.2 present arguments out of the affective domain in favour of the planetarium.

No criticism of the planetarium was brought forward in any of the lectures and reports.
6. **Discussion and Evaluation:**

At their conferences, planetarium directors cum lecturers are among themselves. In the presence of their critical colleagues they have every reason to be very frank and open. This could lend weight to their statements and deliver a true picture of the planetarium's potential and value in the educational field, as it is seen by the planetarium lecturers. In delivering their reports and lectures to the audiences of colleagues, the speakers make use of their stock of experience in practical planetarium teaching.

While in the early meetings much of the discussions were devoted to the basic issues of the planetarium's purpose, place, and value in the educational system, it seems that the meeting reports of later symposiums are concerned mainly with techniques rather than with discussions about the educational aspects of the planetarium. The didactic advantages claimed for the planetarium seem to be completely taken for granted by planetarium directors cum lecturers and were not subject to any new lectures or discussions.

Later parts of this survey are devoted to a systematic study of the opinions and convictions entertained by the population in question as to the educational value of the planetarium. Questionnaires were sent for this purpose and verbal interviews are conducted with an audience of obvious supporters of the planetarium.

After having evaluated meeting reports of planetarium teachers, the following parts describe direct surveys conducted with this population. The following part B of this survey describes a survey conducted with planetarium teachers on the international scene.
PART B: A SURVEY CONDUCTED WITH PLANETARIUM DIRECTORS CUM LECTURERS ON AN INTERNATIONAL LEVEL

1. **Introduction:**

This report describes a survey conducted with planetarium directors cum lecturers on an international level.

2. **Methodology:**

The personal interview was the main instrument employed for data collection. In some cases, telephone interviews were conducted which were followed by private correspondence in several instances. All interviews were informal in character and thus allowed for multiple questioning. A descriptive survey has been performed, which delivered the data for the analysis intended.

3. **Procedure:**

Most of the planetariums involved in this survey were personally visited. The purpose of the interviews was never disclosed, so as not to alert the subjects and to keep the atmosphere unofficial. Using the data thus collected as a base for a part of this thesis has not been considered as being inappropriate by the author, as none of the subjects has been quoted directly and as no revolutionary answers were given to any of the questions.

4. **Rationale of the Questions:**

6 questions were posed in both the cognitive and in the affective domains, and one extra question was added concerning the number of planetariums. This particular question had been intended for a separate survey in the framework of this thesis.

All of the questions were direct in character and phrased positively, the questions selected are the same as those that form the core of the many articles on the planetarium in non-scientific literature. It is on this plane of thought and argumentation that most of the pros and cons of the planetarium are discussed.
In view of the bias of the population involved, the test instrument has been kept simple and has concentrated on the potentials and functions of the planetarium as an expression of educational value.

**Validity** of the questions in the cognitive domain has been ensured by dealing with such points as were determined by survey II/4 on the intrinsic value of the planetarium. These points have also been treated in previous surveys. The questions do cover the subject under investigation. In the affective domain, validity has been ensured by confirming the descriptions of the reactions of planetarium audiences which are well-known from other surveys.

**Reliability** is given by the fact that the set of questions used has produced similar patterns of answers in all individual programmes of this survey.

5. **Limitation:**

As the population of this survey is strongly biased in favour of the planetarium, the questions used in this survey are limited to the very essential technical functions and to essential effects of the planetarium. Only 6 questions are posed in the cognitive domain, enquiring into the planetarium teachers' knowledge about these functions. In the affective domain, the 6 questions are limited to the planetarium's effect on the general public (4 questions) and to students' learning in the planetarium (2 questions). These two groups of questions belong to the routine daily experience of the planetarium teacher and represent a subjective assessment of the planetarium's quality as a teaching tool in these two domains. The planetarium's potentials and functions are investigated with the planetarium teachers as an expression of the planetarium's educational value.

The limitation made for the survey conducted with planetarium visitors on the occasion of the same tours (II/6 A) does not apply for the planetarium teachers as their performance is not being surveyed but the potentials and functions of the planetarium as a teaching tool. The international community of planetarium teachers can be considered as being an entity and hence as being one coherent population for a survey. The international visitors were not a homogenous group.
6. Population:

A total sample size of N=35 out of a population of 18 different planetariums participated in the survey. A cross-section through the international planetarium community was represented by planetariums situated in the Far East, the Middle East, Central Europe and the USA.

A full list of these planetariums is given in the appendix, pages 552-554. Large and small, old and new, conventional and modern planetariums were involved. Sampling was done where the opportunity offered itself on tours that the author undertook mainly for other purposes. This amounts in effect to a random method of sampling.

7. Findings:

Questions and answers are found in table no. 11 on the following page. No rank order has been provided as only a few questions have been asked in each domain and as scores are too close in value for differentiation.

The 6 questions in the cognitive domain confirm general points of the findings presented in survey II/4.

The 6 questions in the affective domain were already treated in other surveys and invite the planetarium teachers' confirmation on grounds of their observation and experience.
TABLE 11

INTERVIEWS WITH PLANETARIUM DIRECTORS AND LECTURERS ON AN INTERNATIONAL LEVEL

Educational Value of the Planetarium

A) Cognitive Domain

B) Affective Domain

<table>
<thead>
<tr>
<th>Arguments Discussed</th>
<th>agree</th>
<th>undecided or no answer</th>
<th>disagree</th>
<th>score</th>
</tr>
</thead>
<tbody>
<tr>
<td>A)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1. The planetarium: simulates nature in perfect illusion; no other medium can achieve the same.</td>
<td>35</td>
<td>0</td>
<td>0</td>
<td>105</td>
</tr>
<tr>
<td>2. The planetarium: is highly instructive, as it presents an educational message dramatically and condenses time.</td>
<td>35</td>
<td>0</td>
<td>0</td>
<td>105</td>
</tr>
<tr>
<td>3. The planetarium: presents shows 3-dimensionally which helps people with difficulties in spatial conception.</td>
<td>31</td>
<td>3</td>
<td>1</td>
<td>100</td>
</tr>
<tr>
<td>4. The planetarium: helps even slow learners to easier understanding, better than talk and chalk.</td>
<td>29</td>
<td>5</td>
<td>1</td>
<td>98</td>
</tr>
<tr>
<td>5. The planetarium: allows multimedia demonstrations and can serve also other disciplines besides astronomy.</td>
<td>33</td>
<td>2</td>
<td>0</td>
<td>103</td>
</tr>
<tr>
<td>6. The planetarium: shows the whole spherical sky in realistic motion. No other projection device, no film or slides can achieve the same.</td>
<td>35</td>
<td>0</td>
<td>0</td>
<td>105</td>
</tr>
</tbody>
</table>

Actual Total Score: $1 - 6 = 616$
Possible Maximum Score: $1 - 6 = 630$
Actual Mean: $\frac{616}{35} = 17.60 (97.77\%)$
Maximum Mean: $\frac{630}{35} = 18$
<table>
<thead>
<tr>
<th>Arguments Discussed</th>
<th>agree</th>
<th>undecided or no answer</th>
<th>disagree</th>
<th>score</th>
</tr>
</thead>
<tbody>
<tr>
<td>B)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>7. The planetarium: exerts a nearly mystic power of attraction, thus stimulating a real interest in its performances.</td>
<td>32</td>
<td>2</td>
<td>1</td>
<td>101</td>
</tr>
<tr>
<td>8. The planetarium: creates or enhances by its mere existence an interest in astronomy.</td>
<td>30</td>
<td>4</td>
<td>1</td>
<td>99</td>
</tr>
<tr>
<td>9. The planetarium: is preferred by school children to other means of learning astronomy.</td>
<td>28</td>
<td>6</td>
<td>1</td>
<td>100</td>
</tr>
<tr>
<td>10. The planetarium: fascinates a whole class of pupils, they don't lose concentration.</td>
<td>30</td>
<td>3</td>
<td>2</td>
<td>98</td>
</tr>
<tr>
<td>11. The planetarium: unites families in erudite entertainment.</td>
<td>31</td>
<td>2</td>
<td>2</td>
<td>99</td>
</tr>
<tr>
<td>12. The planetarium: adds to the cultural importance of a museum or forms an impressive cultural community centre.</td>
<td>32</td>
<td>2</td>
<td>1</td>
<td>101</td>
</tr>
<tr>
<td>13. The planetarium: is not used in sufficient numbers.</td>
<td>33</td>
<td>1</td>
<td>1</td>
<td>102</td>
</tr>
</tbody>
</table>

Actual Total Score: $7 - 12 = 598$
Possible Maximum Score: $7 - 12 = 630$
Actual Mean: $\frac{598}{35} = 17.08 (94.88\%)$
Maximum Mean: $\frac{630}{35} = 18$

**SUMMARY**

35 planetarium teachers of 18 different planetariums in the Far East, Middle East, Europe and the USA were interviewed in order to test their opinion about the educational value of the planetarium. Answers were based rather on observation and experience than on results of any judicious experimentation. Answers given to purely educational questions scored lower in points than other questions. This is ascribed to a lack of follow-up activities by planetarium teachers. The results of the survey show that planetarium teachers rate the planetarium highly as an educational tool.
Basis for the Answers received:

None of the planetarium teachers interviewed had ever conducted judi-
cious experimentation with his audiences in order to verify his con-
victions about the planetarium's value. All statements made are
therefore only personal opinions, the general truth of which is
taken for granted by the participants in the interviews.

All participants agreed that the questions concerning the learning
aspect could only be confirmed on the premises of a well done lecture-
demonstration in the planetarium.

8. Discussion and Evaluation:

A) Cognitive Domain

8.1 - 8.2 - 8.6

The Planetarium's Advantages:

Questions 1, 2, and 6 are descriptive of the planetarium and
point to its advantages over other teaching media. These
questions describe the planetarium's educational value in
terms of technical specialities inherent in the projection
planetarium's construction. These questions met with unani-
mous agreement from the planetariums. This is in confirmation
of the apparently widespread support given by the proponents
of the planetarium to this institution.

8.5

Multi-Media Performances and Service to other Disciplines:

As planetarium programmes in West Germany reveal, other
disciplines besides astronomy are scarcely served by the few
existing planetariums, (Bochum, West Germany, being an exception). In the USA, on the other hand, planetariums are indeed open to other disciplines. (See chapter I for subjects taught in the planetarium.) The extension of the planetarium's educational importance and value into other realms of education seems to be of only marginal significance and could by itself scarcely justify the existence of a planetarium, according to the discussions spun off by this question with the population involved. Multi-media use was also predominantly claimed for enhancing or supplementing astronomical demonstrations. Agreement to the questions was therefore unreserved for the first part of the question dealing with the multi-media use, whereas in the second part of the question an existing educational potential was confirmed rather than a striking feature for daily utilization.

8.3 - 8.4
Learning in the Planetarium:

It seems that in only a few of the planetariums interviewed is the success in learning supervised and measured as is customary in schools. The other planetariums do teach school children by lecture demonstrations but they do not and cannot perform any type of follow-up. Answers given are therefore based rather on observation and experience in the form of informal discussions with pupils and teachers than on any type of measurement or other judicious experimentation. It is noticeable that agreement with the 2 questions dealing with learning is less strongly pronounced although the vast majority sees the planetarium's educational value also in these domains of learning.

B) Affective Domain

It cannot be asserted with certainty that the validity and reliability of the test instrument are equally strong in the cognitive and in the affective domain. Different levels of scores in the two domains do therefore not necessarily mean an unequal engagement in the two sets of questions, though a certain hesitation in answering seems apparent when the realm of facts is interchanged for the realm of feelings.
The Attraction of the Planetarium:

Whilst so many articles ascribe a particular attraction to the planetarium and even the power of creating and enhancing an interest in astronomy - by a curiosity effect or similar reactions of the public - a few of the planetarium teachers cannot follow this argumentation. The majority, however, attribute educational value to the planetarium in terms of the nearly mystically attractive influence it creates by virtue of its mere existence (and the programmes offered to the public).

Student's Reactions to the Planetarium:

In the purely educational questions, agreement is found to be less vivid in comparison to the other questions, which is ascribed to the planetarium teachers' lack of personal contact in their didactic performance with the pupils learning in the planetarium. Still, the majority of the planetarium teachers confirm the particular features of the planetarium's educational value found in the fascination which the planetarium performance holds for pupils so that they do not lose concentration throughout the lecture demonstration and the majority of them also confirm that students prefer learning astronomy rather in the planetarium than by other means.

In other surveys several hundred pupils and other planetarium visitors were asked directly for their preferences.

The Planetarium as a Place for Families:

Experience and observation show that learning in the planetarium is apt to unite complete families for erudite entertainment, not less so than joint visits to zoological gardens, exhibitions or other cultural attractions. This holds true, of course, mostly for public planetariums and less so for small planetariums owned by schools. The question is complementary to the one asked of visitors "Would you like to take your family and friends. (This invites an indirect expression of evaluation.)"

8.12
The Planetarium's Cultural Importance

In view of the many principle statements made in so many general publications on the planetarium's value, question 12 may sound like a truism. The statement made holds true, however, only for those planetariums that are actually open to the public and not for those hidden away in a school for the school's exclusive use. For this reason 2 teachers were "undecided" and 1 "disagreed".

9. Summary:

In the cognitive domain, agreement given to the argumentation presented amounts to 98.05% and in the affective domain the corresponding figure is 94.88%. This attempt of quantifying answers indicates that planetarium teachers rate the planetarium highly as an educational tool in terms of the questions asked.

This investigation performed internationally sets the scene for an identical survey undertaken in West Germany, the main target area for the research.
1. **Introduction:**

After having interviewed planetarium teachers on an international level, it was thought indispensable to conduct a similar survey with the same target group in West Germany, since an essential part of the overall research focuses on their institutes. The circle is not very large and not all planetariums replied in spite of being sent reminders. The large planetariums were included in the survey, as they also serve the neighbouring schools in special sessions.

2. **Methodology:**

While part B, the interview with planetarium directors cum lecturers on an international level was conducted verbally, this part is a survey conducted by mail with the same target group in West Germany. Questionnaires were used which contained essentially the same questions that had evolved during the informal interviews described in part B.

A **descriptive survey has been conducted.**

As the questions in all questionnaires of this survey are of identical content, though slightly different in formulation, the question of validity and reliability does not pose itself anew for each individual part of the survey conducted with planetarium teachers in various parts of the world.

3. **Findings:**

The table of the following page summarizes the findings. A sample size of \( N = 15 \) participated in the survey.

A copy of the covering letter that went with the questionnaires is filed in the appendix p. 563.
TABLE 12
SURVEY WITH PLANETARIUM DIRECTORS & LECTURERS IN WEST GERMANY
THE EDUCATIONAL VALUE OF THE PLANETARIUM
A) Cognitive Domain
B) Affective Domain

Questionnaire translated from the German original

<table>
<thead>
<tr>
<th>No.</th>
<th>Question</th>
<th>Sample Size 15</th>
<th>Rank Order</th>
<th>Score 3-2-1</th>
<th>Yes</th>
<th>Undecided</th>
<th>No</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>The planetarium: simulates nature in perfect illusion; no other medium can achieve the same.</td>
<td>15</td>
<td>3</td>
<td>44</td>
<td>14</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>2</td>
<td>The planetarium: is highly instructive, as it presents an educational message dramatically and condenses time.</td>
<td>15</td>
<td>4</td>
<td>44</td>
<td>14</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>3</td>
<td>The planetarium: presents shows three-dimensionally, which helps people with difficulties in spatial conception.</td>
<td>15</td>
<td>2</td>
<td>45</td>
<td>15</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>4</td>
<td>The planetarium: helps even slow learners to easier understanding, better than talk and chalk.</td>
<td>15</td>
<td>10</td>
<td>38</td>
<td>9</td>
<td>5</td>
<td>1</td>
</tr>
<tr>
<td>5</td>
<td>The planetarium: can serve also other school disciplines — mathematics, physics and geography, even history (mythology), all can profit from the planetarium.</td>
<td>15</td>
<td>6</td>
<td>42</td>
<td>12</td>
<td>3</td>
<td>0</td>
</tr>
<tr>
<td>6</td>
<td>The planetarium: has been and promises to remain as successful a cultural institute as a museum or zoological or botanical garden. It exerts a great attraction on people.</td>
<td>15</td>
<td>7</td>
<td>39</td>
<td>11</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>B</td>
<td>The planetarium: stimulates an interest in astronomy merely by virtue of its existence and reputation.</td>
<td>15</td>
<td>8</td>
<td>39</td>
<td>10</td>
<td>4</td>
<td>1</td>
</tr>
<tr>
<td>8</td>
<td>The planetarium: is preferred by pupils as a place to study astronomy more than the conventional classroom.</td>
<td>15</td>
<td>12</td>
<td>37</td>
<td>7</td>
<td>8</td>
<td>0</td>
</tr>
<tr>
<td>9</td>
<td>The planetarium: fascinates students. There is less lack of attention than in the conventional classroom.</td>
<td>15</td>
<td>9</td>
<td>39</td>
<td>9</td>
<td>6</td>
<td>0</td>
</tr>
<tr>
<td>10</td>
<td>The planetarium: has been enhanced in importance by space travel, which has brought new visitor groups.</td>
<td>15</td>
<td>5</td>
<td>42</td>
<td>13</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>11</td>
<td>The planetarium: unites families in erudite entertainment.</td>
<td>15</td>
<td>11</td>
<td>38</td>
<td>8</td>
<td>7</td>
<td>0</td>
</tr>
<tr>
<td>12</td>
<td>The planetarium: represents a valuable cultural institute for school and adult education.</td>
<td>15</td>
<td>1</td>
<td>45</td>
<td>15</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>13</td>
<td>The planetarium: is not available in sufficient numbers.</td>
<td>15</td>
<td>13</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Actual Total Score</th>
<th>A</th>
<th>B</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 – 6</td>
<td>252</td>
<td>241</td>
</tr>
<tr>
<td>Possible Maximum Score</td>
<td>1 – 6</td>
<td>270</td>
</tr>
<tr>
<td>Actual Mean</td>
<td>16.8 (93.33%)</td>
<td>16.07 (89.26%)</td>
</tr>
<tr>
<td>Possible Maximum Mean</td>
<td>18.00</td>
<td>18.00</td>
</tr>
</tbody>
</table>

Summary

Fifteen planetarium professors out of the small West German planetarium community participated in the survey. The test instrument consists of a set of positive statements found frequently in general publications giving descriptions of the educational value of the planetarium. The respondents rate the educational value of the planetarium highly in terms of the questions posed.

(Question 13 in both tables serves a different purpose and is therefore not counted here.)
6. **Discussion and Evaluation:**

The attempt has been made to question planetarium teachers in West Germany about their evaluation of the planetarium's educational value by a survey instrument consisting of 12 questions. They scored more than 90% in the cognitive domain and nearly 90% in the affective domain of this opinion poll.

While question 12, which summarizes the commonly heard statements and opinions about the planetarium's value, finds the planetarium professors unanimously in agreement, their opinions on many of the other points differ.

It is the strong mixture of small and large planetariums in West Germany that accounts to some extent for the non-uniform picture. An additional reason may be the apparent unfamiliarity of some planetarium professors with their young visitors' reaction towards the performance. As the questions are widely identical to the ones of the preceding part of this survey only 3 of them need to be discussed to explain differences to the results obtained with the international sample.

6.7 The planetarium stimulates an interest in astronomy. This question is in line with question 6 and qualifies the attraction that the planetarium exerts. It states that by virtue of its mere existence and reputation the planetarium stimulates an interest in astronomy. Only two thirds of the planetarium directors can agree to this statement. Planetariums in West Germany have, as a rule, a very small staff and hence not much capacity for public relations. It is easily possible that lack of public relations leaves some planetarium directors unclear about a particular motivation causing the public to visit the planetarium.

6.8 The planetarium is preferred by pupils to the classroom. More than half of the German planetarium teachers are "undecided". In the experiments conducted with West German students (II/10), 96.31% of them agreed with the question, most of them strongly. This is further evidence for the lack of contact between planetarium teachers in West Germany and their juvenile clientele.
6.11

The planetarium unites families in erudite entertainment. Opinions are nearly equally divided on this point. The reason for this obvious discrepancy may be the fact that the smaller school planetariums hardly have any family evenings. Their answer is, therefore, a subjective statement rather than a generalisation referring to the planetarium's potential. Also the oldest and at the same time one of the largest planetariums in West Germany was undecided on this question. A reason was not given. The directors of the other large planetariums have confirmed this statement. The same statement has also been confirmed in the earlier survey conducted with planetarium directors on an international level. It is an indirect question intended to have the planetarium's value confirmed in a roundabout manner.

The very small sample size of this part of the survey induced the author to also seek the opinions of planetarium teachers on the international level, as has been described in part B of this survey. The following part D includes, for the same reason, a survey conducted with planetarium teachers in the USA. Conditions there differ from those in West Germany essentially in 2 points: there is a higher density of planetariums in the USA and most of these planetariums are owned by schools or colleges.

7. Summary:

Planetarium teachers in West Germany rate the planetarium highly as a teaching tool. They score slightly lower than their international colleagues, which is ascribed to the different methodology employed in the two surveys. No negative comments were given.
1. **Introduction:**

In part B, the interviews conducted with international planetarium directors had been performed wherever the opportunity offered itself. In several of the planetariums visited, more than one lecturer was interviewed and a total sample size of 35 resulted. As there are only a few planetariums in West Germany, the resulting sample size has of necessity been very small (N=15). In order to provide a larger total sample and assuming, on the basis of the international survey programme, part B, that conditions and opinions in the planetarium world were essentially comparable, a survey was conducted with planetarium directors cum lecturers in the USA (N=65).

2. **Methodology:**

   A descriptive survey was conducted exclusively by correspondence. Questionnaires were sent to randomly selected planetariums in the USA. No personal interviews were possible with the large sample size.

3. **Rationale of the Questions:**

   Six questions were posed in the cognitive domain and six questions in the affective domain. Questions were kept simple and straightforward as in the preceding surveys. Validity and reliability are therefore ensured in the same fashion with the exception of question 3 which seems not sufficiently clear, as it produced an unexpected result inconsistent with the findings of the other surveys.

4. **Population:**

   The population for this survey is the planetarium directors cum lecturers in the USA.

5. **Procedure:**

   This particular survey was combined with an additional survey intended to provide data for the chapter III of this thesis. Thus two questionnaires were sent out, one of them forming the basis for this research.
programme. When visiting the USA during July 1978, the author had taken 200 sets of questionnaires with him with the intention of sending them out on the spot on base of a randomly selected list of 200 addresses of USA planetariums. However, American friends, very familiar with the planetarium world in the USA, warned that such an action would yield only a 10% reply, in view of the many similar actions continuously taking place in the USA. The author was advised to mail the questionnaires from Europe as this would meet with a higher interest in the activity on the part of the recipients. This advice was followed and each set of questionnaires was sent with a pre-addressed envelope stamped for return seaimail.

The yield was in this way about 3 times higher than it would have been had a similar action been carried out in the USA itself. Table no. 13 is in its text a copy of the questionnaire. Many additional comments were given voluntarily by the respondents, several letters were received with valuable hints, and some of the planetariums added their recent advertising and programme material. 65 replies were received (32.5%), this is approximately 7% of the USA planetarium population. The sample seems to be structurally representative taking into account the types and sizes of the responding planetariums. The low participation, by survey standards, introduces a limiting factor for representativeness.

6. Findings:

Reference is made to the table on the following page which summarizes the action.

Each 6 questions are posed in the cognitive and in the affective domain.

Question 13 is to serve another survey in this thesis.
### TABLE 13

**SURVEY HELD WITH PLANETARIUM DIRECTORS IN THE USA**

"The Planetarium’s Educational Value"

<table>
<thead>
<tr>
<th>Opinion</th>
<th>Rank Order</th>
<th>Agree</th>
<th>Uncertain</th>
<th>Disagree</th>
<th>Score</th>
</tr>
</thead>
<tbody>
<tr>
<td>(A) 1. The Planetarium simulates the night sky perfectly. No other medium can achieve the same.</td>
<td>9</td>
<td>47</td>
<td>11</td>
<td>7</td>
<td>170</td>
</tr>
<tr>
<td>2. The Planetarium performance is dramatically presented. Time is condensed. The performance is highly instructive.</td>
<td>4</td>
<td>58</td>
<td>6</td>
<td>1</td>
<td>187</td>
</tr>
<tr>
<td>3. By the Planetarium projection, students’ difficulties in spatial conception are overcome.</td>
<td>11</td>
<td>33</td>
<td>27</td>
<td>5</td>
<td>158</td>
</tr>
<tr>
<td>4. A Planetarium show helps even slow learners to a better understanding of the subject matter, better than chalk and talk.</td>
<td>7</td>
<td>52</td>
<td>12</td>
<td>1</td>
<td>181</td>
</tr>
<tr>
<td>5. Other school disciplines like mathematics, physics and geography, even history (mythology) can profit from the Planetarium.</td>
<td>3</td>
<td>60</td>
<td>5</td>
<td>0</td>
<td>190</td>
</tr>
<tr>
<td>6. The Planetarium has been and tends to remain a successful cultural institution, comparable to a museum, zoological and botanical garden. It exerts a great attraction on people.</td>
<td>2</td>
<td>62</td>
<td>2</td>
<td>1</td>
<td>191</td>
</tr>
<tr>
<td>(B) 7. The Planetarium stimulates an interest in astronomy purely by its existence and reputation.</td>
<td>10</td>
<td>41</td>
<td>16</td>
<td>6</td>
<td>161</td>
</tr>
<tr>
<td>8. Pupils seem to prefer the Planetarium to the conventional classroom for studying astronomy.</td>
<td>6</td>
<td>53</td>
<td>10</td>
<td>2</td>
<td>181</td>
</tr>
<tr>
<td>9. The Planetarium fascinates pupils. They tend to concentrate better in the Planetarium than in the classroom.</td>
<td>8</td>
<td>44</td>
<td>18</td>
<td>3</td>
<td>171</td>
</tr>
<tr>
<td>10. Space travel has enhanced the importance of the Planetarium and brought new groups of visitors to the Planetarium.</td>
<td>5</td>
<td>54</td>
<td>10</td>
<td>1</td>
<td>183</td>
</tr>
<tr>
<td>11. The Planetarium tends to unite families in erudite entertainment.</td>
<td>12</td>
<td>28</td>
<td>34</td>
<td>3</td>
<td>151</td>
</tr>
<tr>
<td>12. The Planetarium is a valuable cultural institution serving school and adult education.</td>
<td>1</td>
<td>63</td>
<td>1</td>
<td>1</td>
<td>192</td>
</tr>
<tr>
<td>13. Planetariums are not sufficient in number to meet with actual or potential demand of performances.</td>
<td>21</td>
<td>37</td>
<td>6</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Sample Size: 65**

**Summary**

Sixty-five American planetarium professors gave their opinion about the planetarium’s educational value in a questionnaire containing the twelve questions cited above. They rate the planetarium highly as an educational tool. Many were undecided about the planetarium’s value as a family place and as a means of overcoming difficulties in spatial conception.

(Question 13 serves a different purpose and therefore is not counted here.)
7. Discussion and Evaluation:

Only those points are being discussed which show major differences to the results of the survey held in West Germany.

8.1 The planetarium simulates the night sky perfectly. No other medium can achieve the same.

Point 1 contains two statements. Basing on the previous experience gathered in conducting the overall research, the author assumed that he had almost printed truism. While the same question was confirmed by 93.33% of the German planetarium professors, only 47 (=72.30%) of the 65 USA respondents could agree to the statement, with several "uncertain" and "disagree" entries.

The fact is that the larger and the more sophisticated the planetarium projector is, the closer to nature is the night sky simulation. Very small projectors in domes of small diameters do not provide the illusion of being out in the open under the starry night sky.

It is therefore all the more astonishing to find among the 11 "uncertain" voices only 2 coming from very modest planetariums, i.e. 2 NOVA projectors, but 8 from medium size planetariums with good and versatile projectors and even 1 belonging to a STS installation, all of which are well visited and well equipped according to additional information available from a parallel survey. Among the 7 in "disagreement", there is only 1 modest planetarium, (a Spitz 373), the rest being as above and including 1 Zeiss planetarium with the mark VI projector. No further explanation can be furnished for the unexpected results obtained from this survey as these 2 groups of respondents did not supply any more information. There might be other media (the "Farquhar" luminous star globe perhaps) which are unknown in West Germany.
7.3 By the planetarium projection, student's difficulties in spatial conception are overcome.

While the previous surveys have in various forms produced agreement to this point, it drew only a low vote of agreement in the USA survey, (50.76%).

One respondent remarked: "It helps, no guarantee!" Another respondent qualified "overcome" by the adjective "greatly" and added: "but not completely". A third one added "not entirely" and disagreed with the statement. Still another remark reads: "For many students, but not all". Another correction made adds "spherical" in front of spatial. Another disagreeing voice states "not always" in explanation for his negative vote. The last comment reads "somewhat" and continues "this is a difficult one!". The owner of this comment abstained from voting.

The depth of the matter is not explored by the question. The survey does not reveal the full range of reasons leading the respondents to agree or disagree or to be uncertain. The participants were invited in general terms to comment on all questions if they should feel that comments were necessary but, since they had an additional longer questionnaire of another survey to deal with, they may not have bothered to explain their standpoint in each and every case. The fact is that the vast majority of the USA planetariums who participated in the survey are teaching institutions, and it is safe to assume that all, or at least most, of the planetarium teachers have gained quite a wealth of experience by experimenting with their lectures and demonstrations. It is therefore important that as many as 27 feel uncertain about one of the very striking advantages that the planetarium demonstration offers, i.e. facilitating 3-dimensional spatial conceptions.

The claims made for this particular advantage of the planetarium are based on the inherent planetarium features and are in practice confirmed by observation and experience. This strong advantage seemed obvious according to the previous surveys. In the USA survey this question resulted in the lowest
score but one. Perhaps one explanation for this inconsistency is the unprecise formulation of the question. It should have read "spherical projection". The question is more precisely formulated in the German questionnaire.

It may be worthwhile to further explore this problem of a controversy about a seemingly obvious point. This can, however, not be performed in the framework of this thesis.

7.4 A planetarium show helps even slow learners to a better understanding of the subject matter, better than chalk and talk.

This question met with a much higher positive response in the USA survey than it had done in the German survey.

As mentioned before, most of the USA planetariums participating in this survey are pure teaching planetariums and it can be safely assumed that they base their judgement on a stock of relevant experience. One respondent commented: "never proven, at best planetarium is equal in most studies using conventional methods". A second voice stated: "if done well". Two other teachers gave this point a double mark in the "agree" column, showing how strongly they confirm this point. Another comment reads: "for many, but not for all". Still another comment reads: "if it is a programme that really uses the sky". This, of course, is self-understood. One voice in agreement with the question put, however, a question mark behind "better than chalk and talk". This means that agreement was given to the statement "the planetarium show helps slow learners", but doubt was expressed as to whether the planetarium can do this better than chalk and talk.

The final comment in the collection received comes from a planetarium professor who agrees to the statement on grounds of his conviction that "anything is better than chalk and talk!"
7.5 Also other school disciplines like mathematics, physics, and geography, even history - (mythology), can profit from the planetarium.

80% of the German planetarium professors agreed to this statement, and as many as 92.3% of the USA planetarium professors. Both groups tend to rate this point very highly, and it is easily possible that the higher number of school planetariums in the USA has permitted a much wider scope of experimentation compared to the situation in West Germany. Browsing through the programmes of West German and American planetariums one gains the impression that the German planetarium is predominantly utilized for astronomy. This leads to the assumption that in West Germany demands made on planetarium time concentrate on the original purpose of the planetarium, pure astronomy.

Planetarium professors seem to see in the planetarium's capacity to serve other school subjects an additional advantage of their institution in its service to the schools.

7.6 The planetarium has been and tends to remain a successful cultural institution, comparable to a museum, zoological and botanical garden. It exerts a great attraction on people.

This description of the planetarium's importance and effect has yielded a very high affirmative response from the USA planetarium professors. This result is all the more astonishing as most of the respondents stem from small college planetariums. One of the respondents found that the planetarium "vies with television". It is true that television is capable of supplying interesting science programmes including astronomical topics but, as mentioned before, no other medium can show the complete hemispherical sky. Television has been brought into the planetarium, but the planetarium cannot be brought into television, since the television screen can show only a section of the sky, be it the real sky or the planetarium sky.

This question found the second place in the rank order in the USA survey, and place 7 in the West German survey.
Pupils seem to prefer the planetarium to the conventional classroom for studying astronomy.

While less than half of the German planetarium professors agreed to this statement, 81.53% of the 65 USA respondents confirmed it. One may feel inclined to concede that the USA planetarium professors have the sounder judgement as they seem to have more and closer contacts with their student clientele by virtue of the fact that most of the planetariums are owned by schools or colleges. In the German opinion poll only 2 planetariums participated which are actually owned by schools; all the others are only available to schools under special arrangements. One USA planetarium teacher commented: "I know that children and teachers enjoy coming to the planetarium, but I do not know how they feel about the educational value of the planetarium". One voice commented "depends upon the level of education". He marked the "disagree" cell. The same question was asked of the German astronomers and met with the highest score there. The planetarium professors are the observers, the astronomers the theorists. The students themselves, in West Germany the actual group concerned, confirm the statement wholeheartedly, as survey II/10 shows, 77.88% being in "strong agreement" and 18.43% in "agreement".

While it may be true that the USA planetarium professors have a higher degree of direct teaching experience in the planetarium, it seems that they are also more critical about their medium of instruction. But it is difficult in this respect to control the variable of the so much higher N-number of participants. It seems safe to assume that this higher number has contributed to the wider spectrum of opinions delivered.
In contrast to other participants in the survey, several of the American planetarium teachers have added free comments to the questionnaires. On the other hand, the number of participants was much higher in the USA survey which is one variable attributing to the wider scope of opinions supplied by the USA participants, as mentioned before.

7.13 Free comments:

A number of additional comments were given by several of the USA planetarium professors and these are quoted below in their original form:

1. "The planetarium provides astronomy instruction in concepts where elementary teachers are deficient in their knowledge and/or training. The planetarium provides a place for clubs and organisations to meet for an unusual programme."

2. "The planetarium can be quite successful as a tool for language arts (creative writing) instruction."

3. "Our teachers feel as I do that the real educational value of the planetarium experience is not as a "sensation" but as a part of a coordinated effect with pre- + post-activities to reinforce and maintain interest and retention of material."

4. "A planetarium can be shared by both the child and the adult. This results in a shared educational experience from which both parties can benefit, both as an entertainment and also as an education."

5. "Remember that there are roughly 1000 planetariums in the USA. The variety is enormous. Nevertheless, a pure planetarium presentation is probably inferior to a well-done classroom presentation."

6. "Planetariums tend to involve people from many different backgrounds in science, (educational & social)." - "Planetariums act as a perfect supplement to classroom instruction in astronomy." - "Serve to inspire students to learn more about the real sky, much more inspirational than a classroom lecture."
7. "Planetariums provide a unique learning experience that is intensified by its "unusualness" so that a special event occurs that produces a new kind of learning. By providing a break from classroom experiences, planetariums provide a stimulation not found in everyday class."

8. "A planetarium can get authoritative accurate astronomical information to the general public in a "painless" manner."

9. "Planetariums can show basic sky motions best - planetariums are an excellent way to acquaint students with the relative positions of stars. The planetarium dome permits multi-projections and allows for complex visual experiences."

10. "The planetarium is the ultimate in audiovisual machines. The only way one can point out astronomical events in 3 dimensions. - The planetarium is a true space age lab for interpretation of the wonders of the universe for the serious student and interested public. - The planetarium is an invaluable source of summer workshops and learning lab for teachers in our public schools."

No other comments were given.

8. Summary:
American planetarium professors are, in their vast majority, convinced about the high educational value of their institution as tested by the 12-questions-survey according to table 13. The actual scores obtained are very near to the possible maximum scores. The actual mean in the cognitive domain amounts to 92,05% of the attainable maximum mean and in the affective domain the figure reads 88,77%. The verbally conducted interviews on the international level, part B of this survey, yielded higher results which, however, can safely be ascribed to the better method of questioning. The results of the survey in West Germany differ only insignificantly from the results of the USA survey.

No critical comments were made on the planetarium. The general findings of survey II/4 are confirmed, the specific point of the planetarium's advantage in helping students suffering from difficulties in spatial conception was only partly confirmed.
9. Complementary Note:

At one and the same process two surveys were conducted with USA planetarium directors.

Two questionnaires were sent. The first of these is reprinted in table no. 13. The second one is reprinted in the appendix on page 600 together with the covering letter.

10. Summary and Evaluation of the 4 Surveys conducted with Planetarium Teachers:

Planetarium teachers seem to be perfectly convinced about the high value of their institution as a place of culture, learning and erudite entertainment. So deep is this conviction that lectures and discussions on the basic principal issue of educational value and appropriate integration into the educational system took place only during the first meetings. These early meetings also deliver proof of how strongly the educational value of the planetarium is accepted by some educational authorities in the USA. Later meetings of planetarium professors are mostly devoted to technical affairs, questions of equipment and questions of performance improvement.

In the interviews and surveys conducted by mail with planetarium teachers, the questions were limited in scope and content to the bare essentials of the planetarium's potentials and functions and the possible resulting effects on general visitors and students. In this we come back full circle to the introduction to chapter II, and the limitations given there for the participation of the a priori biased groups. The reduction to the barest essentials in scope and content of the questions was made in an attempt to neutralize any bias which it was feared, would otherwise have distorted the answers received to a wider range of questions measuring a broad spectrum of opinions; such as has been done with teachers (81 questions) and with astronomers (32 questions). As no criticism was expected from this group on grounds of previous experience, all questions were phrased positively and the measuring instrument was kept simple with 3 columns only provided for the answers in the questionnaire.
Planetarium teachers are a strong group of lobbyists for the more widespread installation and the more widespread use of planetariums (a few individual voices in the USA excepted). The contribution to this thesis made by planetarium teachers is valuable inasmuch as they belong to those groups concerned with the planetarium and therefore help in constructing a complete image. Furthermore, their active participation confirms essential points of survey II/4 which attempted to establish the planetarium's intrinsic educational value by a study of its potentials and functions in the fulfillment of the requirements set by the school curriculum of astronomy.

The German planetarium teachers' comments on points of value in the affective domain expose certain shortcomings in public relations and contact with the audience and in measuring their reactions. However, any influence of these shortcomings on the apparently underuse of the planetarium could not be established anywhere in this thesis, nor is such negative influence easily assumed. In fact, the full houses and waiting lists of hopeful visitors speak strongly against such a negative influence.

The question posed in survey II/4 on how the value of the planetarium is rated by those concerned with it has been positively answered by the group of planetarium teachers as a whole.

In summing up the experiences of this survey it can be said that the position of the planetarium teachers with regard to the educational value and cultural importance of their institution must be conclusively excluded as being a possible reason for the underuse of the planetarium in education.

The round of interviews and surveys with the planetarium teachers and other proponents of the planetarium will be closed with the report of one additional survey conducted with a knowledgeable audience. After the completion of this last survey, the general conclusion will be drawn for all individual parts of this general survey.

The letters which were sent with the questionnaires to the various groups involved and the second comprehensive questionnaire for USA survey are reproduced in the appendix pp. 563, 600 and 602.
PART E: DISCUSSIONS HELD WITH A KNOWLEDGEABLE AUDIENCE ABOUT THE EDUCATIONAL POTENTIAL OF THE PLANETARIUM AND ITS VALUE

1. Introduction and Population:

In October 1977 the University of Riyadh, Saudi Arabia, conducted a "Week of Astronomy" in which the author participated with two lectures, one of them on "The History and Importance of the Planetarium". The audience of about 50 to 60 consisted of planetarium lecturers, astronomers, science teachers, a very few senior students and several makers of astronomical instruments. 31 members of this audience participated in the subsequent discussions about the educational value of the planetarium.

2. Theme and Purpose and Limitation:

The theme of this report is a discussion conducted with a knowledgeable international audience about the educational value of the planetarium. The purpose of this part of the study continues to be unaltered. The sample remains to be biased. A strong fraction of the sample sought approval for the university's decision to install a major planetarium and met with no criticism. The limitation introduced for the biased groups remains hence in force.

3. Methodology and Procedure:

This study has been undertaken partly by open forum discussions and partly by discussions in smaller groups or personal interviews. All discussions were informal in character and allowed for multiple questioning. A descriptive survey has been conducted. Each seven questions were posed in the cognitive and in the affective domain.
4. Rationale of the Questions:

The statements contained in the questions were partly formulated by the author and partly evolved during the discussions held. All questions were direct in character and positively phrased, for reasons explained earlier in this survey. Questions are mainly general and unspecific and include generally accepted aspects of value in the planetarium. Validity of the questions seems ensured by their directness in which they cover well-established characteristics of the planetarium. Reliability cannot fully be guaranteed as the audience may answer certain questions differently when asked under different circumstances and under a different interview atmosphere. This atmosphere during the interviews favoured replies in support of the planetarium. This introduces a limiting factor, perhaps only a slight one, as only a few questions are involved, i.e. questions 4, 6, 8 and 13.

5. Findings:

Reference is made to the table on the following page: 4 questions deal with the planetarium's effect on the general public, 3 questions deal with functions of the planetarium, and 7 questions deal with various aspects of teaching in the planetarium.

The questions touch on points not yet treated in any of the other surveys, but these are points that do not supply any fundamentally new information, as they appear in the framework of the rich general literature on the planetarium. These questions serve to explore some special aspects of the planetarium's value such as seen by an audience of proponents of the planetarium. Question 11 on the religious aspect of planetarium teaching may be a new aspect, but the director of the Moskwa planetarium is quoted in part A of this survey, argument 3.1. He stated the opposite in saying that the planetarium helps in teaching "scientific atheism".

Questions 5.1 - 5.7 cover the cognitive domain and questions 5.8 - 5.14 cover the affective domain. Question 15 contained in the table deals with the number of planetariums in operation and is intended to serve a separate survey in the framework of this thesis. It was included in this survey for organizational reasons.
**TABLE 14**

**" DISCUSSIONS HELD WITH A KNOWLEDGABLE AUDIENCE ABOUT THE EDUCATIONAL VALUE OF THE PLANETARIUM "**

" Astronomical Week ", University of Riyadh, Saudi Arabia 1977

(A) Cognitive Domain
(B) Affective Domain

<table>
<thead>
<tr>
<th>Arguments Discussed</th>
<th>Agree</th>
<th>Undecided</th>
<th>Disagree</th>
<th>Score</th>
</tr>
</thead>
<tbody>
<tr>
<td>(A) 1) The Planetarium is a very potent teaching tool for the conceptual basis of astronomy.</td>
<td>31</td>
<td>0</td>
<td>0</td>
<td>93</td>
</tr>
<tr>
<td>2) makes one independent of time, climate and location.</td>
<td>31</td>
<td>0</td>
<td>0</td>
<td>93</td>
</tr>
<tr>
<td>3) helps one to understand space-age problems and why so much money is spent for space travel and research.</td>
<td>30</td>
<td>1</td>
<td>0</td>
<td>92</td>
</tr>
<tr>
<td>4) can also be used for teaching related subjects like climatology and environmental topics.</td>
<td>26</td>
<td>3</td>
<td>2</td>
<td>86</td>
</tr>
<tr>
<td>5) helps the layman or arts student to understand more about natural science.</td>
<td>31</td>
<td>0</td>
<td>0</td>
<td>93</td>
</tr>
<tr>
<td>6) performances sharpen the student’s mind to convert observations into useable data.</td>
<td>31</td>
<td>0</td>
<td>0</td>
<td>93</td>
</tr>
<tr>
<td>7) allows repetition of a scene for better understanding.</td>
<td>31</td>
<td>0</td>
<td>0</td>
<td>93</td>
</tr>
<tr>
<td>(B) 8) exerts a strong motivation on students.</td>
<td>31</td>
<td>0</td>
<td>0</td>
<td>93</td>
</tr>
<tr>
<td>9) will form a link between a university and the general public.</td>
<td>30</td>
<td>1</td>
<td>0</td>
<td>92</td>
</tr>
<tr>
<td>10) is good for entertaining guests and other visitors to the university.</td>
<td>31</td>
<td>0</td>
<td>0</td>
<td>93</td>
</tr>
<tr>
<td>11) fosters the religious concept of God’s great creation.</td>
<td>31</td>
<td>0</td>
<td>0</td>
<td>93</td>
</tr>
<tr>
<td>12) has a long and fascinating history as a teaching tool.</td>
<td>31</td>
<td>0</td>
<td>0</td>
<td>93</td>
</tr>
<tr>
<td>13) is awe-inspiring in a mystic way.</td>
<td>24</td>
<td>4</td>
<td>3</td>
<td>83</td>
</tr>
<tr>
<td>14) satisfies a universal appetite for scientific information.</td>
<td>31</td>
<td>0</td>
<td>0</td>
<td>93</td>
</tr>
<tr>
<td>15) ought to be installed in many more places. Planetariums are not available in sufficient numbers.</td>
<td>29</td>
<td>1</td>
<td>1</td>
<td>90</td>
</tr>
</tbody>
</table>

Sample Size: 31

| Actual Total Score: | 643 | 640 |
| Possible Maximum Score: | 651 | 651 |

| Actual Mean:          | 643:31 = 20,74 (98.76%) | 640:31 = 20,64 (98.29%) |
| Maximum Mean:         | 651:31 = 21,00         | 651:31 = 21,00         |

**Summary**

Thirty-one members of a scientific conference, called "Week of Astronomy" held in 1977 in Riyadh, Saudi Arabia, participated in a discussion about the planetarium’s importance and educational value. They almost unanimously agreed on the planetarium’s high educational value and also pointed to the "mystic effect" created by the planetarium.

(Question 15 serves a different survey and therefore is not counted here.)
6. Discussion and Evaluation:

The chance gathering of a competent audience, who participated in a series of lectures on astronomy, including a lecture on the planetarium, seemed to be a good opportunity to discuss some aspects of the planetarium pertaining to its educational value. The topic was a very current one as the University of Riyadh had just bought a complete set of planetarium equipment.

The questions posed by the author or which evolved from the discussions gave rise to no great controversies, but are illustrative of some aspects of the planetarium's educational value. Most discussions ended with a consensus on the respective issues.

In the cognitive domain the arguments which were discussed were those which are frequently heard in favour of the planetarium as a teaching tool.

6.1 While question 1 summarizes the advantages of the planetarium as a potent teaching tool, it limits its application to the conceptual basis of astronomy. This is perhaps too narrow a description, but all participants "agreed" to it without excluding additional fields of application, as the answers to question 4 reveal.

The other questions detail some of the more obvious points in the operation of a planetarium which have obviously contributed to its value as a teaching tool.

6.6 Question 6 is a very pointed argument of particular importance as it treats an essential behavioural objective in science education: "to sharpen the student's mind to convert observations into usable data."

In the affective domain 3 questions are directly concerned with purely educational aspects, in which the planetarium's value as an educational tool can reveal itself. These are:

6.8 All participants believe in the strong motivation exerted on students by the planetarium. If this instrument really should succeed in motivating students for better learning than it would indeed have proved its value in this important domain.
6.11 The promotion of religious concepts is ascribed to the planetarium by all participants which also underlines its educational value for this aspect of teaching astronomy.

6.14 As a public institute the planetarium satisfies a universal appetite for scientific information, according to the unanimous opinion of the 31 participants, which is based on observation and experience. The fulfillment of this function certainly lends educational value to the planetarium. - As other questions in other surveys reveal, the planetarium is also capable of creating an appetite for scientific information.

The remaining questions in the affective domain deal with special functions and quite a particular effect of the planetarium.

6.9 + 6.10

The function of the planetarium as an institute for public relations between a university, visitors to the university, and the general public is a special facet in the range of arguments about the planetarium's cultural importance.

6.12 The planetarium's long history as an educational tool is used as an indirect proof for its educational value, by recording its application and use throughout the centuries.

6.13 "Awe-inspiring in a mystic way". The majority of the participants believe in the "mystic effect" (Ridky 1973)* of the planetarium in the sense that a certain extraordinary tension and an atmosphere of expectancy is created in the planetarium, which tends to enhance both readiness and reception. Some have argued that this could just as easily result in distraction and confusion, at least in the early phases of the performance.

The agreement found to the questions posed is 98.76% in the cognitive domain and 98.29% in the affective domain. The small difference between the two percentages is of no significance as it lies well within the range of experimental error, i.e. unequal weight of the questions in the two domains.

*) Ridky, Robert William, op.cit.
Participants in the discussions held in Riyadh about the planetarium's importance and educational value came from Saudi Arabia, Iraq, U.A.R., USA, West Germany and France.

The members of this international scientific gathering rate the planetarium very highly as an educational tool in terms of the test instrument used.

7. Conclusion:

The results of the 5 parts of this survey support the operational hypothesis which has governed this study, and in doing so the results of this survey simultaneously support that part of the general hypothesis saying that planetariums are believed to be educationally valuable teaching tools in terms of the test instruments used with the population of these studies.

This audience of general proponents for the planetarium have positively confirmed for their group the questions posed in survey II/4 about how the groups concerned with the planetarium rate its educational value.

It is a priori understood that the opinions of the proponents of the planetarium can only be favourable and, as the results of this survey indicate, the possibility that these opinions might be a possible cause for the underuse of the planetarium must be conclusively rejected.

An enquiry conducted with manufacturers of the planetariums follows in the next survey report II/9.
"PLANETARIUM MANUFACTURERS RATE THE PLANETARIUM HIGHLY AS A TEACHING TOOL"

A Survey Conducted with Planetarium Manufacturers

1. Introduction:

   Planetarium manufacturers are perhaps the most biased group to be included in a survey on the planetarium's educational value. But in line with the introduction given to chapter II, the opinions of all groups concerned with the planetarium should be heard for the sake of completeness.

2. Theme and Purpose:

   The theme of this report is an investigation with manufacturers of planetariums as to their opinions and attitudes regarding the educational potential of the planetarium. The purpose of this survey is to seek support on the level of manufacturers for that part of the general hypothesis saying that planetariums are educationally valuable teaching tools. Also confirmation of survey II/4 is sought.

3. Methodology:

   Personal interviews with the population in question were the exclusive means used for collecting the necessary data in this survey.

4. Population and Procedure:

   The author has conducted several informal and formal interviews with the responsible staff members of the Zeiss Company in Oberkochen, West Germany, and with the Spitz Space Systems Company in Chadds Ford, Pennsylvania / USA. The interviews dealt with many aspects of the planetarium including, as an important point, the question of the value of the planetarium as an educational tool. The people interviewed see the planetarium from many angles. Their intimate familiarity with the complete system, their decades-long experience in building, selling, operating and servicing planetariums and their intensive contacts with their educational clientele supply them with a stock of knowledge that allows these specialists to give their answers with some authority. The two above-mentioned companies were
chosen because the former are the inventors of the large projection planetarium and the latter invented the small school planetarium and has equipped about 3/4 of all planetariums in existence, i.e. the vast majority, most of them being in the USA.

The author had no adequate opportunities for similar intensive discussions with other manufacturers of planetariums. This consequently kept the sample small. The total sample size amounts to N = 12 only.

Of course, it is safe to assume that the personnel of the planetarium manufacturers are agreed as to the high educational value of the planetarium - and indeed they are agreed on this point - but they also emphasized the pure entertainment value and the prestige value of the planetarium and gave examples where the two latter points had, in some cases, been the predominant considerations in planetarium purchase.

The discussions were always frank, but no criticism was expected to come from this sample, which is a limiting factor.

5. Rationale of the Questions:

The questions dealt with in the framework of the other research programmes on the educational value of the planetarium, which highlight the planetarium's potential and functions, reappeared during the interviews conducted with the planetarium manufacturers. Those that were selected for presentation in this report seemed also to be the most important ones to the personnel of the planetarium manufacturers in both the cognitive and affective domains. All questions were direct in character and all but one were positively phrased. Only three columns are provided in the table. Rank orders were not calculated, as scores appear too uniform. Because of the factor of the bias of the test group, it was not thought fruitful to construct a finer measuring instrument. Validity seems assured as these questions cover the subject and were selected after judicious studies of the subject. Reliability is nearly self-understood, as it seems safe to assume that the subjects would answer in the same pattern, were the survey to be repeated.
6. Findings

The findings of this survey are listed in the table on the following page.

The questions, the distribution of the answers and the resulting scores are enumerated.

Opinions deviate only very little from full agreement. But opinions had actually to be heard before we could be sure that they were what we expected them to be.

7. Discussion and Evaluation:

The questions in the cognitive domain describe aspects of the potential and of the functions of the planetarium and compare it to other teaching media.

It became obvious that planetarium manufacturers are convinced of the high educational value of the planetarium as a teaching tool, and that they rated it as being generally superior to talk and chalk in all sections of descriptive astronomy. Planetarium manufacturers also see the planetarium as being a good place to supplement teaching in other school subjects such as physics, mathematics, and special aspects of geography and environmental sciences. They believe that planetariums are not sufficient in number.

They furthermore unanimously qualified the basic assertion about the positive educational value of the planetarium by the statement that "the planetarium's success as a teaching tool depends on the degree of the lecturers' capability of teaching a lesson and handling the equipment." Even an automatic demonstration depended for its success on the teachers' ability to create a programme. The equipment itself counted for only a part of the success, once basic requisites as to the equipment's quality and versatility were fulfilled.

The fact was mentioned that several well-equipped planetariums lacked popularity in spite of their good installations, simply because of the insufficient qualifications of the people responsible for conducting the performances, or because of their lack of enthusiasm and
**TABLE 15**  
"THE EDUCATIONAL VALUE OF THE PLANETARIUM"  
Survey with Planetarium Manufacturers

(A) Cognitive Domain  
(B) Affective Domain  

<table>
<thead>
<tr>
<th>No.</th>
<th>Question</th>
<th>Score</th>
<th>Agree</th>
<th>Undecided</th>
<th>Disagree</th>
</tr>
</thead>
<tbody>
<tr>
<td>A 1</td>
<td>The Planetarium is a valuable cultural institution serving school and adult education.</td>
<td>36</td>
<td>12</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>2</td>
<td>The Planetarium is a very potent teaching tool for most fields of astronomy.</td>
<td>36</td>
<td>12</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>3</td>
<td>The Planetarium is independent of time, climate and location when demonstrating celestial events.</td>
<td>36</td>
<td>12</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>4</td>
<td>The Planetarium simulates the sky better than all other educational media.</td>
<td>35</td>
<td>11</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>5</td>
<td>Only the Planetarium can show the full starry spherical sky. Films and slides show only sections.</td>
<td>36</td>
<td>12</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>6</td>
<td>The Planetarium is distinctively superior in the field of astronomy when compared to other teaching media like blackboards, charts and globes.</td>
<td>35</td>
<td>11</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>7</td>
<td>The Planetarium performance is dramatically presented. Time is condensed. The performance is highly instructive.</td>
<td>36</td>
<td>12</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>8</td>
<td>Other school disciplines like mathematics, physics and geography, even history, can profit also from the Planetarium.</td>
<td>34</td>
<td>10</td>
<td>2</td>
<td>0</td>
</tr>
<tr>
<td>9</td>
<td>The Planetarium has been and tends to remain a successful cultural institution, comparable to a museum, zoological and botanical garden.</td>
<td>36</td>
<td>12</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>10</td>
<td>There are not enough Planetariums in operation.</td>
<td>36</td>
<td>12</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>B 11</td>
<td>The Planetarium stimulates an interest in astronomy purely by its existence and reputation.</td>
<td>30</td>
<td>8</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>12</td>
<td>Pupils seem to prefer the Planetarium to the conventional classroom for studying astronomy.</td>
<td>35</td>
<td>11</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>13</td>
<td>The Planetarium exerts a strong motivation on students. They feel stimulated by the Planetarium to a more intensive occupation with the subject matter.</td>
<td>33</td>
<td>10</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>14</td>
<td>Students feel confused by the mystic temple atmosphere of the large Planetarium.</td>
<td>32</td>
<td>1</td>
<td>2</td>
<td>9</td>
</tr>
<tr>
<td>15</td>
<td>Students feel intellectually stimulated by the Planetarium demonstration to contemplation and thought beyond mere factual knowledge.</td>
<td>31</td>
<td>8</td>
<td>3</td>
<td>1</td>
</tr>
<tr>
<td>16</td>
<td>The Planetarium exerts a great attraction on people.</td>
<td>32</td>
<td>9</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>17</td>
<td>As a rule, no visitor would regret having gone to a Planetarium performance.</td>
<td>34</td>
<td>11</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>18</td>
<td>People would develop a pride in their school or community for owning such a cultural institute.</td>
<td>29</td>
<td>7</td>
<td>3</td>
<td>2</td>
</tr>
<tr>
<td>19</td>
<td>The Planetarium tends to unite families in erudite entertainment.</td>
<td>33</td>
<td>10</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>20</td>
<td>Space travel has enhanced the importance of the Planetarium and brought new groups of visitors.</td>
<td>34</td>
<td>11</td>
<td>1</td>
<td>0</td>
</tr>
</tbody>
</table>

Actual Total Score: **678** (94.16%)  
Possible Maximum Score: **720**

**Summary**

Twelve staff members of the two most prominent manufacturers of planetariums valued the planetarium highly as a teaching tool, in both the cognitive and affective domains, but they demand that the planetarium lecturers be well trained to ensure success in the practical use of the equipment.
inspiration. It is obvious that the planetarium manufacturers like to see their installations well operated and successful, as this serves as good recommendations for the next prospective customer.

In the affective domain the manufacturers see the educational value of their equipment mainly in the stimulus it exerts on visitors for occupying themselves with the science of astronomy. They consider it a very attractive place and are convinced that (good) planetarium performances will satisfy their audiences. Space travel has given an additional task to the planetarium: to act as a mediator between a new branch of science and the general public.

As to the "temple atmosphere effect" - called the "mystic effect" by Ridky\(^1\) - an effect that the author has observed in many planetariums, especially the larger ones, most of the gentlemen interviewed confirmed this observation but all did not agree with the term, nor was the term "mystic effect" generally accepted. It was conceded, however, that the dome-topped planetarium chamber, the chamber illumination, the projection equipment dominating the centre of the auditorium plus the arrangement of the entrance hall did create in the audience a "special atmosphere", an atmosphere of expectancy and an air of anticipation of the performance to come. The very beginning of the show was generally described as being awe-inspiring to some degree, especially with younger children. Dean describes this early moment in a planetarium show quite ironically\(^2\) "... will there be a large audience, hushed as the lights dim and the instrument rises mysteriously from the floor while the stereo booms out ... also sprach Zarathustra". It was generally assumed that these moments of expectation and initial experience actually enhanced the audience's state of receptiveness and hence exerted a positive learning effect by creating an open-mindedness towards the lesson to be taught. This point is treated elsewhere in this paper.

---

1) Ridky, Robert William, op.cit.

8. **Conclusion:**

The results of this survey support the operational hypothesis, and in this, support that part of the general hypothesis saying that planetariums are believed to be educationally valuable teaching tools in terms of the 20 questions posed to the planetarium manufacturers.

The results of this survey on the manufacturer's opinions about the planetarium's potentials and functions answer the question posed in survey II/4 of how the value of the planetarium is rated by those concerned with it. This is, of course, highly positive in this survey conducted with planetarium manufacturers. Many of the points contained in the questionnaire of this survey confirm the findings of survey II/4 concerning the planetarium's potentials and functions. The planetarium manufacturers are highly competent in this respect.

9. **Implication:**

As was fully expected, the results of this survey on the manufacturer's opinions about the planetarium's potentials and functions as an expression of its educational value eliminate these opinions as a possible factor responsible for the underuse of the planetarium.

**Outlook:**

This survey closes the round of opinion polls on the planetarium's educational value. Very early in the surveys of chapter II, programme II/4 attempted to define the planetarium's educational value in absolute terms as an intrinsic value by investigating its potentials and technical functions.

The next programme is occupied with yet another attempt to define the planetarium's value in absolute terms. 5 experiments with students were conducted to this effect in 2 West German planetariums.
"PLANETARIA MAY NOT MEET WITH EXPECTATIONS
OF EDUCATIONAL ACHIEVEMENT IN THE ACTUAL
TEACHING/LEARNING SITUATION"

5 Tests Conducted in the Planetarium
"EXPERIMENTS AND TESTS PERFORMED IN THE PLANETARIUM

MAY NOT ESTABLISH ITS EDUCATIONAL VALUE"

Experiments in the Planetarium

Introduction and Synopsis

1. INTRODUCTION:

1.1 Opinion Polls

In the preceding surveys II/5-9 the attempt was made to question all those groups concerned with the planetarium in one capacity or another as to their opinions about its educational value. While the prevalence of a sufficiently high degree of positive opinion (based on intuition, experience, hearsay, industry's successful propaganda, or whatever else) may be adequate justification for the existence of a planetarium and the installation of additional ones, such opinion alone cannot be the proper basis on which to define the planetarium's educational value as a teaching tool in an absolute manner. If such an absolute definition should be possible at all, it has to be based on the results of judicious experimentation and guided by the proven methodologies of educational research.

The study of the planetarium's intrinsic value on grounds of its teaching potentials and technical functions is a different approach to an absolute determination of its educational value. See survey II/4.
1.2 Educational Research

-------------------

It is significant in this context that, both in the pilot survey conducted with the schools in West Germany and in the large survey conducted with the same population, the majority of teachers did rate the planetarium as a good supplement to the more classical media of teaching astronomy, and only a smaller section of the respondents described the planetarium flatly as being superior to these simpler media.

The debate about whether or not the planetarium should be used in the first place has - looking at the research performed as a whole - been essentially shifted to the investigation of the teachers' interest in the planetarium as a teaching tool and their (and others) evaluation of its worth as such a tool - the investigation of a status rather than of a true basic justification for the use of the planetarium as a teaching tool. The teacher and other competent parties have given their personal opinions and their overwhelmingly large acceptance of the planetarium has been found to be based exclusively on intuition, observation and experience, rather than on the results of judicious experimentation with the equipment. It has been stated that the opinions prevailing in the responsible circles decide the planetarium's fate regardless of the base that may have produced the prevailing opinions.

The surveys described in programme II/4 and in this section try to find proof of a more basic justification for the existing enthusiasm towards the planetarium by a determination of its intrinsic value and by testing this teaching tool in active teaching-learning situations.

Prior to beginning one's own experimentation with the planetarium as a teaching tool, it seems expedient to review and to assess the relevant research literature on this subject in order to learn from the previous experience of others and in order to relate one's own research to what has been already done in the field. This has been done in survey II/3.
1.3 The Experiments

5 groups of West German pupils (N = 222, age group 12 - 17 years) were tested in 2 medium-size school planetariums. Tests in the cognitive and the affective domain were conducted to test two principal hypotheses, stating a) that pupils can successfully learn their lessons in the planetarium, b) that the planetarium experience stimulates a positive attitude towards this medium.

Thus an attempt has been made to test the planetarium's educational value both in the cognitive and in the affective domain.
### Table of Contents

<table>
<thead>
<tr>
<th>No.</th>
<th>Section</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Theme and Purpose</td>
<td>282</td>
</tr>
<tr>
<td>2.</td>
<td>Justification for the Research</td>
<td>283</td>
</tr>
<tr>
<td>3.</td>
<td>Null Hypotheses</td>
<td>285</td>
</tr>
<tr>
<td></td>
<td>Principal Hypotheses</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Sub-Hypotheses</td>
<td></td>
</tr>
<tr>
<td>4.</td>
<td>Population</td>
<td>286</td>
</tr>
<tr>
<td></td>
<td>4.1 Localities for the Tests</td>
<td></td>
</tr>
<tr>
<td></td>
<td>4.2 Groups: A) Recklinghausen, Group I, Group II</td>
<td>287</td>
</tr>
<tr>
<td></td>
<td>B) Kiel, Group III, Group IV, Group V.</td>
<td></td>
</tr>
<tr>
<td>5.</td>
<td>Procedure</td>
<td>288</td>
</tr>
<tr>
<td></td>
<td>5.1 Test Instrument</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Cognitive Domain</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Affective Domain</td>
<td></td>
</tr>
<tr>
<td></td>
<td>5.2 Limitation</td>
<td>289</td>
</tr>
<tr>
<td></td>
<td>5.3 Reliability and Validity</td>
<td>290</td>
</tr>
<tr>
<td></td>
<td>Cognitive Domain</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Affective Domain</td>
<td></td>
</tr>
<tr>
<td></td>
<td>5.4 Calibration of the Test Instrument</td>
<td>292</td>
</tr>
<tr>
<td></td>
<td>Cognitive Domain</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Affective Domain</td>
<td></td>
</tr>
<tr>
<td></td>
<td>5.5 Design of the Tests</td>
<td>295</td>
</tr>
<tr>
<td></td>
<td>5.6 Rationale of the Questions of the Attitude Test</td>
<td>296</td>
</tr>
<tr>
<td></td>
<td>5.7 Implementation of the Experiments</td>
<td>298</td>
</tr>
<tr>
<td></td>
<td>and Data Collection</td>
<td></td>
</tr>
<tr>
<td></td>
<td>The Tests</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Data Collection</td>
<td></td>
</tr>
<tr>
<td>6.</td>
<td>Findings</td>
<td>300</td>
</tr>
<tr>
<td></td>
<td>Cognitive Domain and Affective Domain</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Group Achievements</td>
<td></td>
</tr>
<tr>
<td>No.</td>
<td>Section</td>
<td>Page</td>
</tr>
<tr>
<td>-----</td>
<td>-------------------------------------------</td>
<td>------</td>
</tr>
<tr>
<td>7.</td>
<td>Findings</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Affective Domain Total Achievement</td>
<td>305</td>
</tr>
<tr>
<td>8.</td>
<td>Discussion</td>
<td></td>
</tr>
<tr>
<td></td>
<td>8.1 Confirmation of the Quality of the Test Instrument</td>
<td>307</td>
</tr>
<tr>
<td></td>
<td>for the Cognitive Domain</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Comparison with tests performed in the USA</td>
<td>308</td>
</tr>
<tr>
<td></td>
<td>8.2 Discussion of the Findings in the Cognitive Domain</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Bandwidth of Performance - Loosing Points</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Correlation between Low Cognitive Performance and</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Affective Attainment - Group Differences in</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Performance - Evaluation of Results.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>8.3 Discussion of the Findings in the Affective Domain</td>
<td></td>
</tr>
<tr>
<td></td>
<td>The Emotional Questions - The Factual Questions.</td>
<td>315</td>
</tr>
<tr>
<td>9.</td>
<td>Statistical Treatment of the Hypotheses</td>
<td></td>
</tr>
<tr>
<td></td>
<td>and Interpretation of Data.</td>
<td>315</td>
</tr>
<tr>
<td>10.</td>
<td>Conclusion</td>
<td>325</td>
</tr>
<tr>
<td>11.</td>
<td>Implication</td>
<td>326</td>
</tr>
<tr>
<td>12.</td>
<td>Documentation</td>
<td>327</td>
</tr>
</tbody>
</table>
5 TESTS CONDUCTED IN THE PLANETARIUM

1. Theme and Purpose

The theme of this survey is a second attempt to define the planetarium's educational value in an absolute manner, supplementary to survey II/4.

The purpose of this study is to seek a test on the students' level for that part of the general hypothesis saying that "planetariums are believed to be educationally valuable teaching tools".

Educational value has been defined elsewhere in this thesis, and in accordance with the definition given there it is attempted to bring the hypothesis to the test by experimentation. The educational value of the planetarium is thus to be tested in terms of its effectiveness as a teaching tool in both the cognitive and the affective domain.

It is obvious from everything that has been said up to now that the author does not attribute much value to experimentation that compares the planetarium teaching situation with the classroom teaching situation in order to establish which of the two is superior. Only in the affective domain are the subjects themselves invited in one particular question to make a comparison between the classroom and the planetarium learning situations. For it seems to come naturally to students to express their liking for a medium in terms of a preference to other media. The experience gained in the preceding survey with planetarium visitors on an international level has confirmed this. That survey had been exclusively conducted by personal interviews.

Instead of the general classroom - planetarium comparison, the author prefers to test the question of whether or not the planetarium is, in its own right, an effective teaching medium in the cognitive domain. Several teaching tests were performed to prove whether or not students can meet with the behavioural objective of learning an astronomy lesson in the planetarium. This is combined with an attempt to show as closely as possible how well they have learned
the astronomy lesson in the planetarium.

In the affective domain the question is tested of whether or not the planetarium is in its own right an effective teaching medium. This is done by adding an attitude test to the cognitive tests mentioned above. This test was designed to show if the planetarium can serve the behavioural objective of stimulating the students' emotions positively. This is combined with an attempt to show as close as possible the strength of the pupils' attitude towards the planetarium performance.

The emphasis of the tests lies in the affective domain, as little research has been done into this aspect of the planetarium's application as a teaching tool.

In investigating the above 2 research problems, the author arranged for two sets of tests to be carried out in two German planetariums with 5 groups of German school students.

The question of giving the planetarium a rank order place within the array of teaching media available has been left to the preceding school media survey no.II/4 and to the preceding general school survey carried out in West Germany. Experimentation in the planetarium has been limited to the above two questions.

2. Justification for the Research:

It may be argued that the two questions mentioned above could have been sufficiently answered by extracting the relevant information from the 13 research papers reviewed in programme 2 of section II/2. It must, however, be mentioned that all 13 papers reviewed and discussed in programme 2 of section II/2 refer exclusively to work done in the USA, and it cannot be asserted with certainty that conditions in the USA school system can be readily equated with conditions in the school system of West Germany. It is hence doubtful whether results of research performed in the USA school system can be transferred in their full findings and meanings to the conditions prevailing in the school system of West Germany. Even a very superficial attempt of comparing the two systems reveals significant differences, such as hours spent in school during the day, time of vacation,
methods of instruction, scope of compulsory subjects, supervision of students' spare time, guidance provided for youth outside school hours, teacher-student ratio, racial and religious variety in the student population, general environment, percentage of students transferring from primary to intermediate and secondary education, mobility of parents, and possibly a number of other factors. It is true that, broadly speaking, none of the USA research papers reviewed brought evidence to the effect that pupils did not learn their lessons in the planetarium, and it is likewise true that most of the authors who treated the subject at all saw some of the value (if not the main value) of the planetarium as being its effectiveness in the affective domain. It might be safe enough to assume that these broad statements would hold true elsewhere. General literature adequately supports this view. However, it was concluded from the treatment of research literature that each paper seemed valid only for the conditions under which the research had been performed. Additionally, it may be safer to assert that whatever generalizations these papers do allow to be drawn would mainly be valid only for the USA rather than for conditions prevailing elsewhere.

It seemed essential to prove that students in West Germany could successfully learn an astronomy lesson in the planetarium, as it might easily be possible that many disturbing factors could prevent this in the new and unaccustomed environment. Moreover, it seemed particularly essential to prove that students develop a positive attitude towards the planetarium learning situation and thus feel more stimulated towards learning the subject matter presented there. For George Reed (op.cit.) and others have pointed out that the planetariums' value may be more strongly apparent in the affective domain than in the cognitive domain.

The above considerations have lead the author to perform a set of tests in West German planetariums with a population of West German school children in order to seek support for that part of the general hypothesis which is guiding this study.
3. **Null Hypotheses:**

**Principal Hypothesis**

---

1. There is no statistically significant difference in achievement, as measured by the Astronomy Achievement Test between pre-test and post-test by attending a planetarium performance.

**Sub-Hypotheses**

---

2. There is no statistically significant difference in achievement between boys and girls of the same test group, as measured by the Astronomy Achievement Test after a planetarium lecture-demonstration.

3. There is no statistically significant difference in attainment in the affective domain between boys and girls of the same test group, as measured by a 10-question attitude test after a planetarium lecture-demonstration.

4. There is no statistically significant difference in attainment in the affective domain between younger and older pupils, as measured by a 10-question attitude test after a planetarium lecture-demonstration.

5. There is no statistically significant difference in attainment in the affective domain between pupils being lectured in the planetarium and general visitors going there for erudite entertainment, as is measured by a 10-question attitude test after respective planetarium performances.

6. There is no correlation measurable between attainment in the affective domain and achievement in the cognitive domain.

Besides the above hypotheses that can be tested statistically, a further hypothesis is brought forward concerning the planetarium's value in the affective domain. Whereas the tests in the cognitive domain have included a pre-test, thus providing a clear basis to measure achievement in terms of the difference between the two sets
of scores, only a post experience test was possible in the affective domain, as the author was unable to construct a pre-test instrument of equal weight to the post experience test instrument. The hypothesis reads therefore as follows:

7. The planetarium lecture does not produce a positive attitude towards this medium as is measured by a 10-question attitude test performed after a planetarium-lecture-demonstration.

4. Population:

1. Localities for the Tests

It was intended to investigate whether or not suitable tests could be conducted with the help of schools, perhaps in an existing school planetarium, but the idea had to be withdrawn by the author due to difficulties with the official rules regulating such experiments. It proved to be easier to seek an arrangement with existing planetariums not owned by schools but open to schools. Once the planetarium directors agreed to the idea of experimentation, any suitable visiting school groups could be randomly selected by the planetarium staff for conducting the tests.

The planetariums in Recklinghausen and in Kiel, West Germany, were kind enough to accept the author's application and agreed to conduct the experiments prepared by the author. Both planetariums are small planetariums and are used for providing lectures for school groups of different levels of preparation. Many groups coming to the two planetariums have little previous knowledge of astronomy as many of the primary and intermediate schools offer only selected astronomical themes in the framework of their normal school curriculum.

Conducting the tests on neutral ground tends to exclude such difficult variables as schools' eagerness to excel, school teachers' bias in favour or against their own school planetarium, and students' involvement in their own school planetarium's activities.

2. Groups

Five student groups with a total N figure of 222 participated in the tests. The full number was employed in an Astronomy Achieve-
ment Test, while a few less, namely a total of 217, participated in an attitude test. It is not known why 5 students did not participate in the attitude test. Five tests took place, two of them in the Recklinghausen Planetarium and three in the Kiel Planetarium. The groups were distributed as follows:

A Recklinghausen:

**Group I**: N = 56, Girls N = 31, Boys N = 25,
age group 14/15 years. This was a mixed ability group in the sense that an undefined part of them came from a local high school and another, likewise undefined part from a local primary school.

**Group II**: N = 64, Girls N = 40, Boys N = 24,
age group 12/13 years. This was a homogeneous group of high school students. These were the youngest participants.

B Kiel:

**Group III**: N = 14, Girls N = 6, Boys N = 8,
age group 16/17 years. This was a homogeneous class of an intermediate school participating in a special earth science course. As the N number is very small, girls and boys were not treated separately later on in the stage of data evaluation.

**Group IV**: N = 53, Girls N = 22, Boys N = 31,
age group 13/15 years. This was a homogeneous high school group.

**Group V**: N = 35, Girls N = 12, Boys N = 23,
age group 16/17 years. This was a homogeneous group of a vocational school, commercial branch, where no science is being taught. The participants are commercial apprentices who have - as a rule - only one day or one full and one half day of school per week. This group is particularly noteworthy as it is described by the planetarium professor as a group of low motivation for studying the subject of astronomy. They were
chance visitors who simply had nothing else to do on a day off and just happened to find the planetarium open. By virtue of the fact that they are a group of low motivation they are interesting subjects for the tests and can be contrasted with the other four groups to whom customary motivation can safely be attributed since they all come from normal curriculum schools, where science subjects are taught. Their motivation seemed apparent to the planetarium professors according to their comments on the groups.

The groups were randomly selected as they came to the planetarium, and are a representative cross section through the school system prevailing in West Germany, excepting however the upper section (3 top classes) of the high schools and specialized schools. These groups were excluded from the study by virtue of the random selection process.

5. Procedure:

5.1. Test Instrument

The cognitive domain:

In searching for a standardized astronomy achievement test in the cognitive domain, the author compared the various tests used in the research literature described in the preceding programme, II/3, and decided in favour of the standard test designed by W.T. Barnard, as used by D.L.C. Wright in her thesis "Effectiveness of the Planetarium and Different Methods of its Utilisation in Teaching Astronomy", 1968, (op.cit.).

The test consists of 80 comparatively easy questions, suitable for testing knowledge gained after one only planetarium demonstration lecture. In the original version, 40 minutes were allowed for completion of the test, a time apparently sufficient for the eighth grade students who participated in the test. The original test asks the student simply to mark "t" for true, or "f" for false in front of each statement in the test. The author has modified this procedure by inserting a third sign for "don't know". This was done in order to exclude guessing as far as possible at the primary stage.
The 80 questions contained in Wright's paper were translated into German and sent to the two planetariums for selecting approximately 25 questions as pre- and post-test. Limiting the test to 25 questions was a necessity because of the limited time available for the teaching and test procedure.

The planetarium in Recklinghausen selected 25 questions from the list and the planetarium in Kiel selected 27 questions from the original list, both being suitable for the lessons taught. Thus content validity was assured. The questions in the two resulting test sheets are thus not fully identical. Both test sheets are printed in full in the appendix on pages 566 - 569.

The affective domain:
In the affective domain the author could not find a suitable test, with the exception of one "school life test" designed in the USA, but the publishers posed so many restrictions on its use and publication of results - in spite of the fact that the test plus evaluation instrument can freely be bought in the market - that the author saw himself compelled to resort to a test of his own design used already in the earlier planetarium visitors surveys. This offers the advantage of allowing a comparison between the newly tested more organized school groups and the previous groups of free visitors who participated in the planetarium visitors surveys. 10 questions in the affective domain follow the sets of test questions of the cognitive domain in the post-test sheet, in order to test participants' attitude towards the planetarium performance in the same manner as had been done previously in the planetarium visitors survey.

5.2. Limitation

The test used in the cognitive domain measures only accumulated knowledge; the practical application of the knowledge is not measured. Additionally the test is not very specifically planetarium-orientated and could in the authors' opinion - equally be applied for testing pure classroom teaching.

Tests used by other researchers, whose work has been described in the preceding programme might have been more appropriate, but those tests are more complicated, more time-consuming, and
lend themselves less easily to a selective application of the questions which would shorten answering time. Barnard's test can be used selectively without losing much of the broad spectrum which the questions cover, and the "wrong-right" type of question can be answered by the students in a minimum of time.

Time was the decisive factor. The author could not use a planetarium and a sufficient sample size at will. Too many obstacles stand in the way of any researcher who is not firmly integrated into the school- or planetarium system of West Germany, and the author had to be content with the limited opportunities that could be mobilized.

It would have been preferable to use a better designed test instrument for the cognitive domain, but prevailing circumstances did not permit this. The two planetariums could not spare more time and effort for the experiments than they actually did and there is every reason to be grateful to them for the assistance given.

As to the participating subjects, there is no limitation to be made as they represent a typical cross section through the school system of West Germany (except special schools) with contributions from several types of school including an older class of a primary school and a group from a vocational school.

As to the affective domain, a description is included in the next paragraph as to the validity and reliability of the test instrument.

5.3. Reliability and Validity

Cognitive Domain:
In the cognitive domain a standard test has been used. Reliability and validity seem consequently to be assured.

Affective Domain:
In the affective domain the test instrument is self-designed by the author and its reliability has been proved only by the method of producing consistently similar results in repeated applications of the test. The outcome of 13 different tests involving a
total sample size of \( N = 417 \) is fairly consistent within a certain explainable bandwidth. The attitude test may consequently be considered as being reliable. *)

The test instrument seems to have content validity in as much as it samples adequately the usual spectrum of opinions expressing the attitude of planetarium visitors towards its performance. This has been ascertained in the interviews conducted verbally with planetarium visitors on an international level in the frame of the respective pilot survey described earlier in this thesis. "Usual" describes the average attitude expressed by a more or less self-repeating array of argumentations.

The test instrument has face validity in as much as the questions posed are phrased so as to "feel" the visitors true emotions and judgements, as they were articulated by a representative sample in the above-mentioned pilot survey conducted by verbal interviews with a sample size of about 70 participants. The very thing to be measured is being investigated.

The test instrument has predictive validity in as much as the emotional questions contained in the test are arranged in clearly rising steps of strength of emotional expression resulting (as expected) in corresponding steps in the rank order of responses and in the relative percentage score ratings, producing a nearly straight regression line of a linear relationship, the rare case of a nearly perfect negative correlation between these two inter-dependent variables (see figure no. 2 on page331). The items discriminate in the same direction and measure thus the depth of feeling. This result holds true for the grand total of \( N = 217 \), and while a certain individual sub-group may produce a less clearly pronounced correlation, this does not however cloud the impression of the general tendency of the relationship and hence the predictive validity of the test. This internal consistency in the answers also confirms the reliability of the test.

*) This is the sum of all tests performed with both general planetarium visitors (II/6), and the 5 student groups of this survey.

**) Question No. 3 is both rational (factual) and emotional in character and has therefore been included in the graphic analysis which brings the number of questions treated in this way to a total of 7.
5.4. Calibration of the Test Instrument

5.4.1 Cognitive Domain

The score system provides us with a measure of attainment as it shows how much progress an individual subject or a group makes between pre-test and post-test. As there is no publication available in West Germany on experience gained in ranking scores of planetarium achievement, the author discussed a possible rating system with several experienced teachers, who based their suggestions on their classroom teaching experience and the rating system prevailing there. It was duly taken into account that in the tests performed wrong answers had been deducted from right answers in order to compensate for guessing. No other allowances were made, such as for the students unfamiliarity with lecture demonstrations. The following system was evolved:

<table>
<thead>
<tr>
<th>Rating for:</th>
<th>Gain</th>
<th>Post Test Scores</th>
</tr>
</thead>
<tbody>
<tr>
<td>Excellent</td>
<td>11 (and more)</td>
<td>25 (or 27) - 20</td>
</tr>
<tr>
<td>Very Good</td>
<td>10 - 8</td>
<td>19 - 16</td>
</tr>
<tr>
<td>Good</td>
<td>7 - 5</td>
<td>15 - 12</td>
</tr>
<tr>
<td>Pass</td>
<td>4</td>
<td>11 - 8</td>
</tr>
<tr>
<td>Insufficient</td>
<td>3</td>
<td>7 - 5</td>
</tr>
<tr>
<td>Failure</td>
<td>2 (and less)</td>
<td>4 (and less)</td>
</tr>
</tbody>
</table>

The rating scale for the gain scores is constructed for group averages.

It was considered that the system might have some weakness in doing justice to the particular teaching method of a lecture demonstration in the planetarium, since students had no previous experience in being taught in this new environment with no blackboard teaching and customary discussion in support.
To confirm the validity of the rating system adopted, a meaningful comparison was sought to similar tests performed in the USA. This is described later in paragraph 8.

5.4.2 Affective Domain

While tests in the cognitive domain have the customary score-system, which is based on correct and incorrect answers, as a valid standard measure of achievement and for individual and group comparison, the quality of the measure used in the affective domain is, by itself, less pronounced and calls for a standard of interpretation in order to render the score figures meaningful in ordinary terms. The group of the 10 questions in the affective domain has been devised in order to provide a measure for the attitudes that visitors - especially school children - have developed towards the planetarium after having experienced a lecture-demonstration there.

Weak Questions:

While it is realized that question 7 in the affective test, for instance, dealing with the spontaneously aroused desire "to bring family and friends to the planetarium", allows, where it applies, a feeling towards the planetarium to be expressed in a subtle and indirect way, the question does not supply a very rigid or even absolute general standard since considerations completely outside the planetarium experience - such as being at odds at home and with friends - may lead to a negative answer from an individual and thus reduce the total score figure.

In actual fact, however, the point of intersection of the rank order position place of question 7 and its relative percentage score rating place, plotted in the correlation graph for these two variables, deviates only very slightly from a straight regression line. See figure 2. This may be taken as an indication of an unreserved participation in the test.
Similarly, question 6 of the affective test is apt to unduly press on the score figure of any visitor who may feel disturbed by a sneezing or nut-crunching neighbour. Question 6 deals with the possibility that "there may be too much nonsense going on in the dark". It is true that if the dark planetarium chamber is experienced by the majority as being a noisy place, its value as a place of learning and/or erudite entertainment is lowered as long as the apparent disciplinary problem cannot be controlled.

**Factual Questions:**

In the field of the more factual question, in contrast to the predominantly emotional questions to which question 7 treated above belongs, ignorance may be a diminishing factor. Some students may not be able to make the comparison between the planetarium and the real sky in nature, as is invited by questions 8 and 9, and may therefore lose points on the attitude score table. But it is the pupils' attitude that we wish to learn, and it may be influenced by good or insufficient knowledge. The only thing that counts here is what the students feel.

In spite of a certain relative coarseness in some of the 10 questions dealing with the affective domain, these questions do in fact provide a fairly stable and reliable measure of attitude and also allow individual and group comparisons.

**Scale of Definitions:**

The questions of the affective test are presented on a Lickert scale table with the usual five columns that permit the respondent to give his answers strongly or less strongly pronounced, which allows for a certain band-width in the expression of feelings. Still, in view of the relative imprecision in a few of the questions in the attitude test, and as it is realized how unusual it therefore would be for anyone to score the maximum of fifty points, the author has attempted to provide some sort of compensation by describing the highest possible set of score figures, e.g. those in the range of 50 - 45, as expressing an "extremely strong attitude". The scale of definitions
thus reads as follows:

- 50 - 45 extremely strong attitude
- 44 - 40 very strong attitude
- 39 - 35 strong attitude
- 34 - 30 averagely strong attitude
- 29 - 25 weak attitude
- below 24 very weak attitude

In the above list "strong" is used to express a favourable feeling towards the planetarium: "averagely strong" describing a mildly positive feeling, "weak" stands for a negative feeling. It is expected that this system of rating attainment in the affective will do justice to the performance in the test.

5.5. Design of the Tests

In the cognitive domain the pre-test – post-test only design has been applied with no control group for comparison for reasons explained earlier. Achievement has been tested for each individual subject by comparing the scores attained in the pre-test to those of the post-test, and achievement has been expressed in terms of gains and post-test scores. When comparing the groups in their achievement to similar groups in the USA who had undergone the same test, a system of attained percentages of the maximum possible total has been used to measure and to express achievement. Students at the time of the pre-test were not informed that the post-test consisted of the same questions again. They were intentionally kept uninformed in order to exclude any particular alertness to the questions during the performance, that is, any more than was natural as a result of the pre-test situation.

A rights-minus-wrongs scoring formula was used to determine the scores of both pre-test and post-test, such as practised by Wright (op. cit.) from whom the test instrument has been adopted. This method is used to exclude the influence of guessing.

In the affective domain a 10-question attitude test was administered together with the post-test.
5.6. Rationale of the Questions of the Attitude Test

The questionnaire contains 10 questions and is printed immediately after the test questions on the form of the post-test, so as not to be overlooked by the subjects. A short introduction to the test and an invitation to participate is printed before the actual texts of the questions.

The test contains 6 emotional and 4 more factual questions and, while appearing in a random order, the emotional questions follow a system of a stepwise increasing strength of expression which, together with the 5-cell Lickert scale system, seems to the author to provide a sufficiently fine measuring grid. These 6 questions, arranged in the above order but retaining their running number as printed in the questionnaire, read as follows:

1 - "I like to learn astronomy in the Planetarium rather than in the classroom"

5 - "Actually I am sorry I went there"

2 - "I find the Planetarium demonstration too monotonous. Only stars. Boring!"

4 - "A Planetarium demonstration is an elevating and marvellous experience"

7 - "I should like to take my friends and relatives"

10 - "Every visitor must be inspired with enthusiasm by the Planetarium".

The remaining 4 questions are of no particular order of weight:

3 - "The Planetarium made me more interested in astronomy"*)

6 - "There is too much nonsense going on in the dark chamber"

8 - "The Planetarium does not equal reality to a sufficient degree"

9 - "During night time I can see everything just as well outside".

*) When considering question 3 as an emotional question it slips in between 7 and 10 above.
These 10 statements include the essential ones of those used by the author when verbally interviewing planetarium visitors during the pilot survey conducted with planetarium visitors on an international level. All questions are direct ones with the exception of question 7, which asks the respondents' feelings in a more roundabout manner. If someone "likes to take his friends and relatives to the planetarium" then it is safe to assume that he particularly likes the place. Admittedly, in the adverse situation, he may have other reasons than like or dislike, for not bringing them. The factual questions are likewise strong factors in the analysis of an attitude, as they contain criticism.

It was expected that responses would follow the pre-set order of the emotional questions in the sense that the number of affirmative votes would diminish more or less proportionally to the increase in the questions' emotional strength, i.e. it was expected that the first question would draw the most agreement-votes and the last question the least.

When plotting the succession of questions against the attained rank order of the relative percentage score ratings, it was expected that a fairly straight regression line of a slightly negative slope would result as an expression of the nearly perfect negative correlation between these two variables. (This very phenomenon lends predictive validity to the test instrument.)
5.7. Implementation of the Tests and Data Collection

---

Tests

Five tests were conducted, two of them in the planetarium at Recklinghausen and three in the planetarium at Kiel.

The tests and their execution were designed and planned by the author, but the practical administration of the tests was organized and executed by the planetarium directors, Herr Herrmann of Recklinghausen, and Herr Mewes of Kiel. Both gentlemen were most cooperative and very willing to take on the extra burden of work involved.

The execution of the tests proceeded as follows:

1st Test: Planetarium Recklinghausen

The theme of the lecture-demonstration was "A general introduction to the science of astronomy" and the planetarium professor made sure that the test questions corresponded to the subject matter presented. The duration of the performance was 55 minutes. The purpose and the method of the tests were briefly explained to the group of participating pupils. The starfield demonstration was supported by projecting several slides with a slide projector. The theme had not previously been treated in the school syllabus. During and after the performance there was no discussion and no summary of the subjects covered. The pre-test was administered immediately before the lecture demonstration, and the post-test with the joined attitude test followed immediately after the performance. All tests and lectures took place in the planetarium auditorium. Each test took 15 minutes. Students were assured that the tests were carried out independently of their schools and served only for planetarium and media research. Participants remained anonymous as they had to give only their first names and age for correlating pre-and post-test sheets. Students participated willingly, but they were warned not to try to please in the test.
2nd Test: Planetarium Recklinghausen
Theme and procedure of the experiment were as above. Since the participants in the second experiment were younger than those of the former group, they were given more time for the test, namely about 20 minutes for each. Otherwise similar and comparable conditions prevailed.

Both experiments were prepared between September and December 1978 and executed in January 1979.

3rd Test: Planetarium Kiel
The theme of the performance was "A general introduction to the science of astronomy". The duration of the planetarium lecture demonstration was 70 minutes. The purpose and the method of the experiment were briefly explained to the group of pupils participating in the experiment. The starfield demonstration was supported by projecting several slides with a slide projector. The theme had not previously been treated in the school syllabus. There was some discussion during the performance, but no summary was given at the end of it. Testing was carried out in the waiting hall of the planetarium, while the performance took place in the adjacent planetarium auditorium. Each test took about 10 minutes. Otherwise the same conditions as in the first test prevailed.

4th Test: Planetarium Kiel
Theme and procedure of the experiment were as above.

5th Test: Planetarium Kiel
Theme and procedure of the experiment were as above.

Conditions of all three experiments carried out in the planetarium of Kiel were very similar, and results are hence comparable.

The experiments were prepared between September and December 1978 and executed in February 1979.

Data Collection
Evaluation of all test sheets was done by the author by the method of hand-scoring. This was repeated several times and

*) Footnote: The longer lecture time introduces an uncontrollable variable in comparison to Recklinghausen.
cross-checked until all figures were correctly entered into the respective tables. The data collected were: pre-test scores, post-test scores, gain, attitude attainment scores. The highest possible scores in tests 1 and 2 were 25 in both instances in the cognitive domain in accordance with the number of questions. In the 3 experiments at Kiel the highest possible score in the cognitive domain was 27 in accordance with the number of test questions. The highest possible score figure in the attitude test was 50 for all 5 tests.

6. Findings, Cognitive Domain and Affective Domain, Group Achievements

The results of the 5 tests are summarized in 2 tables and 2 figures following after paragraph 8.3. A full set of tables, describing the tests performed by each individual group, is presented in the appendix pp. 570 - 587. Reference to these tables is made in the following descriptions of the findings. In each experimental group girls and boys are treated separately, with the exception of group III. Only 14 subjects participated in this group, too few to make a separation meaningful.

Group I, N = 56 Planetarium Recklinghausen
-------------------------------------------------

Sub-group A consisted of 31 girls. In the achievement pre-test the high score amounts to 20+, and the low score to 2+, a range of 18. In the post-test the high score reached 23+ ("excellent"), and the low score 8+ ("pass"), resulting in a range of 15. The highest gain is 13+ ("excellent") and the lowest is 4- ("failure"), a range of 17. The means are M I = 11.09, M II = 15.93 ("good"), M Gain = 4.84 ("pass"). 3 girls have lost points instead of gaining any.

In the affective domain the highest score is 47, which expresses an "extremely strong attitude". The lowest score is 29, expressing a "weak attitude". This mark is just on the border-line of an "averagely strong attitude". The range amounts to 18. The mean is 39.58 (79.16%), which expresses a "strong attitude". The mean is on the border-line of a "very strong attitude".

Sub-group B consisted of 25 boys. In the achievement pre-test the high score amounts to 21+, and the low score to 1+, a range of 20.
In the post-test the respective values were 23+ ("excellent") and 5+ ("insufficient"), a range of 18. The highest gain is 20+ ("excellent"), and the lowest is 2- ("failure"), a range of 22. The means are $M_I = 10.56$, $M_{II} = 15.88$ ("good"), $M_{Gain} = 5.32$ ("good"). One boy has lost points instead of gaining any.

In the affective domain the highest score is 46, which is expressing an "extremely strong attitude", and the lowest score is 23, expressing a "very weak attitude". The range is 23, extending over the full scale of ratings. The mean amounts to 38.32 (76.64%), expressing a "strong attitude" towards the planetarium performance.

Girls have scored higher in the affective domain, and boys have scored higher in the cognitive domain. This result was in accordance with the planetarium teachers' predictions based on their observation and experience and also with the author's observation and experience. Tables no. 42 and no. 43 summarize the results of the tests with Group I.

Group II, $N = 64$ Planetarium Recklinghausen

Sub-group A consisted of 40 girls. In the achievement pre-test the high score amounts to 17+, and the low score to 2-, a range of 19. In the post-test the high score amounts to 21+ ("excellent"), and the low score to 2+ ("failure"), a range of 19. The highest gain is 16+ ("excellent"), and the lowest is 5- ("failure"), a range of 21. The means are $M_I = 8.13$, $M_{II} = 12.20$ ("good"), $M_{Gain} = 4.08$ ("pass"). 7 girls lost points.

In the affective domain the highest score figure is 49, expressing an "extremely strong attitude". In fact, this particular figure is only 1 short of the maximum possible figure of 50. The lowest score figure is 27, expressing a "weak attitude". The range is 22. The mean reads 42.35 (84.70%), expressing a "very strong attitude" towards the planetarium, in fact the highest in all 5 experiments.

Sub-group B consisted of 24 boys. In the achievement pre-test the high score amounts to 19+, and the low score to 1+, a range of 18. In the post-test the high score amounts to 23+ ("excellent"), and the low score to 8+ ("pass"), a range of 15. The highest gain is 15+ ("excellent"), and the lowest is 7- ("failure"), a range
of 22. The means read $M_I = 10.67$, $M_{II} = 15.79$ ("good"), $M_{Gain} = 5.12$ ("good"). 2 boys have lost points instead of gaining any.

In the affective domain the highest score figure is 48, expressing an "extremely strong attitude". The lowest figure is 33, expressing an "averagely strong attitude". The mean reads 41.25 (82.50%), expressing a "very strong attitude" towards the planetarium performance.

Tables no.46 and no.47 summarize the results of experiment no. 2. The tables 48/49 show the distribution of the responses in the attitude test. See pages 574-577.

Girls have scored higher in the affective domain, and boys have scored higher in the cognitive domain. This result was expected for the same reasons as mentioned before.

Group III, $N = 14$ Planetarium Kiel

The group consisted of 14 boys and girls. Due to the low N-figure they were not separated, but treated as one only group. In the achievement pre-test the high score is 22+, and the low score is 3+, a range of 19. In the post-test the high score is 27+ ("excellent"), and the low score is 7+ ("insufficient"), a range of 20. The highest gain is 15+ ("excellent"), and the lowest is 4- (failure"), a range of 19. The means are $M_{I} = 10.92$, $M_{II} = 16.85$ ("very good"), $M_{Gain} = 5.93$ ("good"). 1 participant has lost 4 points.

In the affective domain the highest score figure is 43, expressing a "very strong attitude", the lowest score figure is 36, expressing a "strong attitude" towards the planetarium performance. The range is 7. The mean reads 40.54 (81.09%), expressing a "very strong attitude" towards the planetarium performance. Only 11 subjects took part in the attitude test; there is no known reason for the abstentions of the others. Table number 50 displays the above results. See page 578.
Group IV, N = 53 Planetarium Kiel

Sub-group A consisted of 22 girls. The high score in the achievement pre-test amounts to 13+, and the low score to 1-, a range of 14. In the post-test the high score amounts to 20+ ("excellent"), and the low score to 2+ ("failure"), a range of 18. The highest gain is 12+ ("excellent"), and the lowest is 4- ("failure"), a range of 16. The means are M I = 5.64, M II = 10.77 ("pass"), M Gain = 5.14 ("good"). 4 girls have lost points instead of gaining any.

In the affective domain the highest score figure is 46, expressing an "extremely strong attitude", and the lowest figure is 28, expressing a "weak attitude". The range is 18. The mean reads 38.80 (77.62%) expressing a "strong attitude" towards the planetarium performance. For unknown reasons 1 girl did not participate in the attitude test.

Sub-group B consisted of 31 boys. The high score in the achievement pre-test amounts to 20+, and the low score is 1+, a range of 19. In the post-test the respective figures read 25+ ("excellent"), and 7+ ("insufficient"), a range of 18. The highest gain is 18+, and the lowest is 1-, a range of 19. The means amount to M I = 11.58, M II = 17.48 ("very good"), M Gain = 5.98 ("good"). This is the highest gain in all 5 tests. 2 boys have each lost 1 point.

In the affective domain the highest score figure amounts to 46, expressing an "extremely strong attitude", the lowest figure amounts to 30, expressing an "averagely strong attitude", on the verge of a "weak attitude". The mean amounts to 38.87 (77.73%), which stands for a "strong attitude" towards the planetarium performance. 1 boy did not participate in the attitude test. The reason for the abstention is not known.

Boys show considerably higher entrance scores, did noticeably better in the cognitive domain, and - as distinct from others- also attained a slightly higher score in the affective domain.

Tables no.52 and no.53 display the above results. See pp.580-581.
Sub-group A consisted of 12 girls. The high score in the achievement pre-test amounts to 15+, and the low score to 4-, a range of 19. In the post-test the high score is 19+ ("very good"), and the low score is 4- ("failure"), a range of 23. The highest gain is 13+ ("excellent"), and the lowest is 5- ("failure"), a range of 18. 2 girls have lost points instead of gaining any. The means are \( M_I = 4.67 \), \( M_{II} = 10.17 \) ("pass"), \( M_{Gain} = 5.50 \) ("good").

In the affective domain the highest score figure is 40, expressing a "very strong attitude". This mark is on the border line of a "strong attitude". The lowest score figure is 30, expressing an "averagely strong attitude". This mark is on the border line of a "weak attitude". The mean amounts to 37.17 (74.34%), which is well in the bracket of a "strong attitude".

Sub-group B consisted of 23 boys. The high score in the achievement pre-test is 17+, and the low score is 1+, a range of 16. The respective figures in the post-test are 24+ ("excellent"), and the lowest is 2- ("failure"), a range of 26. The highest gain is 14+ ("excellent"), and the lowest is 12- ("failure"). This latter figure represents the highest loss of points in all five experiments. The range is 26. The means read \( M_I = 7.74 \), \( M_{II} = 13.61 \) ("good"), \( M_{Gain} = 5.87 \) ("good"). 2 boys lost points instead of gaining any.

In the affective domain the highest score figure is 44, expressing a "very strong attitude". The lowest figure is 25, expressing a "weak attitude". The mark is on the border line of a "very weak attitude". The range is 19. The mean reads 36.91 (73.85%), expressing a "strong attitude" towards the planetarium performance.

Girls have scored higher in the affective domain, and boys have scored higher in the cognitive domain. This result was expected for the same reasons explained earlier.

Tables no.56 till no. 59 summarize the results. See pp. 584-587.

All groups display a considerable band-width in achievement scores but less so in the scores of attainment in the attitude test.
The total sample size in the cognitive domain amounted to 222, and in the affective domain the total N-figure amounted to 217. Table no. 16 displays the results of all 5 experiments. The total means read as follows: \( M_{I} = 9.00 \), \( M_{II} = 14.31 \) ("good"), \( M \text{ Gain} = 5.31 \) ("good"), \( M \text{ Aff-Test} = 39.60 \) (79.20%). The mean score in the affective domain expresses a "strong attitude". The mark lies very close to the border line of a "very strong attitude" towards the planetarium performance.

Table no. 17 displays the total of the various responses towards the 10 questions in the attitude test distributed over the field of the Lickert scale. Tables no. 16 and 17 are on pages 328 and 329.

Comparing the attainment of the 217 students in the attitude test to the 243 participants in the general planetarium visitors' survey indicates a positive correlation. Students scored only very slightly lower than the general planetarium visitors, e.g. 39.60 : 40.59. The variable of the better equipment enjoyed by many general visitors cannot be accounted for but may have influenced results.

7. Findings: Affective Domain Total Achievement

The sequence of rank orders in table no. 17 has been calculated on grounds of the scores obtained for each question. All subjects \( N = 217 \) participated in the treatment of every question. Still, the system of calculating relative percentage scores in addition to the actual scores has been retained, as it was used throughout the overall research in most of the tables. This system provides an easier comparison between values of different but related tables. It was originally introduced as a basis for a just calculation of rank orders in all such cases where the basic population of a particular test participated in unequal numbers in the various questions.

In the following report, questions are treated according to their rank order succession with their running numbers mentioned in brackets behind the rank order number.

1. (1) - Do students prefer to learn astronomy in the planetarium rather than in the classroom?
This question is specially addressed to school visitors who take a lesson in the planetarium (it may be the only time in their entire school life, as is explained
in another survey). Not one of the students disagreed. 169 (77.88%) "strongly agreed". 40 (18.43%) "agreed", and only 8 were "undecided".

2. (5) - Only 1 participant "agreed" that he was sorry to have gone to the planetarium. (He had told) 12 were in doubt, 61 (28.11%) "disagreed" and 143 (65.90%) of the respondents "disagreed strongly".

3. (2) - "I find the Planetarium demonstration too monotonous. Only stars. Boring!"
More than half of the participants, namely 110 (50.69%) "disagreed strongly", 71 (32.71%) of the pupils "disagreed", 31 were "undecided". 3 students "agreed" and 2 "strongly agreed".

4. (8) - "The Planetarium does not equal reality to a sufficient degree."
Only 5 "agreed", no one "agreed strongly" to this negative statement, 26 were "undecided". 106 (48.85%) of the participants "disagreed" and 80 (36.87%) "disagreed strongly".

5. (9) - "During night time I can see everything just as well outside."
This question made more participants unsure. 48 of them were "undecided", 8 "agreed", 4 "strongly agreed", but 84 (38.71%) "disagreed" to this negative statement and 73 (33.64%) "disagreed strongly".

6. (4) - "A Planetarium demonstration is an elevating and marvellous experience."
The majority "agreed", namely 94 (43.32%), and 66 (30.41%) "agreed strongly". 38 of the participants were "undecided", 15 "disagreed" and 4 "disagreed strongly".

7. (7) - "I should like to take my friends and relatives."
7 "disagreed strongly", 10 "disagreed", 69 (31.80%) of the participants were "undecided", but 91 (41.94%) "agreed" and 40 (18.43%) "strongly agreed".
8. (3) - "The Planetarium made me more interested in astronomy."
67 (30.88%) of the respondents were "undecided", 18
"disagreed", 9 "strongly disagreed", but 88 (40.55%)
"agreed" and 35 (16.13%) "strongly agreed".

9. (10) - "Every visitor must be inspired with enthusiasm by the
Planetarium."
This question had the highest number of participants in
the "undecided" column, namely 99 (45.62%). 19 "dis-
agreed", 13 "disagreed strongly". 49 (22.58%) of the
participants "agreed" to the statement, and 37 (17.07%)
"strongly agreed".

10. (6) - "There is too much nonsense going on in the dark chamber."
57 of the participants, this is 26.27% agreed to this
statement. 25 of them "strongly agreed". 45 "disagreed" and
44 "strongly disagreed". This is together 41.01% of all
participants.

The total mean of attainment in the affective test amounts to 39.60
(79.20%) expressing a "strong attitude" towards the planetarium per-
formance, i.e. a high degree of satisfaction with the planetarium
Teaching situation.

8. Discussion
8.1. Confirmation of the Quality of the Test Instrument for the
Cognitive Domain
As the findings of the experiments have been recorded both in
text and tables, and as enough material has been presented to
attempt either supporting or refuting the first null hypothesis,
we find ourselves with a rating system for which some kind of
outside confirmation seems advisable in order to judge more reli-
ably how well students have learned their lesson in the planeta-
rium.

The test questions are related to the concepts presented in the
planetarium lecture demonstration and hence measure the degree
of achievement in the subject matter taught. In fact, we can see
that the students apparently have learned something in the
planetarium. A mean of 14.31 ("good") has been attained in the post-test, resulting from various degrees of pre-given knowledge and an average gain of 5.31 ("good"). But how meaningful are these figures? We need a better answer to this question in terms of confirming the validity and reliability of our rating system, as otherwise we are limited in our testsin saying something more definite about the effectiveness of the planetarium as a teaching tool and simultaneously about its educational value in the cognitive domain. It was not impossible that students would have learned nothing in the planetarium due to the influence of "the mystic effect", mentioned repeatedly in this thesis, or other distractions. But this has been conclusively disproved.

8.1.1 Comparison with Tests performed in the USA

While the rating system adopted is certainly of value as it is based on classroom teaching experience and the customary classroom rating system, some kind of a meaningful comparison may lend more emphasis to the same. A comparison is therefore attempted with the results obtained by similar student groups in similar test situations found in the USA.

Delivee L. Wright (op.cit.) has used the same test instrument in the experiments carried out in the frame work of her thesis, as has been mentioned earlier. Her group I (27 classes, \(N = 737\)) had an astronomy unit in the conventional classroom and took the astronomy achievement test near completion of the classroom unit. Her group II (16 classes, \(N = 450\)) had an additional field trip to the planetarium after the classroom unit and performed the test the day following the planetarium lecture demonstration. Both groups attempted all 80 questions in the test.

High \(N\)-figures were involved in the USA-experiments, which should lend some significance to the results and show what average achievement could reasonably be expected of a pupil in the age group tested, i.e. about 14 years, and under the given circumstances of the experiments.

Though conditions in the school system of West Germany do differ from those in the USA and though many uncontrollable variables contribute towards the results obtained in the USA and West
Germany in certainly quite different manners and different degrees, a comparison to the USA tests has still been attempted. The bare fact exists that there is no other group at all available to which a comparison could be made. The comparison is therefore made with all due reservations due to the above limitations.

An additional limitation derives from the fact that the German groups attempted only 25 and 27 out of the 80 questions of the full test. A last limitation must be made regarding the time spent for the subject. The USA groups both had classroom units, and the second group had received an additional planetarium visit though of only 20 minutes duration. The German groups were taught exclusively in the planetarium, but did spend 55 minutes and 70 minutes there, which may have been of advantage.

Wright used her experiment to prove the superiority of additional planetarium teaching as supplementing the routine classroom teaching in comparison to the exclusive classroom teaching. She found the first method significantly superior.

The author does not intend to test statistically significant differences in the relative achievements attained by the USA pupils and their German counterparts. Too many uncontrollable and also hardly detectable variables contribute to these differences. To establish statistically significant differences would be workable in pure figures, but would create an illusion of precision which is really not there. For our purposes it must therefore suffice to compare results obtained by both groups on a coarser level of general tendencies.

Since Wright does not complain about the customary school standards of the averages of the scores attained by her very many USA subjects, it seems safe to assume that the results of the test are considered as being satisfactory by these standards.

Table no. 18 summarizes the comparison. The high scores and the low scores and the ranges between them are listed. The means of the USA test results and the means of the German post-test results are listed. In the last column these means are converted into attained percentages of the possible maximum. This method allows a comparison to be made between the competing groups. See p.330.
To make the ranges between high scores and low scores comparable, they have to be brought into relationship to the respective number of questions. The USA students had to answer 80 questions, the German groups I and II had to answer 25 questions out of the same test, and the German groups III, IV and V had to answer 27 questions out of the same test. The two USA groups attained ranges 64 and 71 respectively between their scores, and the German groups I and II attained 18 and 23 respectively. To put this on the same level as a basis for a comparison, the following computation is made:

USA group I versus German groups I and II

1.) \( 64 : 80 = x : 25 \)

\( x_1 = 20 \)

USA group II versus German groups I and II

2.) \( 71 : 80 = x : 25 \)

\( x_2 = 22 \)

\[ \frac{x_1 + x_2}{2} = M = 21 \]

Actual mean attainment for the German groups I and II

\[ M = \frac{18 + 23}{2} = 20.5 \]

From the above calculation it is seen that the calculated comparison figure (21) differs only slightly from the figure for actual attainment (20.5). But it must be taken into account that the higher the number of questions the higher tends to be the range between the highest and lowest score.

The German groups III, IV and V attained 20, 19, and 28 respectively as range figures between their high scores and low scores. As above, a computation is made to provide for a level of comparison:
USA group I versus German group IV

1. \( \frac{64}{80} : \frac{x}{27} \)
   
   \( x_3 = 21.6 \)

USA group II versus German group IV

2. \( \frac{71}{80} : \frac{x}{27} \)
   
   \( x_4 = 24 \)

\[ M = \frac{x_3 + x_4}{2} = 22.8 \]

Actual attainment for the German group IV = 19

From the above calculation it is seen that the calculated comparison figure (22.8) differs somewhat from the figure of actual attainment. In the second set of experiments (Kiel) only group IV is of a comparable age and groups III and V are therefore left out. Looking at the pure figures, the German groups have attained relatively no narrower range between high scores and low scores in comparison to the USA groups, and the higher the number of questions, the larger tends to be the range. The pure figures derived so far are therefore not the whole of the story. The calculations are not carried any further as the author is satisfied with presenting rough figures only for a coarse type of comparison that establishes a tendency rather than exact facts. The tendency for both the USA and the German groups is to cover a large range between high and low score which speaks for inhomogeneities in talent within the groups.

The figures of the means can likewise not easily be compared due to considerable differences in both number of test questions and number of participants. The means are therefore converted into percentages of possible attainment, i.e. each mean is computed as a percentage of the maximum possible score, which is 80 for the USA groups and 25 and 27 for the German groups.

When comparing the percentage figures in the last column of table no. 18, it seems that the German groups have done better than the USA groups. The figures for the groups of more comparable age read as follows:
USA group II = 30.87%
West German group I = 63.60%
West German group IV = 54.44%

The German groups' scores are roughly twice as high as those of the respective USA group. General life and teaching experience tell us that the German pupils are not twice as good in school achievement than their USA counterparts, as the figures might suggest. Bearing in mind the general limitations made, and admitting that it is beyond the possibilities of the author to account for all additional factors and circumstances and for the degree of the influence of the limiting elements touched upon above, it is again considered as being sufficient to have established a tendency. The tendency, broadly speaking, is that the German students participating in the test seem to perform in the cognitive domain as well as their comparable American counterparts. The rating system adopted for scoring the results of the German students is therefore supported by what has become apparent as the seemingly acceptable group averages of American students who were subjected to the same test.

The calibration of the test instrument for the cognitive domain is predominantly based on an adaptation of the German classroom scoring system, as recommended by experienced teachers, and is additionally supported by a comparison made with test results produced by similar USA groups who have undergone the same test.

The purpose of this attempt is to give, by performing the above comparison, more weight to the cognitive rating system used and to diminish any feelings of insecurity that could be entertained as to the precision and hence validity and reliability of the rating system used.

8.2. The Findings in the Cognitive Domain

Bandwidth in performance:
All pretests show a considerable bandwidth of scores within each group as a sign of widely different degrees of pre-given knowledge of the subject matter. None of the participating subjects had any previous systematic teaching of astronomy proper, though it can be safely assumed that most had heard of the most basic
elements of astronomy, like the solar system, in the framework of geography courses. The pre-scores seem to reflect previous interest in the subject matter rather than individual differences in academic talent.

The post-scores are more apt to indicate differences in academic talent. The wide gaps between high scores and low scores observed in the pre-tests prevail throughout the post-tests. The planetarium lecture-demonstration evidently could not equalize these differences in performance, which appears to be normal.*)

Loosing Points: (Regression towards the Mean)
Most students were able to gain points by attending the planetarium performance, but some have lost points. It is observed that those who have lost points are mostly found in the group that started with high scores in the pre-test. A strange phenomenon, it seems, to see pupils deteriorating in achievement after experiencing a planetarium performance. No exact explanation can be offered for this strange occurrence, which none of the other authors cited previously have ever reported. It is assumed that, for some students, lucky guessing may have produced high score numbers in some instances of the pre-test and that the following post-test was done more seriously by these pupils. The planetarium lecture-demonstration may also have confused topics that formerly were weakly understood. On the other hand, it cannot be excluded that the considerable length of the lectures, the uncomfortable seating and also the "mystic effect" had a disturbing influence on some of the students. Unfortunately the author had no opportunity to establish the prevalence and influence of the "mystic effect", as the tests could only be performed in a very concise form.*)

Students were not given any "warming up" period in the planetarium and received only the barest minimum of an introduction into the planetarium's equipment functions. This may have exerted a negative influence on some of the results.

*) Footnote: The OU booklet on Experiments E 341, Block E on page 15, paragraph 2.17 states: "There is no consequent narrowing of the spread of scores, or variance, on successive application of the same test ...".**) It is further stated as a probability, "... we can expect those individuals with very high scores on the first occasion to achieve high, but not quite so high, scores on the second occasion ..".
Correlation between Low Cognitive Performance and Affective Attainment: (Hypothesis No. 6)

Of the 222 students participating in the test, 20 (9%) scored 7 ("insufficient") and lower in the post-test. This number is not abnormally high in this sample size according to the judgement of experienced teachers interviewed on this subject. Most of the students with low scores also show low gain figures. There is only one exception to this apparent rule.

Two of the low scoring students did not participate in the subsequent attitude test and therefore cannot be counted in this correlation study. Of the low performers, only one disliked the planetarium lecture-demonstration (28), and on the other side of the spectrum one student is found to have an "extremely strong attitude" (45) in the attitude test. 9 participants showed a "very strong attitude", 6 displayed a "strong attitude", and one student scored an "averagely strong attitude" (34). The mean for the 18 low cognitive performers who participated in the attitude test amounts to 39.72 (79.44%), which expresses a "strong attitude". Hypothesis no. 6 seems supported but is also treated by statistical computation, see paragraph 9, and by a scattergram analysis folded into the appendix, exhibits no. 61 and no. 62. Although those students who scored low in the cognitive domain did not experience the satisfaction of success in learning, they have on the average expressed a high degree of satisfaction with the teaching performance in the planetarium. It is not known whether a similar satisfaction could have been established by a more conventional classroom-situation for those who met with failure in cognitive achievement.

Group Differences in Performance

In the Recklinghausen experiments the group I of older pupils of both sexes performed better than group II of younger pupils of both sexes, which is as expected of older students, according to teaching experience.

In the Kiel experiments the same is observed when comparing group III to group IV, whereas group V has to be viewed apart, as this is the group of low motivation. Still, their performance was above average. The lowest entrance level (4.67) is observed for
girls (16/17 years) of group V, and the highest post-test level (17.48) is observed for boys (13/15 years) of group IV, who also show the highest gain figure (5.98).

Evaluation of Results:

The total mean in the post-test of the astronomical achievement test amounts to 14.31 ("good"). The total mean in the gain amounts to 5.31 ("good"), according to the rating scale devised for this test.

A correlation between a low performance in the cognitive post-test and a likewise low attainment in the affective test cannot be established. - Mathematical proof is delivered in paragraph 9.

It has been established that pupils have learned an astronomy lesson well in the planetarium, using a classroom-rating-based standard to measure achievement.

8.3. Discussion of the Findings in the Affective Domain

Six questions of a more emotional character and four questions of a more factual character form the test instrument in the affective domain. By both content and phraseology, it has been attempted to let the questions of a more emotional character, express in successive steps, a greater strength of the emotional statement. It was expected that the rank orders of the responses would develop according to this pre-determined increase in emotional argumentation. Results were as expected, as is shown in figure no. 2 at the end. This figure presents graphically the relationship between successive rank order positions and the respective relative percentage score figures. A nearly straight regression line results as a sign of a linear negative relationship. In the following discussion questions are listed according to their successive rank order positions, and their original running numbers are retained in brackets. The principal meaning of these questions has already been discussed in survey II/6, but requires a new discussion for these younger groups, as they were tested under the different premise of school lectures.

*) See second foot note concerning question no.3, on page 291.
The Emotional Questions:

1. (1) - Preference for the Planetarium:
   Question 1 is simple and straightforward in content and phraseology, and it clarifies in a plain fashion what preference pupils entertain with regard to the teaching medium for astronomy, which suits them best. No deep pondering is required for answering question 1. The answers result in an overwhelmingly large positive vote in favour of the planetarium. It is of course possible that the result is partly also due to the influence of the planetarium's "mystic effect" and overall attraction with not too much relationship to the content of the lecture itself.

2. (5) - Regretting the Planetarium Visit:
   This question is likewise simple and straightforward and can be answered spontaneously without much reflection. The question met with a similar strong positive response, but had one negative "agree" vote, and 4 respondents more were "undecided", and with a certain fraction shifting from strongly positive to normal positive.

3. (2) - Boring Monotony:
   The question dealing with this point is a bit more demanding on the pupils' intellect. The question attempts to remove the influence of the environment and to measure the affective influence of the lecture demonstration. Some reflection becomes necessary before answering and, as a consequence, the number of those in doubt increases. 31 are now found in doubt, and 5 went to the negative side, 2 of them strongly. The vast majority remains on the positive side, i.e. 181, 110 of them "strongly disagree" with the statement.

6. (4) - An Elevating and Marvellous Experience:
   Question 4 is not phrased in everyday language and may be experienced as being sentimental, romantic,
and too strong as an emotional expression. Some self-analysis is required before an answer can be given. The students have to weigh the strength of their own unarticulated feelings against the pre-given expression of a strong feeling. This renders the question complicated. The number of those who follow this argumentation shrinks further. 19 go over to the negative side, 4 of them even "strongly disagree", and also the number of those being "undecided" increases, namely to 38.

7. (7) - Inviting Friends and Relatives:
It must be remembered that this question is asked immediately after the lecture demonstration when the full weight of the feelings created by the performance is still dominant and has undergone only a few attempts of articulation. The question is an indirect one and forces the respondent to transfer his own wealth of feeling to the nearest kin and kind. "Is my own enthusiasm so strong that I should like those near and dear to me to share the experience with me?" Contemplation is invited which makes answering difficult, and the number of those who can not follow the argumentation of the question increases. Still, only 17 out of 217 are on the negative side, but nearly 1/3 (31.80%) are undecided. The question is particularly critical for young people of the age group tested, as they are in a phase of their development where parents and other relatives are less important as companions for common endeavours. It is therefore noteworthy to find a considerable majority in agreement.

9. (10) - Every visitor must be inspired with Enthusiasm by the Planetarium:
Though this is a direct question, it calls for the transfer of feelings to an unknown multitude of other visitors. It implies that the degree of feelings has reached the level of enthusiasm. The statement is extremely strong in its phraseology. The strong "must" is used instead of a milder form like
"should" or "ought to". "Every" visitor is said instead of the milder "most" or "many" or "the majority". "Inspired with enthusiasm" is used instead of the milder "should also like" or any similar form. The strength of the expressions and the attempt to enforce on the subjects the implication of an extremely strong feeling, namely enthusiasm, combined with the command to transfer this to others, could easily meet with much reluctance. It is therefore not surprising to find 45.62% "undecided", and it is astonishing that only 19 respondents "disagree" and 13 "strongly disagree". 86 respondents are in agreement with the statement.

While it is illuminating to study from figure no. 2 the relationship between the rank order positions of the questions and their relative percentage scores, it is certainly no less informative to study the relationship between the same rank order positions of the questions and the number of "undecided" votes. A positive linear relationship is indicated by the resulting line which connects the points of intersection on the graph, which means the stronger the expression of feelings, the higher is the "undecided" section in the participants. This is broadly speaking the opposite effect to the subjects' behaviour in according rank orders places to the emotional questions according to their strengths of expression.

The more factual questions are likewise important elements in the analysis of the students' attitudes, as they contain criticism.

The Factual Questions:

8. (3) - Interest in Astronomy

Did the planetarium succeed in stimulating an interest in astronomy? More than half, 56.68% said so, nearly 1/3 were in doubt, and a small number of 27 participants "disagreed".

*) See figure no. 3 on page 332
Unfortunately no follow-up study was feasible, and any lasting effect of the stimulation received could hence not be measured.

The general visitors tested in a previous survey responded slightly more positively (67.90%). It seems safe to assume that they went to the planetarium because they were anyway interested in astronomy and most of them saw more attractive performances. As this question is rational as well as emotional in character, it has been included in the graphical analysis of the emotional questions in fig. no. 2. Its low rank order place was expected since one only planetarium performance cannot capture the whole class to the degree of making all of them "more" interested in astronomy, according to observation and experience. Planetarium teachers as well as school teachers were pleased with the result and ascribe to the planetarium performance a high stimulation effect.

4. (8) - The Planetarium does not equal Real Nature in a Sufficient Degree.

5. (9) - During Night time I can see Everything just as well Outside.

These questions imply that the planetarium is a superfluous institution. Those who agree with the statements may very well develop a negative attitude towards the planetarium, and those who do not agree will not be harmed in their attitudes by these two critical questions.

The smaller planetariums, i.e. those with domes of 6 m diameter and smaller, do in fact have a problem in presenting a perfect illusion of the real night sky, as on one hand the cheaper projectors used in these small domes cannot deliver a true-to-nature star field, and the distance between viewer and the sky is not large enough to create the impression of being under the open sky. The particular feature of a nearly perfect illusion is inherent only in larger
planetarium installations. It also seems true that the small planetariums serve their purpose well and their technical shortcomings do not scare their audiences away to the outside sky which is frequently obscured due to climatic reasons or due to the air pollution in industrial areas.

10. (6) - Noise in the Planetarium

One quarter of the students complain about too much nonsense going on in the dark planetarium chamber. Of the general planetarium visitors, only 7.81% complain about this point. Abusing the dark ambience for playing pranks seems to be the privilege of the younger age groups, and this is apparently difficult to control. It is true that adults are more controlled, and this question could relate to question 3 (2) above in the sense that to be bored in a lengthy lecture tends to lead to juvenile misbehaviour.

The number of those pupils with scores below the critical level of 30 is, in fact, very small. Only a few did not like the planetarium performance. Group I had each 1 boy (23) and 1 girl (29) in that category, group II had 1 girl (27), group III none, group IV 1 girl (28), group V had 2 boys (both 26), who evidently did not like the planetarium performance. The vast majority were very satisfied with the planetarium. The mean score value of all 217 participants amounts to 39.60 (79.20%), which signifies a "strong" attitude towards the planetarium performance and is on the verge of a "very strong" attitude. It must be pointed out that both planetariums involved in the experiments are smaller installations which have neither the perfection nor the versatility of the large planetarium.
9. Statistical Treatment of the Hypotheses and Interpretation of Data:

9.1 Differences in Achievement in the Cognitive Domain

Hypothesis 1, "Gain"

Differences in achievement (gains) were tested by a one-tailed t-test according to the formula derived from Lothar Sachs *) for tests of correlated samples with the t-test:

\[
 t = \frac{\overline{d}}{\frac{s_d}{\sqrt{n}}} = \frac{\overline{d_i} \cdot \frac{n}{n-1}}{\sqrt{\frac{\sum d_i^2 - (\overline{d_i})^2}{n(n-1)}}}
\]

The test results for degrees of probability are as follows:

Group I A - 31 Girls
\[ t \text{ gain } = 6.85, \ t \ 99.5\% = 2.75, \ df = 30 \quad \text{hs} \]

Group I B - 25 Boys
\[ t \text{ gain } = 5.41, \ t \ 99.5\% = 2.80, \ df = 24 \quad \text{hs} \]

Group II A - 40 Girls
\[ t \text{ gain } = 5.51, \ t \ 99.5\% = 2.71, \ df = 39 \quad \text{hs} \]

Group II B - 24 Boys
\[ t \text{ gain } = 5.22, \ t \ 99.5\% = 2.80, \ df = 23 \quad \text{hs} \]

Group III - 14 Boys and Girls
\[ t \text{ gain } = 4.37, \ t \ 99.5\% = 3.01, \ df = 13 \quad \text{hs} \]

Group IV A - 22 Girls
\[ t \text{ gain } = 3.90, \ t \ 99.5\% = 2.52, \ df = 21 \quad \text{hs} \]

Group IV B - 31 Boys
\[ t \text{ gain } = 6.61, \ t \ 99.5\% = 2.75, \ df = 30 \quad \text{hs} \]

Group V A - 12 Girls
\[ t \text{ gain } = 3.23, \ t \ 99.5\% = 3.10, \ df = 11 \quad \text{hs} \]

Group V B - 23 Boys
\[ t \text{ gain } = 4.85, \ t \ 99.5\% = 2.82, \ df = 22 \quad \text{hs} \]

*) Lothar Sachs, Statistische Auswertungs-Methoden, Springer Verlag
All tests are significant at the 0.5% level. Degrees of probability were tested at the 99.5% level using the table of Fisher, R.A. and F. Yates: Statistical Tables for Biological and Medical Research, published by Oliver and Boyd, Ltd. Edinburgh (1963) p.46, Table III.

The results of the statistical treatment reject the hypothesis 1.

9.2 Differences in Group Achievement in the Cognitive Domain and in the Affective Domain.

Hypotheses 2 - 5

The differences were tested by the formula for mean scores of unequal sample sizes derived from the same origin:

\[ t = \frac{\bar{x}_1 - \bar{x}_2}{\sqrt{\frac{n_1 + n_2}{n_1 \cdot n_2} \left( \frac{1}{n_1} + \frac{1}{n_2} + \frac{1}{n_1 \cdot n_2} \right)}} \]

\[ df = n_1 + n_2 - 2 \]

A two-tailed t-test at the 5% significance level

**Difference in cognitive achievement** between boys and girls of the same age group:

**Hypothesis 2**

Group I A / I B
\[ t \text{ diff} = 0.43, t \text{ 95} = 2.00, df = 54 \quad \text{ns} \]

Group II A / II B
\[ t \text{ diff} = 3.77, t \text{ 95} = 2.00, df = 62 \quad \text{s} \]

Group IV A / IV B
\[ t \text{ diff} = 0.61, t \text{ 95} = 2.01, df = 52 \quad \text{ns} \]

Group V A / V B
\[ t \text{ diff} = 0.90, t \text{ 95} = 2.04, df = 33 \quad \text{ns} \]

Hypothesis 2 is refuted in 1 instance and supported in 3 instances.

It has been shown that, in the 12/13 year old age groups of the Recklinghausen experiment, there is a statistically significant difference in achievement in the Astronomy Achievement test. In this particular case boys performed significantly better than girls. In the higher age groups, differences are less pronounced, but boys do slightly better than girls in all groups.

*) F. Yates, "Statistical Tables for Biological and Medical Research", published by Oliver & Boyd, Ltd., Edinburgh 1963
Difference in affective attainment between boys and girls of the same age group at the 5% significance level:

**Hypothesis 3**

Group I A / I B - t diff = 0.31  ns
Group II A / II B - t diff = 0.99  ns
Group IV A / IV B - t diff = 0.38  ns
Group V A / V B - t diff = 1.12  ns

Hypothesis 3 is supported.

The small differences which exist between boys and girls in the domain of attitudes is statistically not significant. With the exception of group IV, girls show a slightly higher attainment in the affective domain than boys. This better attainment in the affective domain seems to be in line with general life experience.

**Difference in affective attainment** between younger and older pupils at the 5% significance level:

**Hypothesis 4**

Group Exp. 1 / Exp. 2
\[ t \text{ diff} = 0.13, t 95\% = 1.98, df = 118 \]  ns

Group Exp. 4 / Exp. 5
\[ t \text{ diff} = 0.15, t 95\% = 1.98, df = 87 \]  ns

Hypothesis 4 is supported.

Younger and older pupils of the same test group differ - in statistical terms - only insignificantly in affective attainment, though the younger age groups do score slightly higher - in practical terms - which again seems to confirm general life and teaching experience. Younger pupils seem to be more easily emotionally aroused than older pupils. This probably holds true not only for planetarium performances but for many other types of school performances as well.

Footnote: ns = not significant, s = significant, hs = highly significant
In true score figures the differences read:

Group Exp. 1 / Exp. 2 - score diff. = 2.85
Group Exp. 4 / Exp. 5 - score diff. = 1.80

These differences are too small to be very weighty in practical terms as 5 points are needed to move into another bracket in the scale of ratings devised for the affective test.

**Difference in affective attainment**: between pupils being lectured in the planetarium and general planetarium visitors at the 5% significance level:

**Hypothesis 5**

Gen. Visitors / pupils

t diff = 3.19, t = 95% = 1.96, df = 457

Hypothesis 5 is refuted.

The difference between the 2 groups is significant according to the t-test performed, which statistically secures the result. In score figures the difference amounts to: pupils 39.60 and general visitors 40.59 = d=0.99.

According to the definition given for the meaning of the score figures, both groups are near the border line of a "very strong attitude" which, for all practical purposes, means that the difference is not important.

All statistical tests were computer-processed and therefore only the final result is given here.

9.3 **Calculation of the Correlation Coefficient "r" between Gains in the Cognitive Domain and Attainment Scores in the Affective Domain**.

Hypothesis 6, reference is made to table no.16 on page 328.

The correlation coefficient was calculated according to the formula:

\[
*r = \frac{\frac{1}{n} \sum x_i \sum y_i}{\sqrt{\left(\frac{1}{n} \sum x_i^2 - \frac{1}{n} (\sum x_i)^2\right) \left(\frac{1}{n} \sum y_i^2 - \frac{1}{n} (\sum y_i)^2\right)}}
\]

The results suggest a high degree of linear independence which is in accordance with the impression given by the scattergrams exhibit nos. 61 and 62 which point to a zero correlation, p. 597.

The results of the calculation support the hypothesis 6.

9.4 Positive Attitude

Hypothesis 7

There is no statistical treatment possible for this hypothesis as there is no comparison provided. The test results in the affective domain as presented in the individual group tables and the summary table number 17 produce as a mean a "strong attitude" towards the planetarium.

The results refute the hypothesis 7.

10. Conclusion:

10.1 The Planetarium is an educationally valuable teaching tool in the cognitive domain as demonstrated by the cognitive tests of the five experiments performed.

10.2 The Planetarium is an educationally valuable teaching tool in the affective domain as demonstrated by the affective tests of the five experiments performed.

*) This expresses the percentage of predictability that one set of scores has with regard to the other set of scores.
10.3 Student's attitude as stimulated by the planetarium experience does not correlate to the score values of learning in the planetarium. Bad learners enjoy the planetarium performance as much as good learners do. Attitude had no immediate influence on achievement in the cognitive domain.

10.4 The Planetarium is an educationally valuable teaching tool in the affective domain also as interpreted by the affective test conducted with general planetarium visitors in the framework of survey II/6. The total score of this test is in the same order with the total score results of the 5 experiments. This shows that students who have to go to the planetarium for learning enjoy the performance as much as general planetarium visitors do who go there for erudite entertainment.

The various age groups tested learn more or less equally well in the planetarium as is shown by the means of their gains; they are also more or less equally strongly stimulated in the affective domain by the planetarium. The small differences shown between groups are practically not important.

The results of the 5 experiments conducted in two planetariums refute the operational hypothesis which has guided this survey, and in this the general hypothesis is supported in the sense that this survey has delivered evidence of the planetarium's educational value in the cognitive as well as in the affective domain.

11. Implication:

This is the last of the 3 approaches made in this thesis to investigate the educational value of the planetarium. Each of the three approaches has produced a positive result. From this it is seen that the existence and the use of the planetarium as an educational tool is justified in terms of the conclusions presented in the surveys conducted. Reasons for the underuse of the planetarium could not be established by any of the surveys (with the exception of the school survey II/5 which only delivered a hint to be explored in chapter III on the underuse of the planetarium).
Documentation

This report is illustrated by detailed tables of all tests performed and by 2 figures. The tables which summarize the findings and the 2 illustrative figures are folded at the end of this report. The individual tables are folded into the appendix pp. 588 - 597.

The appendix also contains scattergrams which illustrate achievements in the cognitive domain in a graphic manner, see pages. Additional scattergrams demonstrate graphically the correlation between scores achieved in cognitive gain and scores achieved in affective domain attainment.

In the following survey II/11 the question of an existence of demand for school planetariums is further pursued at the level of ministries of education and manufacturers.
### TABLE 16

#### 5 TESTS IN THE PLANETARIUM

**ASTRONOMY ACHIEVEMENT TEST: COGNITIVE DOMAIN**

**ATTITUDE TEST: AFFECTIVE DOMAIN**

<table>
<thead>
<tr>
<th>Experiment</th>
<th>Group</th>
<th>N</th>
<th>M I</th>
<th>M II</th>
<th>M Gain</th>
<th>M Aff-Test</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Girls 14/15 y</td>
<td>31</td>
<td>11.09</td>
<td>15.93</td>
<td>4.84</td>
<td>39.58 (79.16%)</td>
</tr>
<tr>
<td></td>
<td>Boys 14/15 y</td>
<td>25</td>
<td>10.56</td>
<td>15.88</td>
<td>5.32</td>
<td>38.32 (76.64%)</td>
</tr>
<tr>
<td>2</td>
<td>Girls 12/13 y</td>
<td>40</td>
<td>8.13</td>
<td>12.20</td>
<td>4.08</td>
<td>42.35 (84.70%)</td>
</tr>
<tr>
<td></td>
<td>Boys 12/13 y</td>
<td>24</td>
<td>10.67</td>
<td>15.79</td>
<td>5.12</td>
<td>41.25 (82.50%)</td>
</tr>
<tr>
<td>3</td>
<td>B. + G. 16/17 y</td>
<td>14</td>
<td>10.92</td>
<td>16.85</td>
<td>5.93</td>
<td>40.54 (81.09%)</td>
</tr>
<tr>
<td>4</td>
<td>Girls 13/15 y</td>
<td>22</td>
<td>5.64</td>
<td>10.77</td>
<td>5.14</td>
<td>38.80 (77.62%)</td>
</tr>
<tr>
<td></td>
<td>Boys 13/15 y</td>
<td>31</td>
<td>11.58</td>
<td>17.48</td>
<td>5.98</td>
<td>38.87 (77.73%)</td>
</tr>
<tr>
<td>5</td>
<td>Girls 16/17 y</td>
<td>12</td>
<td>4.67</td>
<td>10.17</td>
<td>5.50</td>
<td>37.17 (74.34%)</td>
</tr>
<tr>
<td></td>
<td>Boys 16/17 y</td>
<td>23</td>
<td>7.74</td>
<td>13.61</td>
<td>5.87</td>
<td>36.91 (73.83%)</td>
</tr>
<tr>
<td>Totals : 5</td>
<td>B. + G. 12-17 y</td>
<td>222</td>
<td>9.00</td>
<td>14.31</td>
<td>5.31</td>
<td>39.60 (79.20%)</td>
</tr>
</tbody>
</table>

*M I = Mean Pre-Test,  M II = Mean Post-Test,  M Gain = Mean Gain,  M Aff-Test = Mean Affective Test.*

#### Summary

5 Groups of pupils were tested in the planetarium, by pre-test and post-test only, immediately before and after a planetarium lecture demonstration. The mean of the gain in the cognitive domain is “good”, the mean of the post-test score is also “good” according to the classroom teaching rating system adopted. The comparison made to USA student groups acc. to table No. 18 similarly speaks for a very satisfying result. The attitude test in the affective domain reveals nearly a “very strong attitude” towards the planetarium performance. The five tests performed seem to confirm the planetarium’s educational value in both the cognitive and the affective domain.
### TABLE 17

**5 TESTS IN THE PLANETARIUM**

**ATTITUDE TEST - AFFECTIVE DOMAIN**

<table>
<thead>
<tr>
<th>OPINIONS EXPRESSED</th>
<th>Rank</th>
<th>% Score</th>
<th>Strongly agree</th>
<th>Agree</th>
<th>Undecided</th>
<th>Disagree</th>
<th>Strongly disagree</th>
</tr>
</thead>
<tbody>
<tr>
<td>1) I like to learn astronomy in the Planetarium rather than in the classroom.</td>
<td>1</td>
<td>94.84</td>
<td>169</td>
<td>40</td>
<td>8</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>2) I find the Planetarium demonstration too monotonous. Only stars. Boring!</td>
<td>3</td>
<td>86.18</td>
<td>2</td>
<td>3</td>
<td>31</td>
<td>71</td>
<td>110</td>
</tr>
<tr>
<td>3) The Planetarium made me more interested in astronomy.</td>
<td>8</td>
<td>71.29</td>
<td>35</td>
<td>88</td>
<td>67</td>
<td>18</td>
<td>9</td>
</tr>
<tr>
<td>4) A Planetarium demonstration is an elevating and marvellous experience.</td>
<td>6</td>
<td>78.71</td>
<td>66</td>
<td>94</td>
<td>38</td>
<td>15</td>
<td>4</td>
</tr>
<tr>
<td>5) Actually I am sorry I went there.</td>
<td>2</td>
<td>61.80</td>
<td>0</td>
<td>1</td>
<td>12</td>
<td>61</td>
<td>143</td>
</tr>
<tr>
<td>6) There is too much nonsense going on in the dark chamber.</td>
<td>10</td>
<td>54.70</td>
<td>25</td>
<td>32</td>
<td>71</td>
<td>45</td>
<td>44</td>
</tr>
<tr>
<td>7) I should like to take my friends and relatives.</td>
<td>7</td>
<td>73.55</td>
<td>40</td>
<td>91</td>
<td>69</td>
<td>10</td>
<td>7</td>
</tr>
<tr>
<td>8) The Planetarium does not equal reality to a sufficient degree.</td>
<td>4</td>
<td>84.05</td>
<td>0</td>
<td>5</td>
<td>26</td>
<td>106</td>
<td>80</td>
</tr>
<tr>
<td>9) During night time I can see everything just as well outside.</td>
<td>5</td>
<td>79.72</td>
<td>4</td>
<td>8</td>
<td>48</td>
<td>84</td>
<td>73</td>
</tr>
<tr>
<td>10) Every visitor must be inspired with enthusiasm by the Planetarium.</td>
<td>9</td>
<td>67.19</td>
<td>37</td>
<td>49</td>
<td>99</td>
<td>19</td>
<td>13</td>
</tr>
</tbody>
</table>

ACTUAL TOTAL SCORE: 8594
POSSIBLE MAXIMUM SCORE: 10850
ACTUAL MEAN: 39.60 (79.20%)
MAXIMUM MEAN: 50.00

Summary

This table summarizes the responses of all 5 tests conducted in the planetarium and shows their distribution over the Likert scale field.

The mean correlates positively with the mean score value obtained in the affective part of the survey conducted with general planetarium visitors, as is shown in table No. 9. The students who participated in the above 5 tests scored only very slightly lower than the general planetarium visitors in the preceding survey did, namely 39.60 (79.20%): 40.59 (81.18%).

The planetarium lecture demonstration and/or the planetarium itself as a teaching medium is found to be highly in favour with pupils who express a "strong attitude" towards the planetarium, which seems to confirm the planetarium’s educational value in the affective domain.
"TESTS IN THE PLANETARIUM"

Comparison between USA and West German Student Groups subjected to the same Test*, though using a different number of Test Questions.

* Test by W.T.Barnad as extended and applied by Delivee Loraine Wright, Ed.D. Thesis 68.

<table>
<thead>
<tr>
<th>Groups</th>
<th>Test &amp; Preparation</th>
<th>High Score</th>
<th>Low Score</th>
<th>Range</th>
<th>M</th>
<th>M %</th>
</tr>
</thead>
<tbody>
<tr>
<td>USA Group I</td>
<td>80 questions</td>
<td>+ 52</td>
<td>- 12</td>
<td>64</td>
<td>19.77</td>
<td>24.71 %</td>
</tr>
<tr>
<td>N = 737 school only</td>
<td>school only</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>age: 14 years</td>
<td>1 Test</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>USA Group II</td>
<td>80 questions</td>
<td>+ 64</td>
<td>- 7</td>
<td>71</td>
<td>24.70</td>
<td>30.87 %</td>
</tr>
<tr>
<td>N = 450 school + planetarium</td>
<td>school + planetarium</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>age: 14 years</td>
<td>1 Test</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>W.German Group I</td>
<td>25 questions</td>
<td>+ 23</td>
<td>+ 5</td>
<td>18</td>
<td>15.9</td>
<td>63.60 %</td>
</tr>
<tr>
<td>N= 56 planetarium only</td>
<td>planetarium only</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>age: 14/15 y.</td>
<td>Post-Test</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>W.German Group II</td>
<td>25 questions</td>
<td>+ 25</td>
<td>+ 2</td>
<td>23</td>
<td>13.55</td>
<td>54.20 %</td>
</tr>
<tr>
<td>N = 64 planetarium only</td>
<td>planetarium only</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>age: 12/13 y.</td>
<td>Post-Test</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>W.German Group III</td>
<td>27 questions</td>
<td>+ 27</td>
<td>+ 7</td>
<td>20</td>
<td>16.85</td>
<td>62.40 %</td>
</tr>
<tr>
<td>N = 14 planetarium only</td>
<td>planetarium only</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>age: 16/17 y.</td>
<td>Post-Test</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>W.German Group IV</td>
<td>27 questions</td>
<td>+ 25</td>
<td>+ 6</td>
<td>19</td>
<td>14.70</td>
<td>54.44 %</td>
</tr>
<tr>
<td>N = 53 planetarium only</td>
<td>planetarium only</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>age: 13/15 y.</td>
<td>Post-Test</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>W.German Group V</td>
<td>27 questions</td>
<td>+ 24</td>
<td>- 4</td>
<td>28</td>
<td>12.42</td>
<td>46.03 %</td>
</tr>
<tr>
<td>N = 35 planetarium only</td>
<td>planetarium only</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>age: 16/17 y.</td>
<td>Post-Test</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

STANDARD OF ACHIEVEMENT:

In seeking a standard of achievement in the cognitive domain for the 5 groups of West German pupils tested in the planetarium, the test results of 2 similar USA student groups who performed the same test is used as such a standard, but with some limitations which makes the outcome tentative rather than absolute.
Scores depend on the questions' growing emotional strength.

Summary

This figure is related to table No. 17. It demonstrates graphically the diminishing value of the relative percentage score depending on an increase in the questions' emotional strength. A nearly straight regression line of linear relationship results which proves a nearly perfect negative correlation. This outcome lends predictive validity to the test instrument. Question No. 3 could be included in this analysis as it has also emotional weight.
FIGURE NO 3

5 TESTS IN THE PLANETARIUM
Attitude Test – Affective Domain
6 Emotional Questions

The Number of "undecided" Votes increases with the questions' growing emotional strength.

Summary

This figure is related to table No. 17. It demonstrates graphically the relationship between the number of "undecided" votes as depending on an increase in the questions' emotional strength represented by increasing rank order numbers. The points of intersection approach a straight rising line indicating a positive correlation. Question No. 3 has been left out as its place in the system of this graph would be irregular which may be due to the double nature of this question.
"THE DEMAND FOR PLANETARIES"

Introduction

1. Historical Demand:

The basic hypothesis assumes that there exists a demand for planetariums in the educational system. This implication may be supported by pointing to the history of the planetarium. We can safely assume that Anaximander, the Greek philosopher-astronomer of the 6th century B.C., invented the first star globe as a means of demonstrating his conception of a spherically shaped universe. His students may have felt the need of such a demonstration model in order to grasp this completely new concept. During the period of classical antiquity the Aratus Globe planetarium (and other planetariums) were specifically invented to be used as teaching tools. (1)

A research project into the motives of the inventors of planetariums of the past would form an interesting separate study. Of the invention of the projection planetarium, it can be said that Prof. Max Wolf, Director of the Observatory in Heidelberg, Oskar von Miller, Director of the "Deutsches Museum" in Munich, and Prof. Bauersfeld of the ZEISS factory in Jena, the spiritual fathers and inventors of the projection planetarium, were guided by educational goals. (See the list of the bibliography on the planetarium in the literature section at the end of the thesis, pages 473 - 536.)

The first projection planetariums were created as temples of culture and of erudite entertainment, but soon were also used for pure teaching of strict astronomy courses, as the early printed programmes of many planetariums reveal. They were used for teaching groups from all sectors of the population: adults, students, military cadets and even small children.


2. Demand from Education Circles:

Field trips to a planetarium have become a regular part of many school curricula. The planetarium evidently met an outspoken or unspoken demand in educational circles. The very existence of the first planetariums helped to create or to formulate a demand for such teaching institutions elsewhere. The planetarium idea has in fact experienced a steady, though geographically very disproportionate, growth, as is shown by the total number of planetariums in existence now. (See table no. 2 for a world census of planetariums)

3. Demand from the Schools in USA:

In the history of the planetarium, Mr. ARMAND SPITZ of the USA, a onetime lecturer at a large planetarium institution, ranks as the man who first answered the demand coming from the schools for a smaller and much cheaper type of planetarium. He invented in 1947 a small projection planetarium suitable in size and price for schools. In the USA (and elsewhere) there was evidently a desire in the schools for such an instrument; due among other reasons to the difficulties encountered in organizing field trips to the large planetariums which were insufficient in number to satisfy all the desires of this very large country. Manufacturers in East Germany, Italy and Japan followed Armand Spitz' example and started to produce small and medium size school planetariums.

4. Demand in the School Sector in West Germany:

The question of a demand for planetariums in the school sector of West Germany has been investigated on the school level in the framework of surveys with the schools II/5 which dealt with the educational value of the planetarium. An interest demonstrated in the planetarium points to an actual or potential demand. The findings of these surveys are questioned in the later school surveys no. III/5 which treat the underuse of the planetarium.

Footnote (cont'd): (Demand is not only want or desire but includes the readiness to purchase at a price.)

In the early phases of dealing with demand in the school sector the term is used in its wider everyday sense, i.e. including the notion of mere wanting or desiring a thing.
Synopsis

In further pursuance of the theme of demand for planetariums in the school sector, 2 additional surveys have been conducted. The first of the surveys has been performed with the 11 Ministries of Education in West Germany including Berlin; the second much shorter survey has been conducted with manufacturers of planetariums.

Both surveys are treated together in the following texts of programme II/11 for which this introduction has been made.
"THERE MAY NOT EXIST ANY DEMAND FOR PLANETARIA INS IN THE
EDUCATIONAL SECTOR"
-------------
A Survey Conducted with the Ministries of Education in the West
German States including West Berlin and with Manufacturers of
Planetariums.

A) THE MINISTRIES

1. Theme and Purpose:

The theme of this report is an investigation conducted with the 11
Ministries of Education of the 11 West German States including West
Berlin on the demand for planetariums. The purpose of this investi-
gation was to seek a test on the level of the policy makers for that
part of the general hypothesis saying that there exists a demand for
planetariums. For this purpose it was intended to establish to what
degree, if any, astronomy is incorporated into the school curricula
of the 11 West German States and what, if any, recommendations are
made regarding the use of planetariums as teaching tools.

2. Methodology:

A descriptive survey has been conducted by correspondence and addi-
tional personal interviews. This survey was undertaken immediately
after survey II/5 A the school pilot survey. Evidence for the
findings presented derives from public data, used in this survey.

3. Population:

In conducting this survey the following population was contacted and
the following design was pursued:

- Correspondence with the 11 Ministries of Education of
  the 11 West German States, including West Berlin.

- Interviews and correspondence with two astronomical
  institutes.

- Correspondence and interviews with several schools,
  a school curriculum agency and a public planetarium.
4. **Procedure:**

Performance: the author addressed letters to the Ministries of Education in the 11 States of West Germany, including West Berlin, with a request for information concerning the subject of astronomy. The author duly introduced himself as being occupied with educational media research and indicated that the outcome of his work might be beneficial to the schools. The letters asked whether astronomy was taught in the high schools of the respective state either as a fully independent subject, or subordinated to physics, geography, or other disciplines, or whether astronomy was taught at least at an elementary level perhaps within the curriculum of physics, or geography, or some other discipline. Furthermore, a request was made for a curriculum on astronomy, if it existed, and for any printed recommendations on instrumentation to be used, if these existed.

All Ministries replied, but because some of the answers plainly contradicted observation and experience, additional outside sources of information were activated such as a school curriculum agency, a public planetarium installed in a college conducting courses for a number of schools, two astronomical institutes offering special courses in astronomy to science teachers, and several schools.

The respective Ministries were reapproached and in this way the first information received from Schleswig-Holstein, Hamburg and Rheinland-Pfalz was corrected. A similar action failed with Bremen, which did not reply to the author's second letter. Information about conditions in Bremen have hence been extracted from information received directly from several schools in this city-state. Reliability has been ensured by double checking the information received. The latest data hereby secured for this survey are summarized in table no. 19, which reflects the true conditions prevailing in West Germany.

5. **Findings:**

Reference is made to table no. 19 on the following page. Astronomy is taught at various levels of intensity and independence as reflected by the decreasing order chosen in the table and the brief descriptions given each time. Where astronomy is taught at a major level it may also reappear in selected topics incorporated into e.g. geography.
Thus astronomy may be offered as an independent subject in certain courses selected by some pupils and may (which seems to be quite customary) be taught selectively - the solar system for instance - in geography which is generally taught as a compulsory subject, also at the primary level.

Similarly astronomy may not appear at all on any higher level in the schools of a certain state and still be treated as a hobby subject by voluntary pupil groups in such schools. There is a growing tendency to include astronomy in more high schools, as not all high schools offer this subject on a major level. This cannot be exactly reflected in the figures of student population sizes.

Astronomy curricula exist or are in preparation in 5 states. Astronomical themes are found in most geography and physics set books. Voluntary astronomy groups exist in many schools.

TABLE 19

ASTRONOMY AS A SCHOOL SUBJECT

Astronomy is taught in the schools of the 11 West German states including West Berlin according to the following distribution table:

<table>
<thead>
<tr>
<th>Level of Astronomy</th>
<th>State</th>
<th>Student Population</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Astronomy or Astrophysics as a course subject in high schools</td>
<td>Schleswig-Holstein</td>
<td>835,000</td>
</tr>
<tr>
<td></td>
<td>Niedersachsen</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Bayern</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Baden-Württemberg</td>
<td></td>
</tr>
<tr>
<td>2. Astronomy as a major subject attached to physics in high schools</td>
<td>Berlin</td>
<td>863,000</td>
</tr>
<tr>
<td></td>
<td>Saarland</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Hessen</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Rheinland-Pfalz</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Nordrhein-Westfalen</td>
<td></td>
</tr>
<tr>
<td>3. Basic astronomy attached to physics or geography in high schools</td>
<td>Hamburg</td>
<td>81,000</td>
</tr>
<tr>
<td></td>
<td>Bremen</td>
<td></td>
</tr>
<tr>
<td>4. Very elementary astronomy incorporated into other subjects in all schools</td>
<td>11 States</td>
<td>9,500,000</td>
</tr>
</tbody>
</table>

cont'd
<table>
<thead>
<tr>
<th>Level of Astronomy</th>
<th>State</th>
<th>Student Population</th>
</tr>
</thead>
<tbody>
<tr>
<td>5. No astronomy at all</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>6. Curriculum for astronomy available or in preparation for high schools</td>
<td>Bayern, Berlin Rheinland-Pfalz Nordrhein-Westfalen Baden-Württemberg</td>
<td>1,252,000</td>
</tr>
<tr>
<td>7. Planetarium recommended by authorities as an educational tool for teaching astronomy</td>
<td>Berlin Baden-Württemberg Nordrhein-Westfalen</td>
<td>857,000</td>
</tr>
</tbody>
</table>

Figures are given to the nearest 10,000. Figures of the student population are the complete figures for the states under review regardless of whether or not astronomy is taught in all schools.

5. Discussion:

5.1 The Number of Students exposed to the Subject of Astronomy:

The table no. 19 is intended to supply the very basic information on whether or not astronomy is taught at all in the schools of West Germany and at what level, naming each time the states in which the respective conditions prevail and also giving the total pupil-population of these states. The totals of the student population given in the table apply only approximately, as it is at this stage impossible to filter out those high schools that do not yet offer astronomy as a major subject. The Ministries could not provide exact figures as the more widespread introduction of astronomy courses is still in the development stage. The figures express a tendency rather than firm facts. Hidden in the pupil-population figure is a certain, though small, percentage of pupils attending special high schools not listed as vocational schools but also excluded from astronomy. These have also not been filtered out. The coarse figures presented serve, sufficiently well, the purpose of providing an overall impression of the population size involved.
5.2 The Planetarium and the School Discipline of Astronomy:

The Ministries of Education in three West German states outspokenly recommend the use of planetariums for teaching astronomy and two astronomical institutes occupied with teachers' training were found in favour of the planetarium. 5 states have provided or are about to provide curricula and/or teaching guidelines for astronomy. Astronomy is widely taught in the schools of West Germany, at least at the elementary level, subordinated to other subjects, be it geography or physics. It is known that schools from states that do not own a planetarium undertake excursions to distant planetariums.

6. Conclusion:

Astronomy is taught very widely in the schools of West Germany, which allows the assumption that there must be an actual or potential demand for planetariums. The responsible Ministries in 3 West German states have already expressly recommended either the installation of school planetariums or the use of the planetarium as an educational tool.

It also seems safe to assume that in the remaining states the responsible Ministries have a latent readiness to either recommend or promote the use of the planetarium.

This report is illustrated by table no. 19 and table no. 63 in the appendix on page

The results of this part of the survey refute the operational hypothesis which has guided this study and in this support that part of the general hypothesis saying that there seems to be a demand for planetariums.

7. Implication:

A lack of potential demand for planetariums does not seem to exist at the level of the makers of educational policies and this question can therefore be excluded as possible cause for the underuse of the planetarium.
B) A Survey Conducted with Planetarium Manufacturers

1. Theme and Purpose:

The theme of this study is an investigation carried out with the manufacturers of school planetariums into the demand for their product. The purpose of this survey is to seek a test on the level of planetarium manufacturers for that part of the general hypothesis pertaining to the demand for planetariums.

2. Methodology, Procedure:

A descriptive survey has been undertaken by both personal interviews and correspondence. Validity is inherent in the questions and for reliability all information was double checked.

3. Population:

The following firms were contacted:

1) GALILEO, Italy
2) GOTO, Japan
3) MINOLTA, Japan (Viewlex)
4) SPITZ, USA
5) CARL ZEISS, East Germany

These are the manufacturers of projection planetariums for schools, i.e. small and medium size projectors, domes and auxiliary equipment.
4. Findings:

4.1 Enquiries from West Germany for Smaller Planetariums

In recent years, (up to the middle of 1980), GOTO had received 3 enquiries from West Germany and 1 order for their E-5 projector. VIEWLEX received 1 enquiry and SPITZ received 2 enquiries. They received 1 order for a medium size planetarium type 512 hyposphere. GALILEO received no enquiries from West Germany and had no sales in that country. ZEISS East Germany had at least 1 enquiry and sold 1 medium size planetarium in 1979/80 to West Germany. Their activities are, however, not exactly known, as - contrary to the other manufacturers - they are reluctant in giving any information.

4.2 Business for the Home Market

GOTO claim to have sold 100,000 of their midget planetariums in Japan and 10 medium ones. SPITZ and VIEWLEX both have a steady business in the USA. ZEISS East Germany continue to produce and to sell their medium size planetariums world wide. There have been sales to England, several East Block Countries and 1 to Libya in recent years. GALILEO had several sales in Italy.

4.3 Large Planetariums

CARL ZEISS West Germany have several projects for their large planetariums pending in West Germany and elsewhere. So have Spitz.

5. Discussion and Conclusion:

As manufacturers have had nearly no enquiries for school planetariums from West Germany throughout recent years, they tend to rate this market as being uninteresting rather than as a virgin market and thus worth exploring. They tend to judge a markets' potential by the number of price enquiries originating from the market area. They observe obvious actual demand and ignore potential demand.

The results of this study support the operational hypothesis printed at the head of this report as far as the West German school market is concerned in terms of views held by manufacturers.
6. Implication:

The narrow viewpoint from which the manufacturers seem to see the West German market is more obscuring than illuminating. Nevertheless, it is this viewpoint which determines their marketing policy and thus makes them partly responsible for the underuse of the planetarium in the school system of West Germany. See report III/8, on the second survey with manufacturers, which provides a closer investigation of this point.

This survey on demand closes the array of 10 research programmes undertaken in order to define the planetarium's educational value and demand for planetariums.
Summary Chapter II

"PLANETARIUMS ARE EDUCATIONALLY VALUABLE TEACHING TOOLS AND THERE EXISTS A DEMAND FOR THEM IN THE SCHOOLS OF WEST GERMANY"

Summary of the Surveys, Studies and Experiments undertaken to determine the Planetarium's Educational Value and the Demand for Planetariums

1. **Theme and Purpose** of the investigations described in Chapter II of this thesis are thematisized by the above rephrased hypothesis. The target group of the research were the school system and all those concerned with the planetarium, and the target area is West Germany. Germany is the country of origin of the projection planetarium.

2. **Population:**

   $N = 1163$ is the total number of subjects involved in the 11 research programmes of Chapter II of this thesis. The participants were:

   - Government officials in Ministries of Education
   - Magazine writers of various categories such as journalists or planetarium professors; school teachers, and educational researchers
   - University professors and university students
   - Astronomers
   - Planetarium directors cum lecturers
   - Manufacturers' personnel
   - General planetarium visitors
   - Pupils visiting 2 planetariums

3. **Methodology:**

   **2.1 Data Collection**

   Evaluation of literature, correspondence, personal interviews, discussions, questionnaires, and practical experiments (tests) were employed in data collection. The general hypothesis was put to the test by operational sub-hypotheses which guided the individual research programmes.
2.2 Quantification

Quantification of data has been attempted for most of the surveys conducted as a help in assessing individual and group achievement. While this produced hard and reliable figures for the experiments performed in the planetarium, the system was only able to express tendencies in opinions and attitudes in the various opinion poll surveys. No absolute standard could be attained there, as no system of adequate weighting for the individual questions used in the various questionnaires and interviews could be provided, nor could the subjects involved engage themselves as a monolithic body in each and every question. Certain factors - for which attempts have been made to provide adequate explanations - have hence exerted influences on particular answers with a diminishing effect on scores. Thus in some instances the total quantitative results of a poll tended to mask the subjects' real engagement in the topic under question. Scores and rank orders in the tables which summarize findings are therefore only a help for analysis and do not represent the definite result itself.

3. Findings and Conclusion:

After an initial exploratory survey into the planetarium world and after a target group survey an attempt was made to define the planetarium's educational value by three different approaches:

The planetarium's intrinsic value was determined by defining its potential and function and a justification for its existence and use was derived from current media research in Germany. The second attempt to determine the planetarium's educational value in a more absolute manner was conducted in the form of practical experiments. Opinion polls were performed with all groups concerned with the planetarium in one capacity or other. In this way the planetarium's reputation as an educational tool, as seen by these groups, was determined. Demand has been investigated in the schools on the level of educational policy-making and on the level of manufacturers. General- and research literature on the planetarium has been evaluated to produce evidence and opinion on the planetarium's educational value.
The general hypothesis has been supported by all surveys with the exception of the survey conducted with manufacturers, which lead to a negative result due to their narrow vision of the market situation in West Germany. Only actual demand is considered by manufacturers, and potential demand remains unobserved.

4. Implication:

If it is true that the planetarium is an educationally valuable teaching tool and if there exists a demand for planetariums, then there must be forces at work which prevent the more widespread use of planetariums.

The results of the various surveys conducted exclude most of the findings presented as possible causes for the underuse of the planetarium. It was concluded that only in the surveys conducted with the schools and with the manufacturers, could material be found that might lead to the deduction of such causes for the underuse of the planetarium.

Chapter III of this thesis is devoted to an investigation of the apparent underuse of the planetarium and the reasons responsible for this underuse.
CHAPTER III

THE UNDERUSE OF THE PLANETARIUM

Introduction and Synopsis

As in the preceding sections of this thesis many findings were excluded as being possible reasons for the underuse of the planetarium as an educational tool, chapter III is devoted to a systematic investigation of this underuse and the more likely reasons responsible for it.

The third part of the general hypothesis states that

"FOR A VARIETY OF REASONS PLANETARIUMS ARE UNDERUSED IN EDUCATION".

As a result of the experience gained from the school pilot survey and based on the preceding part-projects described in chapter II, this third part of the research project has been designed and carried out.

The justification for this part of the overall research project arises as a logical consequence of the facts established by the surveys of the previous chapter. For if it is true that the planetarium ranks highly as a valuable teaching tool and if there exists an actual or potential demand for planetariums, then it is worthwhile investigating the apparent underuse of the planetarium and - as far as is possible for an individual researcher - the reasons responsible for this underuse.

The factors that bring about a certain state of affairs, such as the underuse of the planetarium defined as a research problem by the third part of the general hypothesis, can be manifold. A decision in favour of or against a project or idea, such as the installation of a planetarium, or no decision at all may be due to several or all or even only one of such factors.
In order to treat the research problem exhaustively, a number of operational hypotheses have been devised and form the basis of the research described in this chapter on the underuse of the planetarium.

Several surveys and studies have been undertaken dealing with 3 main fields of enquiry:

1) The planetarium's place in the cultural scene.
2) The planetarium's position in the educational field.
3) Planetarium manufacturers' promotion of the planetarium.

These 3 fields of enquiry have been investigated by 9 survey programmes composed of many sub-questions.

In the section dealing with the educational field, use has been made of the results obtained from the main school survey conducted in West Germany and partly already described in chapter II on the educational value of the planetarium and the demand for planetariums. New surveys have been added for supplementation and for covering the other fields of investigation.

The subjects involved in the surveys of chapter III had to deal partly with only one single question, as in the opinion poll on the number of planetariums, survey III/1, or with an array of questions in other surveys. The total number of new subjects directly involved in the investigations undertaken in the framework of chapter III amounts to \( N = 72 \). Many others had already participated in earlier surveys and are not re-counted here. Additionally, 2420 schools were subjected by a commercial company to an advertising campaign for school planetariums and newspaper advertisements were printed to solicit enquiries for planetariums from the schools. These activities were evaluated for this thesis.

In accordance with the Leitmotiv guiding this thesis (see page no. 16) the work undertaken in chapter III culminates in "Recommendations" to 8 different groups concerned with the planetarium on how its more widespread use could be promoted. See pages 461/62.
"THERE ARE SUFFICIENT PLANETARIUMS IN OPERATION IN WEST GERMANY TO MEET ACTUAL OR POTENTIAL DEMAND FOR PERFORMANCES"

An Opinion Poll Survey on the Number of Planetariums

1.) Introduction:

When treating the problem of an apparent underuse of planetariums, one of the first questions that occurs to the researcher is whether or not there is a sufficient number of planetariums in existence that could be used, but may not be fully used or not be used at all for whatever reasons. If an enquiry should reveal that the number of planetariums in existence is not sufficient to meet actual and potential demand for performances, the next step will be to investigate the causes of the deficiency.

2.) Methodology and Procedure:

In testing the above operational hypothesis several opinion polls were evaluated concerning the question of the number of planetariums and some calculations were performed based on official statistics on the number of schools and pupils and on a census of planetariums compiled by the author. Validity is ensured, as only 1 direct question as to the number of planetariums was asked. Reliability is pre-given, as earlier surveys were used and as official statistics were evaluated.

3.) Population:

Within the framework of the various research programmes conducted in the preceding chapter II, which were carried out in order to establish the evaluation given by various competent groups to the planetarium as an educational tool, 7 of these groups were asked whether or not they considered the number of existing planetariums as being sufficient. The results of this survey are quoted and discussed below. To highlight the theme, international votes and USA votes have also been counted and are quoted in this survey. Reference is made to table 20 on page 358.
4.) Findings and Discussion:

From the comparison table of the planetarium census for West Germany\(^1\), we know that there is one planetarium for 3,032,530 persons in the total population of West Germany including West Berlin, or one for 474,783 pupils of all normal curriculum schools, i.e. primary, intermediate and high schools; all specialized schools, such as vocational training schools, being exempted from the count. Limiting the calculation to intermediate schools and high schools exclusively, again with the exemption of all specialized vocational schools, the resulting ratio is one planetarium to 150,694 pupils.

4.1 Particularly noteworthy among these various enquiries is the survey conducted with schools in West Germany\(^2\). This enquiry is interesting as it is aimed directly at the final target group of the overall research, the schools in West Germany, and as it involves a comparatively large sample size. Both a previous pilot survey and the larger scale survey had ascertained teachers' interest in the planetarium as an educational tool\(^3\)(\(^4\)), and another previous survey had ascertained an actual as well as a potential demand for planetariums for schools\(^5\).

In the large survey, a comprehensive questionnaire\(^6\) containing about 80 different questions was sent to 450 high schools in West Germany including Berlin. Question 28 of this questionnaire in-

---

(1) Table no. I/2, "Planetarium Census", page 57
(2) Chapter II, Programme 5, pages 156 - 178
(3) Chapter II, Programme 5, page 539/540
(4) Chapter II, Programme 5, page 165/66
(5) Chapter II, Programme 11, page 340
(6) Questionnaire "Astronomy in the School" no. 34, question 28, appendix page 546.
formed the schools of the number of planetariums in existence in West Germany and the resulting ratio of intermediate school and high school pupils to one planetarium. The schools were asked whether they considered the number of planetariums as being "too many, sufficient, too low, or much too low." 178 answers were received, resulting in the following range of opinions:

<table>
<thead>
<tr>
<th>Question: Do you rate the number of planetariums in West Germany as being</th>
</tr>
</thead>
<tbody>
<tr>
<td>too many?</td>
</tr>
<tr>
<td>sufficient?</td>
</tr>
<tr>
<td>too low?</td>
</tr>
<tr>
<td>much too low?</td>
</tr>
</tbody>
</table>

Total sample size: N = 178 (100.00%)

As the count reveals, the vast majority of these competent respondents rated the number of planetariums available in West Germany as too low or much too low.

The city-state of Berlin possesses a very active large planetarium with a long history of educational services to the schools and the general public. During 1977, the Berlin Planetarium was visited by 1,998 school classes with 55,062 pupils and teachers. The total population of pupils in the normal curriculum schools amounts to 244,372, according to official statistics. Berlin can hence offer under the present conditions one planetarium performance to each of its pupils once in every 4.43 years, a remarkably better average than is found in the state of Nordrhein-Westfalen, as mentioned farther below. This figure is also better than the average for West Germany as a whole. Still, the vast majority of schools in West Berlin who responded to the questionnaire voted in support of the statement that the number of planetariums is not sufficient.
4.2 Evaluating the interviews conducted on an international level with planetarium directors cum lecturers, we find that 33 of the 35 persons interviewed were of the opinion that planetariums were not sufficient in number on an international level. This is 94% of the respondents interviewed.

4.3 Another programme comprised a survey conducted with the planetarium directors cum lecturers in West Germany. The sample size amounted to 15 persons interviewed, 13 of whom were of the opinion that planetariums in West Germany were not sufficient in number.

One planetarium teacher flatly denied the truth of the statement without giving any explanation for his view. The fact is that he works in a community where planetariums are in relative abundance. In his town there is an old mechanical planetarium with electric bulbs representing the planets, essentially a museum piece but still attractive; there is a very old projection planetarium, a newer model of the large Zeiss projection planetarium, and a smaller school-type planetarium, plus - as it seems - some luminous star globe planetariums. Against the background of such richness his negative answer becomes understandable.

One teacher from a smaller planetarium in Nordrhein-Westfalen expressed the opinion that the one large and the two small planetariums in Nordrhein-Westfalen were sufficient to cover needs there, but he pointed to the total absence of planetariums in some other states of West Germany. His opinion contrasts strongly to the opinions expressed by the school teachers in Nordrhein-Westfalen. Most of the answers received, express the opinion that there are not sufficient planetariums in Nordrhein-Westfalen. A small calculation will support this:

(7) Chapter II/8 page 243
(8) Chapter II/8 page 249
Nordrhein-Westfalen:

<table>
<thead>
<tr>
<th>Number of planetariums:</th>
<th>1 large, 3 small</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of seats:</td>
<td>410</td>
</tr>
<tr>
<td>Days of annual operation:</td>
<td>≈ 250</td>
</tr>
<tr>
<td>Number of seats per year:</td>
<td>102,500</td>
</tr>
<tr>
<td>Average usage 75 %:</td>
<td>≈ 76,875</td>
</tr>
<tr>
<td>Number of pupils:</td>
<td>2,605,035(9)</td>
</tr>
</tbody>
</table>

Frequency of availability of a seat per pupil: 

\[ \frac{2,605,035}{76,875} \approx 1 \text{ seat every 33.87 years} \]

The calculation shows that it would take about 34 years, with the present density of planetariums, to have each pupil in the present school population experience a planetarium performance once. If the number of daily performances were tripled, it would still take 11.3 years to have every pupil in a planetarium once. This could be just once in his entire school life, based on 12 years at school.

The above is an interesting game with figures, quite revealing perhaps, but not realistic by far. The problem of transporting pupils to the planetarium considering the geographical distances in a large territory, as well as the problem of organisation and curriculum requirements, are completely left out of consideration. These problems do, however, exist. Question 12 of the large school questionnaire asks the teacher whether he would like to use a planetarium if it were situated near the school. (The same question was asked in the preceding pilot enquiry and produced 65 % "yes" votes). Question 13 asks the teacher whether he considered it too much trouble and fuss to visit a more distant planetarium with his pupils. Of the 199 respondents in West Germany, most are interested in using a nearby planetarium but half think it too much trouble and fuss to visit a more distant planetarium.

(9) see table no. 63, "Schools in West Germany", appendix II/11, page 598.
In the framework of the pilot enquiry conducted with schools in West Germany\(^{(10)}\), the question was asked at what frequency the schools would like to use the planetarium for a given class. From the replies received to this question the resulting average figure for the frequency is once in every 3 months. Assuming that this figure is also valid for Nordrhein-Westfalen - and there is no apparent reason why it should not be - it is obvious how severely this figure contrasts to the theoretical possibility of having a pupil in the planetarium once in every 12.5 years were all existing planetariums to offer 3 performances daily.

From the above it can be concluded that the number of planetariums in Nordrhein-Westfalen is not sufficient in number.

4.4 Our survey contains additional figures: the two most prominent manufacturers of planetariums were interviewed\(^{(11)}\). The 12 staff members of the two companies who took part in the interviews unanimously agreed that there are not sufficient planetariums installed around the world. The result of this particular point of the enquiry was a 100\% "yes" score, as may have been expected. Surely, selling planetariums is the basis for the manufacturers' existence, and it cannot be considered as unethical for them to base their convictions on this fact, but there is more behind the statements made: the gentlemen interviewed are rather familiar with world market conditions, with the existing number of planetariums, and they certainly have their statistics up-to-date concerning schools, colleges, student populations and other relevant data in various countries. Their answer means consequently that world-wide markets are not yet saturated in view of existing potentials and actual needs. (Though Spitz and others are guilty of having neglected the German market, according to survey III/8).

\(^{(10)}\) see questionnaire of the school pilot survey, table no. 30 appendix II/5A, page 542, question 16.

\(^{(11)}\) see survey II/9
4.5 During the "Week of Astronomy" held by the University of Riyadh, Saudi Arabia, during October 1977, the author had the opportunity of discussing the importance of the planetarium as an educational tool with an international knowledgeable audience being present at two lectures delivered by the author.

According to table no. 14, summarizing the discussions held, the question of whether or not there are sufficient planetariums installed around the world formed part of the interviews and discussions. Of the 31 competent participants, as many as 29 expressed the view that the world-wide number of planetariums is not sufficient. This is 93% of the sample size interviewed. See page 266.

4.6 As a very important target group in the survey conducted concerning the educational value of the planetarium, 60 astronomers in West Germany were contacted with questionnaires, and telephone conversations. A personal correspondence evolved with some of them. As mentioned in table no. 10 A, 43 of the 51 astronomers interviewed expressed the view that there are not sufficient planetariums installed in West Germany. This is 84% of the sample size interviewed. In an analysis of the survey conducted\(^{(12)}\), it was found that the strong inclination of astronomers towards the telescope as a medium for teaching astronomy was chiefly responsible for the relatively low percentage score in the "yes" column. See page 213.

4.7 The 7th and last group interviewed were the planetarium directors in the USA\(^{(13)}\). The survey conducted with this group served to supply the data for other discussions in this thesis, but the particular question concerning the sufficiency of planetariums was attached to the questionnaire dealing with the educational value of the planetarium. See table no. 13 page 254. The opinion of planetarium directors in the USA differs in this point from the opinions expressed by their German counterparts, as a comparison of

\(^{(12)}\) see survey II/7

\(^{(13)}\) see survey II/8 D
the relevant figures reveals. Conditions in the USA differ in many ways from conditions in West Germany, but the main difference may be found in the 10 times higher density ratio of planetariums. There is one planetarium to 67,684\(^*\) students in the USA, and this comparatively high figure may have caused some of the respondents to consider the total number of planetariums in the USA as being sufficient. Other respondents of the USA survey have understood the respective question as referring to their particular place of residence and, therefore, expressed the opinion that their very own planetarium was sufficient for the community which it serves. Only 33\% gave a "yes" vote.

The only USA manufacturer of planetariums who is still in the business is, however, of the opinion that the USA market is not yet saturated.

It is not known to the author what other factors may have influenced the opinions of the USA planetarium directors with regard to the sufficiency of the number of planetariums in existence there. The comparison is hence limited to the assumption that the so pronouncedly higher density figure of planetariums in many cases and the obvious misunderstanding of the question as being relevant only to a particular community are the predominant factors responsible for a visible difference in opinion of planetarium directors in the USA and their colleagues in West Germany.

A second calculation, such as carried out above under no. 4.3, this time for the whole territory of West Germany, may help to illuminate the question for the total target area under review in this thesis:

\[\text{(*) according to a census taken by the author}\]
West Germany

Number of planetariums: 6 large, 10 small & medium ones available to schools *)
(+ 4 small & medium ones installed in nautical colleges)

Number of seats: 1,937
Frequency of annual operation: \( \approx 250 \times \)
Seats per year: \( \approx 484,250 \)
Number of pupils: 9,495,663
Frequency of availability of a seat per pupil: 9,495,663 : 484,250 \( \approx \)
1 seat every 19.6 years

If the frequency of the daily performances were increased to 3, the chance for each pupil to visit a planetarium would increase to 1 \( x \) in 6.5 years. This is, as before, a purely mathematical calculation leaving geographical distances and organizational problems etc. out of consideration.

Conclusion:

Based on the pure arithmetic of the calculations made, and not considering other factors, the final figures obtained support the opinions expressed by the various respondents in West Germany proper, namely that the number of planetariums in West Germany is not sufficient to meet actual or potential demand. Considering the international scene, it is likely that the same holds true for many other countries as well. The results of the surveys conducted outside Germany tend to highlight the findings in the actual target area.

The operational hypothesis saying that "There are sufficient planetariums in operation in West Germany to meet actual and potential demand for performances" is hence refuted by the results of the survey conducted. The results of the survey support that part of the general hypothesis saying that planetariums are underused in education.

The next survey investigates planetarium activities in West Germany.

*) 1 more larger planetarium is not available for teaching purposes.
TABLE 20
AN OPINION POLL ON THE NUMBER OF PLANETARIUMS

"Planetariums are not Available in Sufficient Number"

<table>
<thead>
<tr>
<th>No</th>
<th>Participants</th>
<th>Reference</th>
<th>Sample Size</th>
<th>Yes</th>
<th>Undecided</th>
<th>No</th>
<th>Scores % yes</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Teachers in West Germany</td>
<td>Survey with Schools II/5</td>
<td>178</td>
<td>165</td>
<td>0</td>
<td>0</td>
<td>92.70%</td>
</tr>
<tr>
<td>2</td>
<td>Planetarium Directors, International</td>
<td>International Interviews II/8</td>
<td>35</td>
<td>33</td>
<td>1</td>
<td>1</td>
<td>94.28%</td>
</tr>
<tr>
<td>3</td>
<td>Planetarium Directors, West Germany</td>
<td>Survey with Planetariums II/8</td>
<td>15</td>
<td>13</td>
<td>1</td>
<td>1</td>
<td>86.66%</td>
</tr>
<tr>
<td>4</td>
<td>Planetarium Manufacturers</td>
<td>Interviews II/9</td>
<td>12</td>
<td>12</td>
<td>0</td>
<td>0</td>
<td>100%</td>
</tr>
<tr>
<td>5</td>
<td>A Knowledgeable Audience, International</td>
<td>Discussions II/8</td>
<td>31</td>
<td>29</td>
<td>1</td>
<td>1</td>
<td>93.54%</td>
</tr>
<tr>
<td>6</td>
<td>Astronomers in West Germany</td>
<td>Survey with Astronomers II/7</td>
<td>51</td>
<td>43</td>
<td>7</td>
<td>1</td>
<td>84.31%</td>
</tr>
<tr>
<td>7</td>
<td>Planetarium Directors, USA</td>
<td>Survey in the USA II/8</td>
<td>65</td>
<td>21</td>
<td>37</td>
<td>6</td>
<td>33%</td>
</tr>
</tbody>
</table>

N = 387

Summary
A total of 387 respondents, who have participated in various surveys, have given their comments on the number of Planetariums available. American Planetarium directors scored lowest, Planetarium manufacturers scored highest. Teachers, Astronomers and Planetarium directors in West Germany are, in their vast majority, convinced that the number of Planetariums in West Germany is not sufficient to meet actual or potential demand for performances.
"PLANETARIUMS ARE USED AS ROUTINE TEACHING TOOLS
WHEREVER THEY EXIST"

A Survey into the Activities of Planetariums in West Germany

1.) Introduction:

After planetarium directors cum lecturers in West Germany had been invited to be their own judges with regard to the educational value of their institutions (see report II/8), they were contacted again with a request for information on their activities.

2.) Theme and Purpose:

The theme of this survey is an investigation into the activities of planetariums and the purpose of this investigation is to seek a test for the operational hypothesis, printed at the head of this report, which is guiding this study. This is, at the same time, to provide support for that part of the general hypothesis saying that planetariums are underused in education.

3.) Methodology and Procedure:

A descriptive survey has been conducted by personal interviews, telephone interviews and questionnaires sent through the mail. The data collected are not subjected to a score and rank order system, as no considerations of value categories are involved. To highlight some of the data obtained, a comparison is made to conditions prevailing in the USA.

4.) Population:

The population of this survey is the planetarium directors cum lecturers in West Germany and, for comparison purposes, relevant data from the second survey conducted with USA planetariums are used.
5.) **Rationale of the Questions:**

The questions have been kept simple and are of a direct nature. The questions are designed to cover the theme under study and possess validity. **Reliability** is assumed as no reason is conceivable why wrong answers should have been given.

6.) **Findings and Discussion:**

5 large and 3 small planetariums participated in the survey. *)

Reference is made to table no. 21 at the end of this report, p. 366.

6.1 **Number of Planetarium Performances:**

All the above planetariums participated in this question.

a) **For the General Public**

An average of 13 performances take place per week in the large planetariums and an average of 2 performances take place per week in the small planetariums.

b) **For the Schools**

The corresponding number amounts to an average of 14 performances in the large planetariums and to an average of 5 performances in the small planetariums.

The average number of pupils per performance amounts to 136 in the large and to 65 in the small planetariums.

Two of the larger planetariums do not differentiate between general and school performances.

Estimations of how many times the average pupil could witness a planetarium performance during his school life run between 1 to 4 times in the large planetarium and to 1 time in the small planetarium. Only 2 large and 2 small planetariums participated in sub-question c by giving the estimates asked for.

*) Footnote: All public planetariums were invited to participate, but several of the small planetariums ignored the invitation inspite of reminders.
6.2 **Who arranges the School Children's Visit to the Planetarium?**

Are these visits arranged by the school authorities, the headmasters, the individual teachers, or does the planetarium approach the schools?

It seems that the school authorities have no part in arranging visits to the planetarium for their schools. It is either the school's headmaster or the individual teacher who occupies himself with this task.

Some of the planetariums inform the schools of their respective area of their programmes, the others do so on request.

6.3 **Who arranges the Planetarium Programme?**

In the large planetariums it is the institute itself that arranges the programmes in most cases. Schools either have or wish for little influence on the programmes. In Stuttgart the school's influence amounts to only 1 %, in Berlin to 10 %, in Bochum to 20 %, and in Hamburg to "very little". In Hamburg, there is only an occasional request from teachers to treat a particular question in the framework of the standard performances.

In the small planetarium the schools' influence on the performance amounts to an average of 20 %.

6.4 **Sufficiency of the Planetarium Performances**

It seems that only during certain periods is the demand for performances higher than can be met by the planetarium, with the exception of one small planetarium that can only rarely cope with the demand, despite having 2 school performances daily. The planetariums are used to capacity and could not increase their teaching load with their present staff and equipment. Only one planetarium in West Germany is automised; the other planetariums do not think that they could benefit from automatisation of their equipment with regard to an increase in their capacity. Some planetariums think that the users' capacity is not fully utilized.
Some planetarium directors recommend that schools should try to make more use of the planetarium and that teachers should be encouraged to include planetarium performances in their lessons.

7.) Evaluation:

It seems that the existing planetariums can serve their surrounding school clientele sufficiently well and that generally no more demands for performances are made on them than they actually satisfy. Offer and demand seem sufficiently balanced with some marginal deficiencies on either side of the scale at certain periods of the year.

Advertising is scarcely made. There seems to be no need for this in view of the size of demand and it is only logical that therefore no interest exists on the side of planetarium directors to increase their institutes' capacity by installing automatisation for their equipment.

Conditions in the USA look different:

In contrast, USA planetarium directors believe that automatisation could increase their capacity. Of 47 USA respondents in the second survey conducted with USA planetariums, 15 believed it could be increased by 25 %, 22 believed it could be increased by 50 %, 4 believed it could be doubled, and 6 believed that it could be more than doubled. 25 (37.31 %) out of 67 of the USA respondents stated that their planetarium was underused, and 57 (86.36 %) out of 66 believed that more advertising would help in filling their planetariums better. See exhibit 65 on pages 600-601.

Mean Value of Possible Visits:

The planetarium of Berlin claims that every pupil of the City State of Berlin could see a planetarium performance once in 3 years
(i.e. 3 to 4 times in his school life). This can be verified by a short calculation, using the data collected in the framework of this thesis:

Number of planetarium school performances 10 per week

Average participation ≈ 150 pupils
≈ 1.500 pupils per week

45 weeks x 1.500 pupils 67.500 pupils per year

Number of school children in the 3 types of normal curriculum schools 244.372 *)

244.372 : 67.500 ≈ 3.62 years x)

The figure given by the planetarium of Berlin for the number of performances available to the individual pupil is thus correct, within a permissible degree of error.

A similar calculation performed for the schools of the City State of Hamburg is given hereunder:

Number of planetarium school performances 10 per week

Average participation ≈ 100 pupils
≈ 1.000 pupils per week

45 weeks x 1.000 pupils ≈ 45.000 pupils per year

Number of school children in the 3 types of normal curriculum schools 241.053 *)

241.053 : 45.000 ≈ 5.36 years

The average pupil in Hamburg can expect to see a planetarium performance once in every 5 years, i.e. 1 to 2 times during his school life.

*) See table of school census in West Germany, appendix I page 598.

x) This calculation differs slightly from the one made for the year 1977 exclusively in report III/1.
The Kiel planetarium states that 75% of the Kiel school children see a planetarium performance only once in their entire school life, while 25% (participants in courses) see 10 or 20 performances in the same time.

The above 3 instances may be taken as being representative of the the whole planetarium community of West Germany, and also confirm in principle the findings of survey III/1 on the sufficiency of the number of planetariums in West Germany. This survey states that, under the most ideal conditions, a pupil can expect to see 1 planetarium performance in his school life. Survey III/1 is valid for the whole of West Germany providing an overall average.

8.) Conclusion:

Whereas the school pilot survey hinted at a desire of schools to use a planetarium once in every three months, the reality is far from this goal. Even where a planetarium exists, it seems that 1 performance in 4 years is the best mean value of possible visits that the average pupil can expect to make. This means 2 or 3 planetarium performances during his school time.

It is true that most planetariums do not complain about a lack in their capacity in view of the existing demand, but it must be emphasized that there really seems to be no greater demand. It follows that schools, out of inertia, organizational difficulties, by discouragement in view of the few existing possibilities, or because of unknown other reasons do refrain from asking for more performances, although this could force the planetariums to increase the number of their weekly activities by any appropriate method, maybe including automatisation.

There does not seem to be more demand for planetarium performances, as more performances are not being supplied. Demand has adjusted itself in time to the scarcity of the performances being supplied.

The new planetariums in Stuttgart and Erkrath support this view. Demand there is very pronounced and the supply of performances does not meet this demand. This causes the schools to become discouraged and results in the demand for performances tending to adjust itself downwards to the level of the scarce supply, according to the personnel of the two planetariums who were interviewed on this question.
The results of this investigation can not convince one that the planetarium is used as a customary routine teaching tool for the schools. Its application is the exception rather than the rule.

Even where a planetarium exists, its capacity is not sufficient to allow its application as a routine teaching tool that could be used regularly for teaching astronomy, let alone as a teaching tool for related sciences as in the USA.

The number of existing planetariums would have to be increased substantially if their more regular application were really to be the goal, as is recommended by the Ministries of Education in 3 West German states including Berlin.

The results of the survey refute the operational hypothesis printed at the heading of this report, and thus support the general hypothesis in that part saying that planetariums are underused in education.

A translation of the questionnaire used in this survey is printed as table number 21 and serves for the completion of this report.

The following survey III/3 investigates the available literature on planetarium construction and equipment selection as to its worth as a help to prospective planetarium owners.
TABLE 21
A SURVEY INTO THE ACTIVITIES OF PLANETARIUMS IN WEST GERMANY

<table>
<thead>
<tr>
<th>Questions concerning Planetarium Performances conducted for Schools</th>
<th>N</th>
<th>Planetariums</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Large</td>
</tr>
<tr>
<td>1) Number of weekly Planetarium performances:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1.1 For the general public</td>
<td>8</td>
<td>13</td>
</tr>
<tr>
<td>1.2 For schools</td>
<td>8</td>
<td>9</td>
</tr>
<tr>
<td>1.3 Average number of students per performance</td>
<td>8</td>
<td>136</td>
</tr>
<tr>
<td>1.4 How many time in his school life can the same pupil expect to see a Planetarium performance? (Estimate)</td>
<td>4</td>
<td>1x-4x</td>
</tr>
<tr>
<td>2) Who arranges the schools’ visits to the the Planetarium?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2.1 The educational authorites?</td>
<td>8</td>
<td>No</td>
</tr>
<tr>
<td>2.2 The school headmasters?</td>
<td>8</td>
<td>occasionally</td>
</tr>
<tr>
<td>2.3 The individual teachers?</td>
<td>8</td>
<td>mostly</td>
</tr>
<tr>
<td>2.4 The Planetarium approaches the schools?</td>
<td>8</td>
<td>1</td>
</tr>
<tr>
<td>3) Who arranges the Planetarium programmes?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3.1 The Planetarium?</td>
<td>8</td>
<td>Yes</td>
</tr>
<tr>
<td>3.2 The schools ask for a certain programme?</td>
<td>8</td>
<td>seldom</td>
</tr>
<tr>
<td>3.3 In case of the schools, what is the percentage?</td>
<td>8</td>
<td>1-20%</td>
</tr>
<tr>
<td>4) Number of Planetarium performances for the schools:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4.1 Are there more demands than can be satisfied?</td>
<td>8</td>
<td>rarely</td>
</tr>
<tr>
<td>4.2 If so, by what percentage would your capacity have to be increased to meet these demands?</td>
<td>8</td>
<td>-</td>
</tr>
<tr>
<td>4.3 By what percentage could automatization of your equipment increase your capacity?</td>
<td>8</td>
<td>none</td>
</tr>
<tr>
<td>4.4 Are you not interested in such an automatization?</td>
<td>8</td>
<td>1</td>
</tr>
<tr>
<td>4.5 Are offer and demand balanced for your performances?</td>
<td>8</td>
<td>Yes</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4.6 In case of a surplus in demand, why can’t you increase the number of performances?</td>
<td>8</td>
<td>impossible</td>
</tr>
<tr>
<td>4.7 In case of a surplus in offer, may lack of advertising in the schools be the reason for your underused capacity?</td>
<td>8</td>
<td>-</td>
</tr>
<tr>
<td>4.8 Or may lack of interest on the part of the schools be the cause of your underused capacity?</td>
<td>8</td>
<td>-</td>
</tr>
</tbody>
</table>

Summary

This survey investigates the planetarium's relationship to its school clientele. Even where Planetariums do exist, they do not have a sufficiently large capacity to accommodate school classes for routine teaching. The visit to the planetarium is the exception rather than the rule.
"THE INSTALLATION OF PLANETARIUMS AND THE SELECTION OF ADEQUATE INSTRUMENTATION IS NOT EFFECTIVELY PROMOTED BY EXISTING LITERATURE"

An Assessment and Evaluation of a Thesis written as a Guideline for the Construction of Planetariums and the Proper Selection of Equipment

1. Introduction:
Teachers entertain strong fears concerning the complexities and problems associated with the installation of a planetarium. Only 56 (29.17%) out of 192 teachers did not share such fears according to the survey summarized by table No. 25 question no. 2. According to the same table, question no. 7, many teachers fear that a lack of standard comparison tests to form a basis for choice between the various available planetarium models could entirely prevent the acquisition of a planetarium. Only 40 (21.17%) out of 184 do not share this fear. See page 402.

It is indeed not an easy task to choose between existing planetarium models. Five manufacturers compete on an international basis for the school market with 12 different models of planetarium. In addition, there exists a 6th manufacturer offering luminous projection star globes who calls these planetariums. These globes project black dots on a bright hemispherical dome, thus demonstrating a star field. See chapter I, page 36.

Research literature on the planetarium is scarcely known among German teachers, as has been established by an earlier survey. But even when undertaking the tedious job of searching for publications to act as a guideline for decision making in the installation of a planetarium, one is bound to end up with a very meagre result, as only a few articles and only one doctoral thesis by N.J. Dean (1) have ever been published on the subject.

(1) Norman Jack Dean, "Guidelines in the Selection of Planetarium Instruments", Doctoral Dissertation 1971, University of Maryland, USA.
2. **Theme and Purpose:**

The theme of this survey is the assessment and evaluation of Dean's thesis on the installation of planetariums. The purpose of this undertaking is to seek a test for the operational hypothesis printed at the heading of this report and, in doing so, to seek a test for that part of the general hypothesis saying that planetariums are underused in education.

3. **Methodology and Procedure:**

Dean's thesis is reviewed and critically assessed. The merits of this work are weighed against its shortcomings.

4. **Limitation:**

As the author could not get hold of more relevant literature, he has had to limit himself to a review of Dean's work.

5. **Findings and Discussion:**

In assessing Dean's thesis, the following advantages embodied in his work need to be mentioned:

5.1 The fact that somebody has sat down and attempted to produce a guideline for prospective planetarium owners ought to be commended.

5.2 A general survey of most of the existing model varieties of planetarium projectors is offered.

5.3 Various forms of planetarium chamber designs are described and several useful comments given on these designs.

5.4 The development of the planetarium into an elementary and secondary school instrument is described, and many existing installations are named, including relevant sources of information in the USA and Canada.

5.5 Existing relevant literature has been thoroughly evaluated.
5.6 Many basic practical hints for planning a planetarium are listed.

5.7 The problems of providing suitable programmes are presented and literary references are given for teachers who seek advice in this respect.

5.8 Results of a survey concerning the level of education of planetarium lecturers are presented, though no recommendations are made, nor is a list of training possibilities provided.

5.9 Dean provides a range order of topics suitable (or not) for planetarium demonstrations in order to refute exaggerated claims by manufacturers concerning the multi-topic range capabilities of the planetarium. Even such odd subjects as psychology, music or foreign languages are included. (See page 61 of Dean's thesis.)

5.10 Dean proves that only the smaller planetarium projection instruments are actually being used for students' active investigations and experiments. Larger instruments, usually installed in the public planetariums, are not used for this purpose.

5.11 Dean lists a series of important questions to be asked by those seeking advice from existing planetariums.

5.12 Dean mentions the smallest dome diameter under which a planetarium projector can create a perfect illusion of being out in the open under the starry sky.

5.13 Dean indicates to the maximum attendance figure of pupils that can be taught efficiently by a single teacher.

While the above are useful and valuable points, the very basic disadvantage of Dean's work is its limitation to a consultation undertaken only with planetarium personnel. He himself very frankly denigrates his only source of information by mentioning that most of his respondents lack experience beyond the confines of their own installation. Dean has not conducted any experiments, has not heard any other views, has neither interviewed planetarium visitors nor any educationalists, nor any architect, nor astronomer. Apart from the thorough evaluation of existing literature and the other literary
references that Dean presents, the complete picture of his thesis appears to be rather one sided and hence very limited.

Even when accepting the above limitations, the following shortcomings in Dean's thesis are evident:

5.14 Projectors:

In the text, on page 11, Dean mentions the existing large star field projectors, such as Zeiss / West Germany, Minolta, Viewlex, and Spitz STP and STS; but he does not give any specifications for the two latter instruments, nor does he mention the Zeiss Jena instruments.

5.15 Comparison:

Dean fails to provide any comparison of the projection instruments mentioned, whether large or small. In the appendix he just reprints the specifications received from the suppliers without any attempt at classification or comparison; he also refrains from specific recommendations or comments.

As Dean's presentation of the above subjects lacks the desireable depth, it was only fair, to the various suppliers, to refrain from making his own recommendations for equipment. Dean lists only the recommendations made by various planetarium owners, and he concludes that users tend to recommend their own equipment or equipment that is more expensive. The whole chapter leaves the naive novice exactly where he was before. In this particular chapter the absence of any experimentation carried out by himself, or tests or presentation of neutral opinions, e.g. those of astronomers, degrades the value of his study.

5.16 Projection Systems:

A further omission is the complete absence of any comparison between, or any description of the two fundamentally different projection systems used in planetarium projectors: i.e. slide projection with projection lenses in one type and direct lamp image projection by individual aperture holes or individual star lenses used in the other type of projectors. (*)

(*) Footnote: See description given in chapter I of this thesis, page 37.
Since the method of projection is a significant characteristic for
classification of a planetarium projector, it ought at least to be
mentioned so that the reader, using Dean's guidelines, can try to
attempt the necessary comparisons by himself. However, the existence
of the two different systems can only be deduced by the reader from
a short phrase contained on page 2 of Dean's thesis: "Lenses and/or
perforations in the sphere are positioned to project the stars ...". Regrettably this is all he says.

5.17 Starfield Quality:

Dean fails to give any comment on the starfield quality of the
various projectors.

5.18 Auditorium Seating:

Dean fails to elaborate on the relative merits of the various
types of seating in the planetarium chamber.

Dean only reports the opinions of planetarium personnel and has again
not conducted any studies of his own, nor has he consulted any addi-
tional sources of information. He merely mentions e.g. that some
manufacturers recommend uni-directional seating but he leaves his
audience without advice as to the most appropriate kind of seating.
On page 90, in the framework of his chapter "guidelines", Dean men-
tions briefly: "Should seating be arranged for teaching (chevron
or unidirectional) or for entertainment (circular)?" At some other
place in his thesis Dean mentions that round seating will provide
more places in the chamber. Dean omits the crucial hint that, in uni-
directional seating, the 4th axis of the planetarium projector is an
indispensable feature. Dean's work must be criticized in this point as
being only sketchy and incomplete, and, as such, not capable of offer-
ing much serious advice. Anyway, it may be considered to be of value
that Dean has hinted at all at the various types of seating arrange-
ments for the planetarium chamber and left the prospective planetarium
owner to try to work his own way out from there. Dean's work does not
contain any indication as to inclined seating (though he mentions the
Spitz STS projector which is intended to work with inclined seating).
But on the other hand this has become more fashionable only since
Dean's work was written.
5.19 Multi Media Use:

Dean mentions on page 83/84 of his text the multi media use of the planetarium chamber. Dean finds that the multi media use of the planetarium chamber "is not related to the type of seating, type of main instrument, or whether or not the instrument is on an elevator".

The absence of any useful comment does not make the above a guideline for prospective planetarium owners. For, quite contrary to what Dean states, the multi-purpose use of the planetarium chamber has to be very well coordinated with the type of instrument and seating. If a planetarium is also to be used as an ordinary lecture hall and/or cinema or for other multi media presentations, such as slide projection, overhead projection, stage show, etc., seating must of necessity be essentially uni-directional toward the front where the events take place, and this entails - for the purpose of planetarium shows - the necessity of choosing a planetarium projector with a 4th axis in order to change the azimuth perspective for the audience. Additionally, the main projector must be provided with some mechanism for moving it out of the way of the projection beam of a cinema projector, etc. An elevator or lateral horizontal transporting rails for moving the projector out of the chamber are the two solutions to this problem. Nowadays, in multi-purpose planetariums, the dome is tilted or at least the dome is extended in front of the audience beyond the 180° horizon to provide a screen for auxiliary projection (hyposphere dome). Of the existing planetarium projectors, only the Spitz STS does not have to be moved away because of its exceptionally low profile. (2)

5.20 Part-time Personnel and Equipment Choice:

On page 85 of his thesis Dean discusses the question of the availability of personnel and uses the point of part-time personnel to draw extremely narrow lines for the equipment choice possible for operation by part-time personnel.

In fact, it is not the time that the operator/lecturer can devote to the job, it is his qualification and his involvement with the job that counts. Whether he operates the cheap, very small equipment exclusively

recommended by Dean for part-time operators, or a projector that is a bit larger or even a really large one, is in fact insignificant. The question of part-time or full time personnel, other things being equal, should not decide the question of instrumentation. Following Dean's advice may be directly detrimental to educational interests. In fact, there exists a number of planetariums with quite a sizeable equipment installation which operate only a few hours per week while, in the remaining time, the responsible personnel are occupied with completely different tasks.

The uncritical enumeration of conditions prevailing in a majority of installations surveyed does not provide a guideline for others.

5.21 Simulation of a Spacecraft's Tumbling:

Roll, pitch and yaw features "should not be purchased", (p.88) recommends Dean. At this point of his thesis he gives no reasons for this statement, so that one has to go back to previous pages (55 + 69) where he states that, according to information received from users, this feature is not valued very widely.

Dean has omitted to ask his respondents why they do not value this feature. The fact is that this feature is intended exclusively for the simulation of space travel experiences. It should have been mentioned that lectures on space travel are not too numerous in planetarium programmes compared to all the other topics taught there. When, however, such a lecture takes place the feature of roll, pitch and yaw is extremely useful as the audience will experience by simulation and not by a mere demonstration the sensation of the spaceship's roll, pitch and yaw movements. For some people this may very well be one reason more to go to that particular lecture in the planetarium. The basis for Dean's negative recommendation is very slim indeed and lacks the necessary probes into the depth of the matter. He should perhaps have asked his respondents the more specific question, as to whether they thought that the feature of roll, pitch and yaw was of value for the purpose it had been designed for and not only the more general question if it is "a valuable asset for the planetarium instruction" in general.
5.22 Elementary School Equipment:

In the framework of recommendations collected by Dean in his users' survey, he concludes that, in view of the restricted curriculum in force with elementary schools, only small cheap planetarium projectors with limited features should be installed.

This recommendation of Dean's, however, does not consider future trends in curriculums. If the curriculum should change, which it is quite apt to do, the school which has taken Dean's advice may find itself eventually stuck with an instrument that can be used only for a part of the performances desired. This would be a very embarrassing discovery. At least this point should have been discussed before presenting a recommendation.

5.23 History of the Planetarium:

Dean states on page 12 of his text that planetarium education "is a speciality which was, in essence, created by a manufacturer". (This would be Zeiss, the inventors of the projection planetarium)*

Dean is guilty of a principle error concerning one point in the history of the planetarium, as in fact Zeiss themselves report in many publications that the idea of the planetarium originated with the people from the Deutsches Museum in Munich, i.e. from educationalists, when one considers a large lecturing museum like the one in Munich as being an educational institute. (3)

5.24 The Planetarium Dome:

Dean fails to mention and to comment on the differences in dome construction material, the various qualities of such material, and the various types of coats of paint existing for the domes as reflecting material.

As the dome is an integral part of the planetarium equipment, and as Dean claims to provide guidelines for the selection of planetarium equipment, he should definitely have treated this point.

(3) Dr. H.Werner, "Vom Arat Globus zum Zeiss Planetarium", op.cit.
* Footnote: Insertion in brackets by the author.
Many a prospective planetarium owner wonders whether he should be satisfied with a cheap canvas dome, a cheap plastic dome or the more expensive aluminum metal dome, and whether a white glossy paint would be superior to a darker grey shade. Manufacturers have indeed done a lot of research into the question of dome manufacturing, dome installation and dome painting, and it would have been a good idea to include in the study presented at least some descriptions available from the various manufacturers. His own experimentation and comparisons would have been an additional asset to the study.

5.25 Chamber Illumination:

Dean delivers neither a description nor any recommendation concerning the illumination of the planetarium chamber.

Architects and manufacturers compete in the question of chamber illumination. Manufacturers offer elaborate illumination coves which contrast sharply with cheaper urn-lamps that can be mounted on arms protruding underneath the dome from the walls of the chamber. Proper illumination is quite a large factor responsible for the atmosphere created in the planetarium chamber. Not little of the mood of expectancy noticeable in a planetarium audience prior to the beginning of the performance can be ascribed to the effects of the interior illumination. Dean would have done well to complete his work with a chapter on illumination.

6. Conclusion:

Within the very narrow limitations given by Dean himself for his work it can be stated that he supplies many valuable hints to those seeking advice in planning and installing a new planetarium, and the criticism exerted is, though pointing to the shortcomings of Dean's work, intended to be constructive in that it points to possible pit-falls and seeks to avoid them.

While there seems to be a number of more general articles available on the subject of planning a planetarium *) , and while manufacturers offer a lot of advice to prospective planetarium owners, it seems that no specific work has ever been done on providing a critical description of available planetarium equipment and of providing systematic com-

*) Footnote: Not mentioned here.
parisons of the available planetarium models and their wide scope of accessories. It is known, however, that various committees who decide about the purchase of planetarium equipment have sat down and provided comparison tables of the instruments under review, but these tables have usually been made exclusively for internal purposes and have not been published.

The results of this investigation tend to support the operational hypothesis and likewise tend to support that part of the general hypothesis saying that planetariums are underused in education by hinting at the possible cause for that underuse, namely the absence of comprehensive literature offering complete advice on the installation of planetariums and equipment choice.

7. Implication:

In the absence of more relevant literature, the only advice that can be given to the prospective planetarium owner is that he should provide himself with as much information as possible from the various manufacturers, should perhaps follow many of Dean's general hints and establish a table of comparison for the various planetarium models and accessories, and should visit several planetariums, large and small, to clearly define their purposes, and should obtain general advice from the manufacturer chosen in order to establish an overall concept which would permit him to realize his wish of having a planetarium.

The next programme describes a survey of the cultural interests of the general public undertaken with the aim to determine the percentage interested in the planetarium.
"THE GENERAL PUBLIC MAY NOT BE INTERESTED IN VISITING PLANETARIUMS"

A Survey into the Cultural Interests of the General Public as a Possible Source of the Underuse of the Planetarium

1. Introduction:

Central Planetariums in West Germany serve both the cultural needs of the general public and the educational needs of the school system. It is known from observation and experience gathered during the initial preparatory survey with the planetarium world (programme II/1) and elsewhere that cultural-educational authorities prefer to receive the impetus from both cultural and educational sides - and if possible also from additional quarters - before embarking on the task of contemplating the installation of a central planetarium.

If an interest in the planetarium from the side of the general public cannot be taken for granted, than authorities may hardly feel motivated to attempt the installation of a central planetarium. It is therefore necessary to investigate the general public's spare-time interests with a view to their cultural inclinations. From the preceding surveys, it seems to have been sufficiently well established that the planetarium, as an institution is situated in the cultural as well as in the educational sphere, as opposed to sports venues, beaches and similar areas of recreation.

2. Theme and Purpose:

The theme of this study is an investigation of the cultural interests of the general public in West Germany as a possible reason for the underuse of the planetarium. The purpose of this study is to seek a test for that part of the general hypothesis saying that planetariums are underused in education for a variety of reasons.
3. Methodology and Limitations:

Little primary work has been done by the author in the field of study under review, as it seemed that this large field could hardly be covered by any single individual within a reasonable period of time. It is also true that this field seemed to have been adequately explored by other well-equipped researchers. The author has therefore freely drawn on the work of others. Validity and reliability seem to be ensured as the published data of well reputed institutions are being used in addition to own data accounted for in other surveys.

4. Procedure:

Research reports of professional opinion poll survey institutes have been utilized as well as the author's own data.

5. Findings:

5.1 The Cultural Interest of the General Public:

The city-state of Bremen, population 500,000, had its cultural scene recently systematically surveyed\(^{(1)}\) with the result that no member of its population wished to see the spectrum of cultural events reduced. On the contrary, most of the respondents involved in the survey wanted to see it expanded. The surveyors found that 2/5th of the population are "culturally underdeveloped" but could be won over by good advertising. Their cultural needs were not articulated. Complaints focused on opening times of cultural institutes, restrictive entrance fees and clothing rules, which all tended to make the cultural scene the exclusive domain of the social upper classes.

The surveyors are convinced that their findings are transferrable to other cities in West Germany and that they are therefore representative of the rest of West Germany.

Bremen does not own a public planetarium.

---

\(^{(1)}\) Dr. Karla Pohrberg, Zentrum für Kulturforschung Hamburg
"Kulturszene Bremen" 1979
5.1.1 Cinema Visitors

Much or even most of the cultural needs of today's modern population seems to be covered by television programmes. Reading and radio may cover a further large section of such needs.

Of the cultural and entertainment events taking place outside the confines of one's own home, the cinema seems still to rank highest in public appeal and patronage.

5% of the West German population over the age of 14 went to the cinema once a week in 1977/78. This results in 120 million cinema visits in that year. The respective survey(2) dealt only with German nationals and left the more than 3 million foreign residents uncounted for. Similarly, multiple visitors, who went to the cinema more than once a week were not counted.

More single than married people made use of this form of entertainment and those of a better educational level are over-represented among the cinema visitors (9.9% versus 3.5%).

5.1.2 Concert Visitors(3)

The musical interests of the West German population are predominantly focused on popular hits.

Only 1.4% of the West German population above the age of 14 have said that they attend concerts frequently. 14.7% attend occasionally and 83.3% never attend any concerts.

The social upper classes are strongly over-represented and an interest in concerts is more strongly pronounced in the over-25 age group.


(3) MARPLAN, Offenbach "euro data" 1975.
5.1.3 Theatre Visitors

The theatre, the oldest form of cultural entertainment for the general public, may have lost much of its clientele to television and to the cinema. Only 3.7% of the West German population over the age of 14 stated that they frequent the theatre; 22.9% go there occasionally and 73.4% stated that they never visit any theatre.

The social upper classes are over-represented among the theatre visitors.

5.2 The Planetarium's Position in the Cultural Scene:

5.2.1 The Percentage of Planetarium Visitors in the Population

Sig Wieser reports on undefined surveys performed in Canada saying that only 5% of the population was found to be interested in visiting a planetarium performance. He believes that if the performance were of a less instructional but a more entertaining character one could increase this low percentage to 11% and by additional means even to 20% of the population.

No similar exact surveys are available to use as a reference in West Germany. The Canadian results are therefore presented here to try and provide a meaningful comparison for the below estimate. This rough calculation may provide the basis for an estimation of the percentage of the West German population interested in the planetarium:

1. Planetarium Berlin

<table>
<thead>
<tr>
<th>Number of annual visitors</th>
<th>152,492</th>
</tr>
</thead>
<tbody>
<tr>
<td>less 20% regular visitors</td>
<td>121,993</td>
</tr>
<tr>
<td>Approx. size of the population of school age and over</td>
<td>1,848,090*</td>
</tr>
<tr>
<td>Percentage of visitors referred to the population</td>
<td>6.5%</td>
</tr>
</tbody>
</table>

(Regular visitors = 1.6%)

(4) ibid

(5) Sig Wieser, "The Automated Show" IPS "Planetarian" Vol. 8, No.1, 1979, page 18

(*) Status 31.11.76 Official Statistical Data, Source Märplan Offenbach
2. Planetarium Hamburg

Approx. number of annual visitors .... 120,000
less 50% regular visitors .... 60,000

Approx. size of the population of
school age and over .... 1,617,000(*)

Percentage of visitors referred to
the population .... 3.71%
(Regular visitors = 3.71%)

The mean value resulting from these 2 case studies amounts to 5.1%. From previous surveys it is known that the number of performances barely meets the demand. This is particularly true for the Stuttgart Planetarium. The two above case studies can be considered as being representative for the whole (small) community of public planetariums in West Germany. It seems therefore safe to assume that, where planetariums exist, approximately 5% of the population show an interest in planetarium performances. It seems furthermore safe to assume that the results of this estimate can be transferred to other potential places for planetariums, i.e. all of the larger cities in West Germany. For the cultural scene in West Germany is largely homogeneous. The following table summarizes the data.

**TABLE 22**

**THE CULTURAL INTEREST OF THE GENERAL PUBLIC IN WEST GERMANY**

<table>
<thead>
<tr>
<th>Cultural Events</th>
<th>Regular</th>
<th>Occasionally</th>
<th>Never</th>
</tr>
</thead>
<tbody>
<tr>
<td>Concert Visits</td>
<td>1.4%</td>
<td>14.7%</td>
<td>83.3%</td>
</tr>
<tr>
<td>Theatre Visits</td>
<td>3.7%</td>
<td>22.9%</td>
<td>73.4%</td>
</tr>
<tr>
<td>Cinema Visits</td>
<td>5.0%</td>
<td>unknown</td>
<td>unknown</td>
</tr>
<tr>
<td>Planetarium Visits</td>
<td>2.65%</td>
<td>5.1%</td>
<td>unknown</td>
</tr>
<tr>
<td>Planetarium Visitors in Canada</td>
<td>5%</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

* coarse estimate only

(*) Status 31.11.75 Official Statistical Data, Source Marplan Offenbach
5.2.2 Number of Planetariums

According to the results of survey III/1 there are not enough planetariums in operation in West Germany to meet actual or potential demand for planetarium performances. Only a few cities in West Germany have a planetarium, large or small.

5.2.3 Capacity of Planetariums

In the framework of survey III/1 and during other contacts with the planetarium directors in West Germany, the author has learned that, with the exception of Nürnberg, planetariums can barely meet the demand for performances for the general public.

5.2.4 The Planetarium's Clientele

A social cross section

Observation and experience show that the planetarium's clientele seems to represent a cross section through society and that those interested in this form of astronomical study seem to come from all walks of life. Though the better-educated section of the general public seems to be slightly over-represented, the planetarium is not an exclusive place for the social upper classes.

A faithful clientele

Planetariums seem to have a faithful clientele according to survey II/6 conducted with planetarium visitors in West Germany. Of 243 visitors 190 (=78.19%) confirmed that they had been to the planetarium once before and 150 (=61.73%) confirmed that they had already been there on more than one occasion.

But planetariums count also many newcomers. According to verbal information received from the Hamburg and the Berlin Planetariums the rate is approximately 20 regular visitors to 80 newcomers for the Berlin Planetarium and 50 : 50 for the Hamburg Planetarium.
5.2.5 Authorities' Readiness to Install New Planetariums

In survey III/6 question no. 7 asks whether or not "the acquisition of a medium-size planetarium for a school region (and adult education) could be considered". 21 (=34.34%) "agreed", 26 (=42.62%) were "undecided" and only 14 (=22.95%) "disagreed". See table 27 on page 418.

It is known in the planetarium world of West Germany that 4 large cities in West Germany are contemplating the installation of larger planetariums.

6. Discussion and Evaluation:

The 5% of the Canadian population claimed to be interested in the planetarium seem to correspond with the similar fraction of the West German population sufficiently close to support the estimate made for the latter (5.1%).

The cultural needs of the population in West Germany seem to be not sufficiently well articulated and the cultural offerings do not seem to be adequate in either size or scope.

Where planetariums exist in most cases they do not fully meet the existing demand for performances, while demand could most likely be further increased by suitable advertising. (Many American planetarium professors also share this view. See comprehensive questionnaire of the second survey conducted with planetariums in the USA. Appendix exhibit no. 65 on pages 600-601.

Cultural needs are more strongly pronounced in the social upper classes. Even the cinema attracts the greater part of its clientele from the better educated section of society. In contrast, the planetarium has the capacity, due to its greater flexibility in level and scope of performances, to satisfy the demands of all social strata. If approached efficiently, educational authorities do not appear to be hostile towards the planetarium idea.
7. Conclusion:

Based on the premise that the planetarium is a cultural institution of the same rank order and broad category as concert halls and theatres, it seems safe to assume from the figures and representative estimate presented that the fraction of the population interested in the planetarium is well within the normal range of those in the population that are culturally interested.

It further seems that the planetarium attracts people from all walks of life rather than being an elitarian institution for the social upper classes. This also holds true for the cinema, though it seems to be more favoured by the better-educated. If authorities were to refuse to buy planetariums for lack of interest on the part of the general public, then the educational opportunities would suffer proportionally. There are few planetariums in existence in West Germany. It can therefore be implied that the estimates made about the percentage of the population interested in the planetarium would also hold true for the rest of West Germany, if more planetariums were to exist.

The results of this study refute the operational hypothesis and in this exclude one important possible cause for the underuse of the planetarium, namely the absence of an interest in this cultural-educational institution on the side of the general public.

The following 3 surveys investigate the planetarium's position in the educational field in search of reasons responsible for the underuse of the planetarium.
"THE UNDERUSE OF THE PLANETARIUM AS AN EDUCATION TOOL"

The Planetarium's Position in the Educational Field - 3 SURVEYS

INTRODUCTION

In the educational field itself a number of various reasons can be traced which can be said to be either directly responsible for the underuse of the planetarium or to contribute significantly to its underuse. There are also latent reasons which may first come into effect when the installation of a planetarium is being actively pursued. Such reasons are defined as "hypothetical" reasons in the following 3 investigations.

Some of the considerations that may have an adverse influence on the installation of a planetarium have already been named in earlier surveys but were treated there from a different viewpoint. They reappear in the following 2 school surveys and are treated under the aspect of the preventative influence they may exert on the use of the planetarium in education.

The first two of the following 3 investigations on the underuse of the planetarium were conducted in the schools in West Germany. The results are compared with the conditions prevailing in the USA, as established by the second survey conducted with planetarium directors in the USA.

The main school survey performed in West Germany delivered the main data for the studies undertaken.

Opinions, biases, and misgivings that teachers entertain when facing the task of installing a planetarium have been investigated and interpreted as reasons tending to hinder or even to prevent the installation of school planetariums.

A third survey was conducted with educational authorities in West Germany whose actions, omissions or attitudes may additionally or solely be responsible for the underuse of the planetarium in the school system of West Germany.
"PLANETARIUMS ARE UNDERUSED IN EDUCATION BUT NO REASONS FOR THIS UNDERUSE ARE INHERENT IN THE SCHOOL SYSTEM ITSELF"

PART A: A Survey Conducted with Schools in West Germany

1. Theme and Purpose:
The theme of this survey is an investigation carried out within the realm of the schools on the underuse of the planetarium in education and some of the reasons responsible for it. The purpose of this survey is to seek a test on the school level for that part of the general hypothesis saying that the planetarium is underused in education and to critically question the results of the school survey II/5 accordingly.

2. Procedure:
Main School Survey in West Germany - USA Planetarium Survey

This investigation is essentially a part of the extensive school survey and the data treated here have been selected from the large comprehensive questionnaire serving this survey. In order to highlight certain points, a meaningful comparison with conditions prevailing in the USA has been attempted by conducting a survey among the planetarium community there. - The strength of teachers' confidence in the planetarium's educational value is measured against impeding factors.

3. Methodology:
The general hypothesis states in its central part that

"for a variety of reasons planetariums are underused in education ...".

In order to put this part of the general hypothesis to the test an operational sub-hypothesis, printed as the heading of this survey, has been devised, a test for which is sought by means of this investigation. This is a descriptive survey in one part and an explanatory survey in an other part exploring the reasons for the existing situation.
4. Rationale of the Questions:

The questions used in this survey are direct in character and are arranged in such a form that they deal consecutively with 5 fields of investigation: information, teachers' attitude, technical points, didactic points and the problem of purchasing and funds.

Questions are either positive or negative in character. Scoring is done as in the previous school survey II/5. Validity is ensured likewise, as the questions stem from the same large comprehensive questionnaire.

Reliability of the previous school survey II/5 was ensured by testing the consistency of answers to the more salient points through a system of cross references, (see table 8). The positive result established there allows the implication to be drawn that the rest of the comprehensive school questionnaire, of which all school survey tables are part, is similarly reliable. In the same sense, the internal and external consistency of a number of answers recorded in the following part B of this survey (table 25) has been ascertained as a test of reliability. This procedure has included points from table 23, which results in a confirmation of external consistency for these points and likewise allows the same implication of general reliability to be claimed for table 23. See paragraph 5 on "Evidence" pp. 399/400.

Questions are not of equal weight and importance. No attempt has been made to compensate for this shortcoming in the table no. 23. This avoids arbitrary weighting of the questions. Scores, and the resulting rank order sequence, therefore do not create a system of successive steps of importance. The answer that results in the lowest rank order is thus not necessarily the one that expresses the worst obstacle for the acquisition of a planetarium, but reflects only the participant's engagement in this particular question.

The discussion attempts to compensate for this shortcoming in the rank order of the questions.

5. Population:

The population for this study was comprised of 201 schools in West Germany and 70 planetariums in the USA. Both were randomly selected. The representativeness of these samples has been discussed before.
6. Findings:

**TABLE 23**

"REASONS FOR THE UNDERUSE OF THE PLANETARIUM AS INHERENT IN THE SCHOOL SYSTEM"

N = 201

(Selected and translated from the German Original) *

<table>
<thead>
<tr>
<th>No.</th>
<th>Questions</th>
<th>N</th>
<th>Rank</th>
<th>% Agree</th>
<th>% Disagree</th>
<th>Undecided</th>
<th>Agree</th>
<th>Undecided</th>
<th>Disagree</th>
</tr>
</thead>
<tbody>
<tr>
<td>1)</td>
<td>Is the large projection planetarium known to the teachers?</td>
<td>195</td>
<td>7</td>
<td>80.85</td>
<td>473</td>
<td>129</td>
<td>20</td>
<td>46</td>
<td></td>
</tr>
<tr>
<td>2)</td>
<td>Do you know of the existence of small planetariums for schools?</td>
<td>200</td>
<td>11</td>
<td>74.33</td>
<td>446</td>
<td>117</td>
<td>12</td>
<td>71</td>
<td></td>
</tr>
<tr>
<td>3)</td>
<td>Have you ever received information material from suppliers on projection planetariums?</td>
<td>198</td>
<td>26</td>
<td>48.99</td>
<td>291</td>
<td>39</td>
<td>15</td>
<td>144</td>
<td></td>
</tr>
<tr>
<td>4)</td>
<td>Is it possible that you have received so much advertising material from the school industry that any planetarium advertising might have disappeared in the lot?</td>
<td>198</td>
<td>5</td>
<td>86.36</td>
<td>513</td>
<td>18</td>
<td>45</td>
<td>135</td>
<td></td>
</tr>
<tr>
<td>5)</td>
<td>Do you know of any research literature concerning the educational value of the planetarium?</td>
<td>196</td>
<td>29</td>
<td>39.97</td>
<td>235</td>
<td>16</td>
<td>7</td>
<td>173</td>
<td></td>
</tr>
<tr>
<td></td>
<td>If you do not, do you see in this draw-back a reason to dispense with the planetarium as a teaching medium?</td>
<td>177</td>
<td>4</td>
<td>89.45</td>
<td>475</td>
<td>14</td>
<td>28</td>
<td>135</td>
<td></td>
</tr>
<tr>
<td>6)</td>
<td>Numerous, admittedly much debated, publications of educational research in the U.S.A. have produced the result that the modern audiovisual media do not make learning any easier for the pupils when compared to the classical media talk and chalk.</td>
<td>194</td>
<td>18</td>
<td>68.21</td>
<td>397</td>
<td>51</td>
<td>83</td>
<td>60</td>
<td></td>
</tr>
<tr>
<td></td>
<td>a) Do your own teaching experiences confirm such opinions?</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>b) Do you believe that in the light of such research one should dispense with the planetarium as a teaching medium?</td>
<td>180</td>
<td>3</td>
<td>90.93</td>
<td>491</td>
<td>5</td>
<td>39</td>
<td>136</td>
<td></td>
</tr>
<tr>
<td>7)</td>
<td>Would it be too much trouble and fuss for you to visit a more distant planetarium with your pupils?</td>
<td>196</td>
<td>21</td>
<td>60.71</td>
<td>357</td>
<td>94</td>
<td>43</td>
<td>59</td>
<td></td>
</tr>
<tr>
<td>8)</td>
<td>Are you in your own teaching fully satisfied with using only blackboard, globe, charts &amp; pictures in treating astronomical subjects?</td>
<td>199</td>
<td>13</td>
<td>72.53</td>
<td>433</td>
<td>55</td>
<td>54</td>
<td>90</td>
<td></td>
</tr>
<tr>
<td></td>
<td>In case this is so, would this be a reason for you to dispense with</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>a) using a planetarium?</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>b) buying a planetarium?</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
The attempt has been made, by posing 29 realistic questions, to investigate on the teachers' level a number of reasons that could be responsible for the underuse of the planetarium. The questions do imply that the planetarium is actually underused. Questions are no of equal weight, and rank order places are therefore no absolute measure of the questions' importance. Lack of information, lack of funds, and teachers' inertia rather than didactic and technical considerations, as treated in this survey, are the reasons that seem to be largely responsible for the underuse of the planetarium in the school system of West Germany.

See the large comprehensive Questionnaire of the main School Survey in the appendix, pages 546 - 551.

<table>
<thead>
<tr>
<th>No.</th>
<th>Questions</th>
<th>N</th>
<th>Rank</th>
<th>% scores</th>
<th>Agree</th>
<th>Undecided</th>
<th>Disagree</th>
</tr>
</thead>
<tbody>
<tr>
<td>9)</td>
<td>Do you think that it will be very difficult</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>a) to prepare the programmes?</td>
<td>195</td>
<td>14</td>
<td>72.14</td>
<td>422</td>
<td>37</td>
<td>89</td>
</tr>
<tr>
<td></td>
<td>b) to operate the equipment?</td>
<td>192</td>
<td>9</td>
<td>80.03</td>
<td>461</td>
<td>20</td>
<td>75</td>
</tr>
<tr>
<td>10)</td>
<td>Would you promote a training course for a teacher?</td>
<td>196</td>
<td>2</td>
<td>91.16</td>
<td>536</td>
<td>156</td>
<td>28</td>
</tr>
<tr>
<td>11)</td>
<td>Would you teach some pupils the handling of the equipment and let them</td>
<td>193</td>
<td>12</td>
<td>73.23</td>
<td>424</td>
<td>75</td>
<td>81</td>
</tr>
<tr>
<td></td>
<td>experiment with the equipment in order to deepen the understanding of the</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>subjects taught?</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>12)</td>
<td>Do you consider the possibility that pupils could carry out independent</td>
<td>177</td>
<td>17</td>
<td>68.93</td>
<td>366</td>
<td>74</td>
<td>41</td>
</tr>
<tr>
<td></td>
<td>experiments with the planetarium as being a possible argument for the</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>acquisition of a planetarium?</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>If not, is it because you</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>a) are afraid of the damage that could be done to the equipment?</td>
<td>101</td>
<td>27</td>
<td>46.53</td>
<td>141</td>
<td>69</td>
<td>24</td>
</tr>
<tr>
<td></td>
<td>b) consider experimenting to be of lower educational importance?</td>
<td>68</td>
<td>8</td>
<td>80.39</td>
<td>164</td>
<td>7</td>
<td>26</td>
</tr>
<tr>
<td>13)</td>
<td>Do your purchasing regulations demand that only the cheapest offer will</td>
<td>193</td>
<td>19</td>
<td>67.18</td>
<td>389</td>
<td>70</td>
<td>50</td>
</tr>
<tr>
<td></td>
<td>be considered?</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>14)</td>
<td>Are you permitted to choose a more expensive offer, in case of better</td>
<td>188</td>
<td>6</td>
<td>82.80</td>
<td>467</td>
<td>114</td>
<td>51</td>
</tr>
<tr>
<td></td>
<td>technical specifications?</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>15)</td>
<td>Why does your school not possess a small planetarium?</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>a) lack of information?</td>
<td>127</td>
<td>20</td>
<td>61.42</td>
<td>234</td>
<td>62</td>
<td>23</td>
</tr>
<tr>
<td></td>
<td>b) do you think that the costs are too high?</td>
<td>156</td>
<td>28</td>
<td>42.74</td>
<td>200</td>
<td>127</td>
<td>14</td>
</tr>
<tr>
<td></td>
<td>c) has the question never been considered?</td>
<td>146</td>
<td>23</td>
<td>56.85</td>
<td>249</td>
<td>85</td>
<td>19</td>
</tr>
<tr>
<td></td>
<td>d) do you think it not so important?</td>
<td>133</td>
<td>16</td>
<td>69.67</td>
<td>278</td>
<td>32</td>
<td>57</td>
</tr>
<tr>
<td></td>
<td>e) other reasons (please state on reverse)</td>
<td>45</td>
<td>25</td>
<td>53.33</td>
<td>72</td>
<td>28</td>
<td>7</td>
</tr>
<tr>
<td>16)</td>
<td>Assuming the purchase price of a planetarium to be of agreeable order,</td>
<td>132</td>
<td>22</td>
<td>58.08</td>
<td>230</td>
<td>59</td>
<td>50</td>
</tr>
<tr>
<td></td>
<td>would you consider buying one by</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>a) earmarking the necessary funds?</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>b) would you apply for the necessary funds?</td>
<td>169</td>
<td>10</td>
<td>75.54</td>
<td>383</td>
<td>80</td>
<td>54</td>
</tr>
<tr>
<td></td>
<td>c) would you try to collect the necessary funds by public performances</td>
<td>146</td>
<td>24</td>
<td>55.02</td>
<td>241</td>
<td>24</td>
<td>47</td>
</tr>
<tr>
<td></td>
<td>by the school, donations from parents, donations from industry and trade</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Free Comments:

A number of free comments were received in addition to the responses given to the printed questions. Most of these praised the planetarium as an educational tool; some explained why no planetarium could be installed.

20 teachers complained that no funds were available for a school planetarium. 9 of the respondents complained that there was no space in their school for installing a planetarium. 3 teachers complained that a planetarium would be something out of proportion at the school level. 3 teachers complained that even the nearby planetariums were severely underused by schools because of lack of interest in this teaching tool.

Many of the other comments elaborated on the questions posed and illustrated the answers given.

Several teachers asked for information on teaching media for astronomy.

Only two teachers claimed to have asked for funds for a planetarium, in vain, as they complained.

While a sincere interest in the planetarium was visible from the comments received, they breathed an atmosphere of helplessness created apparently by the sudden and unexpected confrontation with the idea of contemplating the acquisition of a planetarium for the own school or in partnership with a number of other schools.

None of the teachers confirmed a "Back-to-Basis" effect on planetarium installations such as is noticeable in the USA, according to table 24, question 2.
7. Discussion and Evaluation:

7.1-5 Information

Teachers are widely underinformed about the planetarium, as the answers received to questions 1 to 5 reveal. Nearly one quarter of them did not know of the existence of the large planetarium, more than one third did not know about the existence of the small planetarium, three-quarters of the participating teachers have never received any informational material on the planetarium and, of those who claimed to have received such material, it is not sure whether they had understood the question properly and have perhaps mistaken the advertising material for a luminous globe for information material on projection planetariums. The author firmly believes that none of the four manufacturers of school projection planetariums has ever sent any information material to West-German schools or teachers and this belief is supported by results from a survey undertaken with the manufacturers described later in this chapter.

Nearly 90% of the teachers confessed that they did not know of any research literature on the educational value of the planetarium, and again the author is convinced that, according to earlier surveys, virtually none of the teachers interviewed was familiar with any research literature on the subject.

Conditions in the USA

The situation is compared to the situation prevailing in the USA. Not teachers but planetarium directors, most of them in charge of college or school planetariums, were interviewed. Nearly all of these USA planetarium directors complained about a lack of research literature on the educational value of the planetarium, in spite of the fact that an estimated two dozen theses, dissertations, or other research articles are available there. Two thirds of the USA planetarium directors interviewed believed that the lack of research literature (or, as can be deduced, lack of knowledge about research literature) could have an adverse influence on the installation of new planetariums. Table 24 summarizes the USA survey.
TABLE 24

"REASONS FOR THE UNDERUSE OF THE PLANETARIUM AS INHERENT IN THE SCHOOL SYSTEM"

Data for meaningful comparisons extracted from the questionnaire of the survey conducted with planetarium directors in the USA

A Survey Conducted with PLANETARIUMS IN THE USA

<table>
<thead>
<tr>
<th>No.</th>
<th>Questions</th>
<th>N</th>
<th>Yes</th>
<th>Undecided</th>
<th>No</th>
</tr>
</thead>
<tbody>
<tr>
<td>1)</td>
<td>Many teachers seem to be quite content with the existing classical media (blackboard, books, charts, globes) and therefore tend to refrain from using the Planetarium.</td>
<td>68</td>
<td>40</td>
<td>10</td>
<td>18</td>
</tr>
<tr>
<td>2)</td>
<td>There is an educational movement active in the USA called &quot;Back to Basics&quot; advocating the exclusive use of the most simple teaching media. This movement has adversely influenced the use of Planetariums.</td>
<td>65</td>
<td>11</td>
<td>30</td>
<td>24</td>
</tr>
<tr>
<td>2.1)</td>
<td>......the installation of new Planetariums.</td>
<td>60</td>
<td>19</td>
<td>29</td>
<td>12</td>
</tr>
<tr>
<td>3)</td>
<td>Do you feel that there is a lack of research on the educational value of the Planetarium?</td>
<td>62</td>
<td>52</td>
<td>0</td>
<td>10</td>
</tr>
<tr>
<td>3.1)</td>
<td>If so, do you think that this may have an adverse influence on the installation of new Planetariums?</td>
<td>49</td>
<td>33</td>
<td>0</td>
<td>16</td>
</tr>
<tr>
<td>4)</td>
<td>Do planetarium manufacturers offer you software for your performances?</td>
<td>65</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4.1)</td>
<td>Sufficient</td>
<td>13</td>
<td>0</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>4.2)</td>
<td>Insufficient</td>
<td>31</td>
<td>0</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>4.3)</td>
<td>None at all</td>
<td>21</td>
<td>0</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>4.4)</td>
<td>Would you like them to do so?</td>
<td>64</td>
<td>49</td>
<td>0</td>
<td>15</td>
</tr>
<tr>
<td>4.5)</td>
<td>Do you have other sources for software?</td>
<td>58</td>
<td>41</td>
<td>0</td>
<td>17</td>
</tr>
<tr>
<td>4.6)</td>
<td>Are you independent of such sources and Do you produce your own programmes?</td>
<td>68</td>
<td>66</td>
<td>0</td>
<td>2</td>
</tr>
</tbody>
</table>

Summary

A Survey has been conducted with planetarium directors in the USA in order to provide data for meaningful comparisons to conditions in West Germany.
German teachers can hardly substantiate any claim for a planetarium other than by a personal belief in its value.

7.6 Effectiveness of Audiovisual Media

Question 6 deals with the effectiveness of audiovisual media. 59, i.e. about one quarter of the teachers interviewed confirmed that, according to their experience, modern audiovisual media do not make learning any easier for their pupils when comparing these modern media to the classical media like talk and chalk; but this does not influence their attitude towards the planetarium. Such negative effect seems stronger pronounced in the USA according to table 26, question no. 1.

7.7 Attitude

Teachers' attitude is tested by question 7 and 8. Nearly half of the teachers considered it to be too troublesome to visit a distant planetarium. This could be a cause of some larger planetariums being underused. Of the few larger planetariums that exist in West Germany, this had been true for the Nürnberg planetarium, which did not have enough visitors for a long period of time. The situation has improved only more recently.*

Incentives to Authorities

If half the teachers, or more, cannot decide on using a more distant central planetarium, authorities are deprived of half or more of the incentive to install one. (Incentive is expressed here in terms of interested schools.) For educational authorities have the choice of installing a large planetarium for a larger geographical school region, a medium-size planetarium for a smaller geographical school region, or small planetariums for individual schools.

* (Telephone interview with the director in early 1979.)
7.8 Satisfaction with Classical Media

55 of the participating teachers were fully satisfied with classical media for teaching astronomy, and 24 of them would refrain from buying a planetarium on these grounds. It is true that only 3 teachers think that they should dispense with planetarium performances. This negative effect seems stronger in the USA according to table 24, question 1.

7.9-10 Technical Considerations

As to the technical considerations dealt with by questions 9 and 10, the acquisition of a planetarium does not seem to be very much endangered by fears of difficulties in preparing programmes for the planetarium performance, nor by fears of difficulties in operating the equipment. Those teachers who believed in the above difficulties were outweighed by the vast majority, who would advocate a training course for teachers. Also USA planetariums have no problems with programmes.

7.11-12 Didactic Considerations

In the field of didactics, about one fifth of the teachers would not teach students the handling of the equipment in order to deepen their understanding of the subject taught. In fact, astronomy is the only science that does not allow the manipulation of the object under investigation. Stars cannot be handled; only observation and recording material, such as photos and spectrographic recordings, can be actively evaluated. It might therefore deepen students' understanding if they could handle the planetarium projector. Many teachers were undecided about this point and about 35% of the teachers who answered question 12 did not think that the possibility of experimenting with the equipment would be a good argument in favour of the planetarium, though only 7 teachers believed that experimentation is of lower educational importance.

One teacher remarked that it would not be a good idea to let the students operate the equipment; this would result in "astronomical football" rather than in judicious experimentation.
7.13-14 Purchasing Regulations

Purchasing regulations are dealt with in questions 13 and 14. Not much trouble seems to arise from this point, as only 23 teachers stated that they suffered from their respective purchasing regulations in the sense that they could buy only cheap equipment even in the light of better technical specifications. It could, therefore, be possible that a low-priced star globe could be imposed on them in lieu of a projection planetarium.

7.15 Owning a School Planetarium

Question 15 asks why schools do not possess a small planetarium. 32 teachers stated that the planetarium was not very important. Many confessed to having no information, the vast majority thought that the planetarium was too expensive for them. Another strong fraction has never considered the question.

7.16 Funding the Acquisition of a Planetarium

Earmarking funds and begging for funds are extraordinary actions when pursuing the acquisition of a planetarium, since applying for funds would be the normal procedure. Only 80 teachers expressed their readiness to apply for funds, while 35 teachers "disagreed" and a strong fraction of 54 were "undecided".

It is obvious that, as a rule, only those who are ready to invest the necessary efforts into funding a planetarium can hope to acquire one. While so many teachers attributed high educational value to the planetarium and have expressed their wish to own or co-own a planetarium, many of them seem to need additional motivation to induce them to undertake efforts for procuring the necessary funds.
8. **Summary and Conclusion:**

The underuse of the planetarium in education and a number of reasons responsible for this underuse have been investigated by 29 questions included in the large comprehensive questionnaire of the main school survey. Some of the themes dealt with by the questionnaire have been emphasized by presenting a comparison to corresponding conditions prevailing in the USA. The respective comparison data have been selected from the questionnaire used for the second survey with USA planetariums. See exhibit no. 65 in the appendix to survey III/2 p.600.

The questions deal with 5 fields of enquiry: information, attitude, technical points, didactic points, funds and purchasing. This inhomogeneous variety complicates the interpretation of the total score. Teachers' lack of information about the school planetarium seems to be a strong factor preventing its more widespread use. It is not the lack of confidence in the planetarium's educational potential but the lack of knowledge concerning its price, (which implies lack of knowledge about the existing model variety), and the further lack of knowledge about the planetarium's space requirements and overall technicalities.

In the field of attitude, teachers' inertia seems to be another important factor as may be apparent in the unreadiness of many teachers to visit a more distant planetarium. For some it is the omission of considering the question of possessing a small school planetarium, for a large number it is the unreadiness to procure funds for a school planetarium, and most of them seem to have been unable to develop their own initiative for acquiring information about the school planetarium. The author also is not sure whether it is not the teachers' inertia that counts to some extent for many of the "undecided" votes and abstentions, which seem to be unnecessarily high in number for some of the seemingly easy questions like those dealing with the provision of funds for a school planetarium, or the importance of the planetarium, or satisfaction with media.

Lack of funds is likely to be the strongest factor preventing the more widespread use of school planetariums, though participation was low in this question for an unreserved generalisation.
Didactic reasons of equipment handling, as treated in this survey, in their own right do not weigh very heavily for or against the planetarium, and tend to be important only in conjunction with other considerations.

Technical points of programming and handling of the equipment are points of some concern for a small number of the teachers interviewed but these points seem to be balanced by the very large number of teachers who are ready to take training courses.

The planetarium is obviously underused in education in the sense that most schools neither own nor co-own one, nor do they have easy access to one.

The survey hence supports the third part of the general hypothesis saying that planetariums are underused in education.

The results of the survey have refuted the operational hypothesis by naming a number of reasons inherent in the school system which tend to be largely responsible for the underuse of the planetarium in education. This result, in turn, supports that part of the general hypothesis saying that a variety of reasons is responsible for the underuse in the planetarium by naming a number of such reasons.

Remark:

Teachers' Inertia

The term inertia is limited in its meaning to a lack of action in one specific clearly defined respect. It is in no way intended to denigrate any individual person or a group of persons as possessing inertia as a trait of character. Preoccupation with other pressing matters, and/or lack of access to necessary information are recognized as being the most likely reasons for showing inertia, i.e. lack of action, in a specific desirable direction.

The following part B of this survey investigates a number of fears and prejudices on the part of the teachers as further likely reasons for the underuse of the planetarium.
"TEACHERS TRUST THAT NO SERIOUS OBSTACLES COULD STAND IN THE WAY OF ACQUIRING SCHOOL PLANETARIUMS"

PART B: An Enquiry conducted with Teachers in West Germany in the Framework of the Main School Survey.

1. Theme and Purpose:

The theme of this part is an investigation into the possible fears and negative considerations that might prevent teachers from acquiring a planetarium. The purpose of this survey is to seek a test on the teachers' level for that part of the general hypothesis saying that planetariums are underused in education and that a variety of reasons is responsible for this underuse of the planetarium.

2. Procedure and Population:

This part continues the part A of this survey III/5 and forms part of the main school survey, and data have been selected from the large comprehensive questionnaire provided for the main school survey. The survey conducted with planetariums in the USA has been used for comparison purposes.

3. Methodology:

An operational sub-hypothesis has been devised which is printed at the head of this survey report. This operational sub-hypothesis, which guides this survey, has been put to the test on the teachers' level by means of 16 mostly hypothetical questions included in the large questionnaire of the main school survey. The results are summarized in table no. 25, and table no. 26 provides the comparison to the USA. See pages 402 and 405. This is an explanatory survey.

4. Rationale of the Questions:

As has been shown by the school pilot survey and the preceding part A, teachers did not seem to have received much information about the planetarium, nor had most of them ever tried to procure a planetarium for their school. It therefore could not be expected of the teachers that they should possess any practical experience in dealing with a deeper probe into possible reasons that might stand in the way of
acquiring a planetarium for their school. In this survey teachers were therefore not asked what actual obstacles stood in the way of realizing a planetarium project, but what possible negative conceptions could - in their view - prevent the acquisition of a planetarium for their school, if such acquisition were actively pursued.

It is known from experience that the mere fear of the possible existence of certain difficulties and obstacles is sufficient to prevent a serious attempt from being made to undertake the realization of a certain concept. Fears may take on the form of solid biases.

5. Evidence:

Questions are direct in nature and do adequately cover the subject under study. Questions have therefore face and content validity.

Reliability of the test is ensured by establishing internal and external consistency in the pattern of answers given to interrelated questions:

Value
Questions nos. 10 and 12 concern value, and the answers are consistent with one another, occupying rank order places 2 and 1 respectively. Both questions are consistent with question 13 on value in table 7 of the school survey II/5. That question occupies rank order place 2 in its table.

Cost
Questions 1, 3, 8 and 9 involve considerations of cost. A similar pattern of answers is received for the strong questions 8 a and 9, which occupy rank order places 15 and 16. The lower agreement attained for question 8 b is perfectly logical and therefore consistent with questions 8 a and 9. Question 3 shows a similar negative tendency, while question 1 is not entirely concerned with cost but counts more in the field of knowledge. This group of questions shows external consistency with question 15 b, on costs, in table 23.
Knowledge

The questions demanding knowledge about the planetarium and some familiarity with its technicalities produce consistently a very high fraction of undecided votes. These are questions 1 (88), 13 (100), and 14 (78). More marginal in this context are questions 4 (51) and 7 (60). A pronounced coherence in the pattern of answers is visible. Point 13 shows an external consistency with point 9 a in table 23, both treat the question of programmes.

General External Consistency

Question 15 concerning problems of transport to a central planetarium has 63 voices in disagreement, and question 7 in table 23 concerning trouble and fuss involved in visiting a more distant planetarium has 59 voices in disagreement. The similar figure indicates consistency in the answers to these two related questions.

Implication

It seems safe to assume that those questions for which no internal or external interrelationship and hence consistency of answers exists, were answered with the same degree of seriousness as those for which consistency in answers could be established inside and/or outside the limits of the test.

Likewise it must be stated that the reliability of both the earlier school pilot survey and the school main survey (II/5) could be established by performing cross references in test of consistency of many of the answers. Both surveys dealt with the same population, and in fact the school main survey draws its data from the same large comprehensive questionnaire which is feeding the present survey. The positive result of the consistency test performed for survey II/5 can hence be considered as being an indication for the reliability of the complete large questionnaire and consequently also for the present part of this questionnaire under review in this survey.

The above considerations seem to produce evidence for the reliability of the results of this survey.
6. **Scoring:**

All questions are negative in character, and scores are therefore calculated by the factors 1 through 5 applied in rising order from left to right, i.e. "strong agreement" = factor 1 \(x\), "strong disagreement" = factor 5 \(x\). Total scores which determine the rank order places are - as is customary for most tables in this thesis - given in relative percentages and also in absolute figures. The height of the numbers is a measure of the extent to which a certain statement is accepted relative to the other questions. No attempt of weighting questions by any method seemed to be necessary for this survey, and the rank order places thus determine directly the relative importance of a given question as seen by the participants.

7. **Findings:**

The table no. 25 on the following page summarizes the action.

---

**Rank Order:**

All questions have only one theme, "obstacles for the acquisition of a school planetarium", and all questions measure in the same direction. Rank orders seem therefore not only to produce evidence of the subjects' engagement in a particular question but seem also to express the relative importance of this question. The higher the rank order number the stronger the argument seems to weigh against the acquisition of a planetarium.
### TABLE 25

**"TEACHER'S FEARS AS POTENTIAL REASONS FOR THE UNDERUSE OF THE PLANETARIUM IN EDUCATION"**

A Survey conducted with Schools in West Germany

Excerpted and translated from the German Original

<table>
<thead>
<tr>
<th>Questions</th>
<th>N</th>
<th>Rank Order</th>
<th>% of Agree</th>
<th>Strong Agree</th>
<th>Agreement</th>
<th>Undecided</th>
<th>Disagree</th>
<th>Strong Disagree</th>
</tr>
</thead>
<tbody>
<tr>
<td>Do you believe that the following set of possible negative considerations could prevent the acquisition of a planetarium for the school?</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1) The lifetime of the equipment might be too short in view of the high initial purchasing costs.</td>
<td>185</td>
<td>4</td>
<td>60.88</td>
<td>563</td>
<td>8</td>
<td>37</td>
<td>88</td>
<td>43</td>
</tr>
<tr>
<td>2) The installation of a planetarium is too complex and problematic.</td>
<td>192</td>
<td>9</td>
<td>54.27</td>
<td>521</td>
<td>31</td>
<td>59</td>
<td>46</td>
<td>46</td>
</tr>
<tr>
<td>3) The running costs of a planetarium might be too high.</td>
<td>186</td>
<td>12</td>
<td>53.00</td>
<td>493</td>
<td>23</td>
<td>65</td>
<td>58</td>
<td>34</td>
</tr>
<tr>
<td>4) There is a lack of trained operators.</td>
<td>200</td>
<td>10</td>
<td>54.00</td>
<td>540</td>
<td>24</td>
<td>71</td>
<td>51</td>
<td>49</td>
</tr>
<tr>
<td>5) The necessity of repairs may develop into a very large problem with the complicated machinery.</td>
<td>191</td>
<td>14</td>
<td>48.27</td>
<td>461</td>
<td>33</td>
<td>80</td>
<td>46</td>
<td>30</td>
</tr>
<tr>
<td>6) Even routine maintenance is a problem.</td>
<td>184</td>
<td>13</td>
<td>52.28</td>
<td>481</td>
<td>16</td>
<td>82</td>
<td>46</td>
<td>37</td>
</tr>
<tr>
<td>7) There is a lack of standard comparison tests as a basis for choice among the various models available.</td>
<td>184</td>
<td>11</td>
<td>53.04</td>
<td>488</td>
<td>27</td>
<td>57</td>
<td>60</td>
<td>33</td>
</tr>
<tr>
<td>8) The frequency of use of the planetarium may not be sufficiently high to justify the high costs for a:</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>a) school planetarium only for one's own school</td>
<td>189</td>
<td>15</td>
<td>38.52</td>
<td>364</td>
<td>78</td>
<td>71</td>
<td>19</td>
<td>18</td>
</tr>
<tr>
<td>b) central school planetarium for a group of schools.</td>
<td>160</td>
<td>6</td>
<td>58.75</td>
<td>460</td>
<td>10</td>
<td>49</td>
<td>47</td>
<td>49</td>
</tr>
<tr>
<td>9) The initial purchasing costs may be too high for the benefit of only one discipline with only little additional advantage for other disciplines.</td>
<td>186</td>
<td>16</td>
<td>37.31</td>
<td>347</td>
<td>67</td>
<td>90</td>
<td>18</td>
<td>9</td>
</tr>
<tr>
<td>10) There are doubts concerning the educational value of the planetarium.</td>
<td>191</td>
<td>2</td>
<td>74.14</td>
<td>708</td>
<td>3</td>
<td>17</td>
<td>41</td>
<td>102</td>
</tr>
<tr>
<td>11) An astronomical telescope is more important.</td>
<td>187</td>
<td>8</td>
<td>56.72</td>
<td>521</td>
<td>30</td>
<td>41</td>
<td>58</td>
<td>55</td>
</tr>
<tr>
<td>12) Planetarium performances belong rather in the domain of cinema and circus, i.e. pure entertainment, and not so much to the realm of school teaching.</td>
<td>190</td>
<td>1</td>
<td>88.95</td>
<td>845</td>
<td>0</td>
<td>4</td>
<td>16</td>
<td>61</td>
</tr>
<tr>
<td>13) It is feared that there will be no supply of ready programmes.</td>
<td>194</td>
<td>3</td>
<td>62.99</td>
<td>611</td>
<td>6</td>
<td>32</td>
<td>100</td>
<td>39</td>
</tr>
<tr>
<td>14) Any mistake in operating the equipment could seriously damage the machinery.</td>
<td>189</td>
<td>7</td>
<td>58.31</td>
<td>551</td>
<td>9</td>
<td>54</td>
<td>78</td>
<td>40</td>
</tr>
<tr>
<td>15) The installation of a central school planetarium for a group of schools would produce many difficult transportation problems.</td>
<td>189</td>
<td>5</td>
<td>59.89</td>
<td>566</td>
<td>20</td>
<td>34</td>
<td>72</td>
<td>53</td>
</tr>
</tbody>
</table>

| Actual Total Score: 8.530 | Maximum Possible Score: 14.985 | Percentage Attained: 56.92% |

**Summary**

The questionnaire investigates the prevalence of teachers' fears that may have a negative influence on the acquisition or use of a school planetarium. The survey attempts to probe deeper into teachers' conceptions by naming mostly hypothetical reasons that become apparent only at "second thought", as experience shows. For about two-thirds of the questions enumerated above, the number of those in agreement with the negative assumptions outweighs the contradicting voices. Rank order numbers express the relative importance of a question: the higher the number, the stronger the danger posed for the acquisition of a planetarium. If teachers cannot be supplied with fuller and better information on the school planetarium models and their technicalities, it seems to be easily possible that fears and biases entertained by many teachers could become decisive if it should come to the realistic question of acquiring a planetarium for their school.
The 15 questions deal with several fields of enquiry:

1) Educational Value
2) Considerations of Cost
3) Technical Points
4) Problems of Installing and Operating a Planetarium
5) Selection of a Telescope as an Alternative to a Planetarium

The questions are randomly mixed but were presented as one coherent group in the large comprehensive questionnaire, where their negative tenor was balanced by many neutral and positive questions.

The questions concerning technical considerations probe deeper into any relevant misgivings on the part of the teachers than any of the earlier questions did and are thus able to reveal more easily whether ignorance is a source of such misgivings.

8. Discussion and Evaluation:

Questions are discussed in their rank order succession with their running number given in brackets behind. For reasons of logical coherence some exceptions have been made: questions 7 (8b) and 15 (8a) are treated together, also questions 6 (14), 13 (6) and 14 (5) are treated in direct sequence.

1 (12) - Entertainment:
The vast majority of teachers, i.e. nearly 90%, object to the statement that planetarium performances belong rather to the domain of entertainment than to the realm of school teaching. Teachers hence accept the planetarium as an educational tool. The above percentage approaches the figure of those 99.38% who rated the planetarium highly as an educational tool according to question 13 in table no. 7 of programme II/5.

*) Footnote: "Inferior" was voted by 0.62%, i.e. 99.38% voted positively.
2 (10) - Doubts:

This question deals with doubts as to the educational value of the planetarium, and it is noted that the enthusiasm, so clearly apparent in the answers to the previous question, is slackening off. The majority of those denying the statement has shrunken somewhat and more are "undecided".

Research literature on the educational value of the planetarium is virtually unknown to teachers in West Germany, as a preceding survey revealed. The many teachers who do not have any doubts as to the educational value of the planetarium must, therefore, base their convictions on observation and experience on hearsay and intuition.

Conditions in the USA:

In the USA, where the planetarium is a more widely-used teaching tool, many planetarium directors are convinced that a substantial number of educationalists do not have much confidence in the planetarium.

Of 66 USA planetarium directors, 39 (=59,09%) believe that a substantial number of educationalists are not convinced of the superior cognitive educational value of the planetarium when compared to conventional school media. They further believe that this tends to impede the more widespread use of the planetarium. 32 (=48,48%) believe that this tends to impede the installation of new planetariums. 20 (=35,09%) out of 57 USA planetarium directors believe that the same negative influence also holds true for educationalists' considerations in the affective domain.

(See table no. 26).

Reference is made to the report on USA research literature, see programme II/3. USA educationalists who disbelieve in the planetarium's superiority over conventional media can substantiate their convictions with relative research literature.
TABLE 26

"TEACHERS' FEARS AS POTENTIAL REASONS FOR THE UNDERUSE OF THE PLANETARIUM"

Data for meaningful comparisons extracted from the Questionnaire of the Survey conducted with Planetarium Directors in the USA

A Survey Conducted with PLANETARIUMS IN THE USA

<table>
<thead>
<tr>
<th>No.</th>
<th>Questions</th>
<th>N</th>
<th>Agree</th>
<th>Uncertain</th>
<th>Disagree</th>
</tr>
</thead>
<tbody>
<tr>
<td>1)</td>
<td>A substantial number of educationalists are not convinced of a superior cognitive educational value of the Planetarium when compared to conventional school media. This tends to impede the more widespread use of the Planetarium.</td>
<td>66</td>
<td>39</td>
<td>17</td>
<td>10</td>
</tr>
<tr>
<td>1.1)</td>
<td>This tends to impede the installation of new Planetariums.</td>
<td>66</td>
<td>32</td>
<td>22</td>
<td>12</td>
</tr>
<tr>
<td>1.2)</td>
<td>The same holds true for considerations in the affective domain.</td>
<td>57</td>
<td>20</td>
<td>28</td>
<td>9</td>
</tr>
<tr>
<td>2)</td>
<td>How do you consider the cost effectiveness of your Planetarium in the cognitive domain, compared to conventional media?</td>
<td>60</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2.1)</td>
<td>Equal</td>
<td></td>
<td>14</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2.2)</td>
<td>Superior</td>
<td></td>
<td>32</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2.3)</td>
<td>Inferior</td>
<td></td>
<td>2</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2.4)</td>
<td>No comparison</td>
<td></td>
<td>12</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3)</td>
<td>How do you finance your operational costs?</td>
<td>68</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3.1</td>
<td>Grants</td>
<td></td>
<td>1</td>
<td>3 partly</td>
<td></td>
</tr>
<tr>
<td>3.2</td>
<td>Earned income</td>
<td></td>
<td>5</td>
<td>7 partly</td>
<td></td>
</tr>
<tr>
<td>3.3</td>
<td>Official budget</td>
<td></td>
<td>53</td>
<td>5 partly</td>
<td></td>
</tr>
</tbody>
</table>

Summary

A survey has been conducted with planetarium directors in the USA in order to provide data for meaningful comparisons to conditions in West Germany.
Prospective planetarium owners in West Germany are used to looking to the much larger USA planetarium community for inspiration, according to the author's observation and experience, but USA research literature seems to remain largely unnoticed.

It seems, therefore, that for the time being there is not much danger to the schools in West Germany from a negative infection of unfavourable trends in the USA. West German school teachers seem to be able to pursue any plan they may have regarding the installation of planetariums undisrupted from outside, basing on their own private convictions of planetariums' educational value.

Programmes:
A lack of ready-made programmes worries nearly one fifth of the respondents, who see in this possible handicap a reason to refrain from the installation of a planetarium. It is indeed a time-consuming job for a teacher to prepare a good programme by himself and some teachers have, in their open comments to the questionnaire, complained that they feared that the extra time would not be available.

This question met with the strongest "undecided" fraction which is as expected, from the inexperienced. Question 9 a in table 23 had produced similar results. Experienced USA planetarium directors show themselves independent in the question of programmes according to table 24.

Lifetime:
The lifetime of the equipment might be too short. About one quarter of the participating teachers share the belief that the lifetime might be too short to justify the price of the planetarium equipment. Nearly half the teachers were "undecided", which can be explained by most teachers never having received any information material from manufacturers, and as 71 out of 200 teachers have confessed to not knowing the small school planetarium.
5 (15) - Transportation:
Difficulties in transporting students to a central planetarium are seen by 54 out of 189 participating teachers. More than one third of the respondents are "undecided". Lack of experience and/or imagination, and perhaps the impossibility of sitting down and drawing up a transport plan just to be able to answer one hypothetical question in a questionnaire may be responsible for the large number of those being undecided.

6 (14) - Technical Difficulties:
Fear of possible technical difficulties guides the vote of many participants. One third of the participating teachers are afraid that they could seriously damage the equipment by mistakes in handling it. Most of the teachers have seen the large ZEISS planetarium, and the mere sight of this huge and impressive machinery is well apt to induce this fear. While a strong fraction is undecided about the question of the consequences of a possible mishandling of the equipment, those not sharing this fear are in the minority. The ratio of agreeing to disagreeing voices is 63:48.

13 (6) - Maintenance:
The fear of possible technical difficulties is further manifested in the question of routine maintenance. More than half the participants believe that the unresolved question of maintenance could prevent the acquisition of a planetarium. The ratio of believers to non-believers is 98:40 with 46 being "undecided" out of the 184 participants.

14 (5) - Repair Problems:
Strongest in the ratings among the technical points is the fear of repair problems. The statement speaks of "big" problems that may result from the necessity of repairs and further of "the complicated machinery". The statement in this form seemed to be acceptable to the majority of the participants. The ratio of believers to disbelievers amounts to 113:32, with 46 being "undecided" out of the 191 participants.
8 (11) - An Alternative Choice:

An astronomical telescope is rated as being more important than a planetarium by a ratio of 71:58 out of 187 participants, while 58 are "undecided". In fact, there are many more schools that do own a telescope than schools that own a planetarium, but there is no indication that the two possibilities were considered as being alternatives, when considering the high number of schools (144 out of 198) that had never received any information material on planetariums.

Presented now with the possibility of an alternative choice, 71 of the teachers voted in favour of a telescope. Reasons for this decision have not been explored by this survey and no material which would make the choice easier had been given to the teachers. The question stressed, however, the relative "importance" of the equipment, which is a purely didactic consideration, and it may be safe to assume that such considerations guided the votes.

A discrepancy is noted here; as 148 schools out of 200 schools had clearly voted for having a planetarium. (See table no. 7 of survey II/5 on page 165.) Only 58 supporters of the planetarium remained when faced with an alternative choice.*

Wanting a telescope (first) obviously does not exclude the fact that a planetarium may be wanted later as an addition to the telescope. Though this particular question had not specifically been asked, programme II/5 has brought evidence to show that, of the many schools who do own a telescope, nearly all were also interested in either owning, co-owning or at least in using a planetarium. With this in mind, it may be easier for those who want to see school planetariums installed to digest the apparent infidelity of teachers to the planetarium idea by their apparent readiness to sacrifice it for the idea of having a telescope.

* For question 8 (11) 55 teachers marked the "disagree" cell and 3 teachers marked the "strongly disagree" cell = 58 in total.
9 (2) - A complex and Problematic Installation:
A strong fraction of the participating teachers believe that the installation of a planetarium is too complex and too problematic. The ratio of believers to disbelievers is 90:56, with 46 teachers being undecided out of the total of 192 participants.

Lack of information and knowledge is a likely explanation for the unfavourable ratio. There exists practically no helpful literature as a guide for this critical problem with the exception of 1 thesis written in the USA. The importance of this question justifies a separate treatment of this thesis in report III/3.

10 (4) - Operators:
The lack of trained operators worried 95 out of 200 teachers.
In fact, there are no trained planetarium operators available on the labour market of West Germany. There is virtually no institution that produces operators as in the USA. The 54 confident teachers must therefore either not know about this shortage or be confident of their own abilities to learn how to handle the equipment.

As the previous part, table 23, question 10 of the accompanying table reveals, 156 (=79,59%) are in favour of a technical training course for teachers. This tends to diminish the thread of a decision against the planetarium on the grounds of a lack of trained operators provided, of course, that training could actually be arranged.

At the moment, two German Universities offer special courses in the didactics of astronomy to high school teachers, but planetarium technology is not included in the syllabus as neither institution possesses a planetarium.
11 (7) - Comparison Standards:
The lack of standard comparison tests as a basis of choice among the various planetarium models is a worry to 84 (=45.65%) of the teachers. This result shows the widespread insecurity among teachers who visualize themselves as being compelled to make a choice for which they have no qualifications. Many teachers would apparently rather capitulate than make a wrong choice. The result is not very surprising when considering teachers' low level of information, which has been mentioned several times before. - Research literature covering this domain is discussed in report III/3.

12 (3) - Running Costs:
Schools have, as a rule, only a meagre budget for maintenance of equipment. It is, therefore, no surprise to find the question of the running costs of a planetarium at rank order place 12. The ratio of believers to disbelievers in this point amounts to 88:40. The answers show how little is actually known about the technical side of school planetariums.

Comparison to Conditions in the USA:
Of 68 USA planetariums interviewed, 53 (=88.33%) finance their running costs from an official budget, the others earn part of their costs or have grants.

15 (8a) - Frequency of Use:
The frequency of use of a school planetarium is weighed against its costs. It is stated that this relationship may be unfavourable when considering only one school. The ratio between agreement and disagreement rises to 149:21 (7:1).
Though it seemed that teachers, according to the results of the school pilot survey, do not know the price of school planetariums, the conception of a disproportionate cost - use relationship seems to frighten most of them. The main survey does confirm that impression of unfamiliarity with prices.
Conditions in USA:

USA planetarium directors seem to possess experience and insight concerning the question of the cost-effectiveness of the planetarium, according to the results of the survey conducted with 70 USA planetariums. Of 60 planetarium directors interviewed as to the cost-effectiveness of their institution, 32 (=53.33%) claim superiority for their institution over conventional media in the cognitive domain, and only 2 of the respondents consider the planetarium as being "inferior". (Table 26)

Though no special survey has been conducted to really establish the degree of a school planetarium's cost-effectiveness, the responses received from the USA do hint at the possibility that a satisfying ratio could be attained. This would be an interesting separate study but is beyond the scope of this thesis.

7 (8b) - The above point is continued and extended to a central school planetarium. It is stated that the same unfavourable cost-use relationship may also prevail for a central school planetarium.

It is obvious that a central school planetarium is likely to be used at a higher frequency rate than a single school planetarium. Still, those in agreement with the statement outweigh those in disagreement to a ratio of 59:54.

16 (9) - High Costs:
The strongest point of concern in the scale of negative considerations is another question dealing with the cost-effectiveness. The possibility of high costs being invested in equipment for the benefit of only one discipline with only little advantage to other disciplines worries most of the teachers.

Does the question appeal to the teachers' altruism or to their practical sense? The question is perhaps more practical as it is well-known how many school disciplines compete with one another for the allotment of a share in
the meagre funds available. Teachers seem to be afraid that they could not make a good stand against all the other applicants for school funds. It is very widely believed among teachers that they would lose on the grounds of representing only one single discipline. The ratio of believers to disbelievers in this difficulty is 157:11 (14:1) with only 18 being "undecided". This is the lowest but one "undecided" number.

Earlier surveys show that a certain number of teachers are ready to procure the necessary funds for a planetarium. Evidently only a very few of the teachers are confident that they may succeed.

Survey no. III/7 investigates the question of finance for school planetariums, and the following survey III/6 investigates the attitudes of budgetary authorities.

In view of the apparent readiness of many teachers to actively pursue the procurement of funds for a planetarium, it may be safe to assume that the possible handicap pointed out by question 16(9) is not seen so much as existing within the teachers' group but rather outside among those that have to impartially allot funds, bearing in mind the great number of interests which must be satisfied.

9. **Review Summary:**

The conclusions to be drawn may be illustrated by the following review summary:

Some of the various questions presented to the school teachers in the large comprehensive questionnaire of the school main survey function like a filter with an increasing degree of fineness, with a stronger selective effect in each successive step.

| Total of the participating schools: | 201 |
| No knowledge about the planetarium: | 32 (15.92%) |
| Interested in using a nearby planetarium: | 154 (76.62%) |
| Interested in owning a planetarium: | 148 (73.63%) |
| Ready to finance a planetarium: | 128 (63.68%) |
| Supporting the planetarium over a telescope: | 58 (28.85%) |
In the field of questions dealing with biases and fears the following were the most salient points:

- Afraid of low cost-effectiveness in terms of frequency of use: 141 (70.14%)
- Afraid of low cost-effectiveness in terms of service to one single subject only: 157 (78.10%)
- Fearing technical difficulties: 91 (45.27%)

The last 3 points may become less weighty with an increase in information and knowledge about the planetarium.

10. **Summary, Conclusion and Implication:**

The teachers' interest in the planetarium and their demand for the school planetarium has been established by the preceding survey II/5.

While the high educational value attributed to the planetarium by teachers has been widely re-confirmed in this survey by the answers given to the questions of rank order places 1 and 2, it is noted that from rank order place 6 onwards the votes in confirmation of the negative statements outweigh the objecting votes. The total relative score percentage amounts to only 56.86% but would have sunk below the 50% mark had it not been for the first two statements on the rank order scale. The total score seems to indicate the weight of the total of the misgivings. Strongest in the range of doubts that may govern the decision about acquiring a planetarium are considerations of the planetarium's cost-effectiveness and of the technical side of the planetarium equipment, i.e. misgivings concerning the operation of the equipment, its service and its repair problems. Ignorance is the likely source of doubts.

Teachers' confidence in the planetarium as displayed by the results of earlier surveys may not be so firmly rooted that it is unlikely to be shaken by the offer of an alternative equipment choice and by a deeper probe into the pros and cons that may govern the final decision.

It cannot be said with certainty to what degree teachers have treated the questions as being hypothetical or as real, and this also does not really matter. It has been established that - other things being equal - the set of questions answered by the teachers in this survey tends to a large extent to negatively influence most of the teachers in their decision to acquire a planetarium.
On the other hand, as teachers totally lack information about the school planetarium, their fears seem of the nature of intuitional biases, rather than representing the outcome of judicious judgement.

From the results of this survey it can be deduced by inversion that the planetarium is underused in education. Teachers have confessed that a great number of obstacles, as defined in this survey, could stand in the way of installing a school planetarium. The respective considerations are meaningful only under the premises of an existing underuse of the planetarium, in the sense that the vast majority of the schools interviewed neither own nor co-own a planetarium, nor have easy access to one.

The results of this survey have refuted the operational hypothesis and with this lend support to the general hypothesis in that part saying that the planetarium is underused in education, and results help to support that part of the general hypothesis saying that a variety of reasons is responsible for the underuse of the planetarium by naming several of such possible reasons.

The survey implies that the ministries who have recommended the school projection planetarium and other parties interested in the school planetarium have severely omitted to supply the schools with relevant information, which could have eased many of the worries that have manifested themselves in the present survey, as factors which tend to impede the more widespread use of the planetarium as an educational tool.

The next survey investigates the position of educational authorities in the question of the installation of planetariums for the school.
"REASONS FOR THE PLANETARIUM'S UNDERUSE IN EDUCATION ARE NOT FOUND IN EDUCATIONAL AUTHORITIES' ACTIONS, OMISSIONS AND ATTITUDES"

A Survey conducted with Educational Authorities in West Germany

1. **Theme and Purpose:**

   The theme of this survey is an investigation into the educational authorities' actions, omissions and attitudes that may have a negative influence on the use of the planetarium in the school system of West Germany. The purpose of this survey is to seek a test at the level of educational authorities for that part of the general hypothesis saying that the planetarium is underused in education and that a number of reasons are responsible for this underuse.

2. **Procedure:**

   This investigation is the third one in the framework of the surveys conducted in the educational field. 140 educational authorities in West Germany were approached in order to find out whether or not they were wholly or partly responsible for the underuse of the planetarium in the educational system of West Germany. The purpose of the survey and the present status of the overall research forming the subject of this thesis were shortly explained in a letter and participation was invited by requesting these authorities to fill in a questionnaire containing 12 questions.

3. **Methodology:**

   **Type of Survey:** A descriptive survey has been conducted by exclusive means of a questionnaire, which delivered the data for the analysis intended.

   An operational sub-hypothesis has been devised which is printed as the heading of this programme. This operational sub-hypothesis guiding the survey has been put to the test at the level of educational authorities in West Germany.

   The results of this survey are displayed in table no. 27.
4. Rationale of the Questions:

The 12 questions posed are direct and straightforward and have not been weighted in any particular way. 11 of the 12 questions are negative in character and only question 7 is positive in character. The 11 negative questions enumerate reasons each of which, when taken by itself or when grouped together, could prevent the acquisition of a school planetarium, and only question 7 asks directly whether or not a planetarium could be considered. As is customary in this thesis, the scoring system is devised so that answers in favour of the planetarium received the highest score. This permits an easy comparison of the results of the various surveys.

5. Population:

The survey has been limited to 2 states of West Germany, namely Baden-Württemberg, the only state in West Germany apart from Berlin that recommends the school planetarium, and Nordrhein-Westfalen, whose Ministry of Education at least recommends the use of the planetarium for teaching astronomy to school children. 140 educational authorities were randomly selected according to their geographical situation from a simple map. This selection was made as the respective recommendations of the Ministries of Education in these 2 states, form an adequate basis for the survey, as it was possible to show their ministries' involvement in the subject matter to the authorities approached. It was expected that this would offer some incentive to the educational authorities to participate in the survey. According to the author's experience with the school market in West Germany, the results will permit generalisations whose tendencies can be assumed to be valid also for the remaining states of West Germany not subjected to this particular survey. 61 of the authorities replied. This seems a good average according to professional market researchers interviewed on this question. The sample size seems to be representative in composition. Most of the respondents have answered directly, some of them have sent photostat copies of the questionnaire to the schools of their regions. Apparently this has been done in such cases where schools administer their budgets exclusively by themselves. The answers received from schools in this fashion are therefore considered as answers received from educational budgetary authorities.

*) = 43.27%
6. **Evidence and Findings:**

The questions can be grouped into the following broad categories:

1. **Familiarity** - Questions 1, 5, 6, and 11.
3. **Attitude** - Questions 2, 10 and 12.
5. **Technicalities** - Question 8.

**Validity** of the test instrument seems ensured as the questions are straightforward and do adequately cover the subject to be studied. The questions are based on the author's practical experience in discussing planetariums with budget authorities. This experience was gained during the surveys II/1 and II/5 and elsewhere. As no additional comments were received from the respondents, the theme under study seems also to have been sufficiently treated.

**Reliability** seems to be ensured by virtue of the internal and external consistency noticeable in the answers received. Questions 5, 6 and 8 found strong agreement and were confirmed by teachers in the previous surveys. Answers to questions 3 and 4 on finance reveal internal consistency, as do the answers to questions requiring familiarity with the problems connected with installing school planetariums, i.e. nos. 1, 5, 6 and 11.

Questions 10 and 11 dealing with alternatives to the planetarium similarly show consistency in the answers.

The total pattern of answers given to the questions posed appears to have a logical coherence.

Consistency in answering is rated as one indication for the reliability of the test instrument. Otherwise reliability is assumed, as it is difficult to imagine that a different pattern of answers would be given by the sample were the survey to be repeated.

Table 27 on the next page summarizes the action.
TABLE 27

"REASONS FOR THE UNDERUSE OF THE PLANETARIUM AS INHERENT IN THE SCHOOLS' BUDGETARY AUTHORITY SYSTEM"

Translated from the German Original

N = 61

<table>
<thead>
<tr>
<th>No.</th>
<th>Questions</th>
<th>N</th>
<th>Rank Order</th>
<th>% Score</th>
<th>Agree</th>
<th>Undecided</th>
<th>Disagree</th>
</tr>
</thead>
<tbody>
<tr>
<td>1)</td>
<td>The recommendation of the Ministry of Education to use school projection planetariums for teaching astronomy is not known.</td>
<td>61</td>
<td>7</td>
<td>52.46</td>
<td>41</td>
<td>5</td>
<td>15</td>
</tr>
<tr>
<td>2)</td>
<td>There are doubts concerning the educational value of the planetarium.</td>
<td>61</td>
<td>1</td>
<td>81.42</td>
<td>4</td>
<td>26</td>
<td>31</td>
</tr>
<tr>
<td>3)</td>
<td>The price for a school planetarium might be too high for a single school.</td>
<td>61</td>
<td>10</td>
<td>47.54</td>
<td>87</td>
<td>38</td>
<td>20</td>
</tr>
<tr>
<td>4)</td>
<td>For the benefit of one single discipline it is not easy to allot a larger sum in the budget.</td>
<td>61</td>
<td>9</td>
<td>50.81</td>
<td>93</td>
<td>40</td>
<td>10</td>
</tr>
<tr>
<td>5)</td>
<td>There is a lack of information on the planetarium.</td>
<td>61</td>
<td>8</td>
<td>52.46</td>
<td>96</td>
<td>41</td>
<td>5</td>
</tr>
<tr>
<td>6)</td>
<td>Until now no school has ever applied for a budget for a planetarium.</td>
<td>61</td>
<td>11</td>
<td>46.99</td>
<td>86</td>
<td>43</td>
<td>11</td>
</tr>
<tr>
<td>7)</td>
<td>The acquisition of a medium size planetarium for a school region and adult education could be considered.</td>
<td>61</td>
<td>2</td>
<td>70.49</td>
<td>129</td>
<td>21</td>
<td>26</td>
</tr>
<tr>
<td>8)</td>
<td>Schools may have no place to install a planetarium.</td>
<td>61</td>
<td>12</td>
<td>43.71</td>
<td>80</td>
<td>46</td>
<td>11</td>
</tr>
<tr>
<td>9)</td>
<td>A central planetarium for a school region cannot be considered because of the difficulties of transporting pupils from the surrounding schools.</td>
<td>61</td>
<td>3</td>
<td>66.12</td>
<td>121</td>
<td>19</td>
<td>24</td>
</tr>
<tr>
<td>10)</td>
<td>Schools can easily arrange their lessons with the aid of cheaper media. Expensive apparatus are not necessary.</td>
<td>61</td>
<td>4</td>
<td>57.92</td>
<td>106</td>
<td>23</td>
<td>31</td>
</tr>
<tr>
<td>11)</td>
<td>The question of installing a planetarium has not yet been considered.</td>
<td>61</td>
<td>5</td>
<td>56.83</td>
<td>104</td>
<td>34</td>
<td>11</td>
</tr>
<tr>
<td>12)</td>
<td>Other demands are more important for the schools.</td>
<td>61</td>
<td>6</td>
<td>53.00</td>
<td>97</td>
<td>30</td>
<td>26</td>
</tr>
</tbody>
</table>

Maximum Possible Score = 2196
Actual Total Score = 1244 = 56.65%

Summary

Sixty-one educational authorities were approached to investigate their position regarding school planetariums, which was found to be generally unfavourable, due to lack of relevant information, the schools omitting to ask for funds, financial considerations, assumed lack of space and a neutral attitude towards the value of this educational tool.
7. Discussion and Evaluation:

The majority of the school teachers are in favour of the school planetarium, as previous surveys have shown. When faced with the problem of budgeting and purchasing many of the positive respondents lost interest and a further section lost interest when faced with the additional problems of alternative choices and a screen of negative considerations that could prevent the acquisition of a school planetarium. However, a hard core of teachers interested in the school planetarium remained faithful to this idea throughout the whole set of questions of the school main survey which served for the various individual studies undertaken. (See comprehensive questionnaire no.34, pp. 546-551.

This survey seeks to investigate the difficulties that the "faithful" teachers may have to deal with when meeting the educational authorities that have to decide about school budgets.

Knowledge

As the results reveal, there is little knowledge about the subject of planetariums for the school. The recommendations of the ministries to use planetariums in the schools is scarcely known to the educational authorities. The vast majority also have no information about planetariums, and only a very few of the authorities have ever received a budget application for a school planetarium. Most of them have consequently never considered the question of installing a school planetarium.

* See surveys nos. II/5 and III/5.
Finance

The majority of the education authorities have reservations as to the financing of a school planetarium.

Attitude

It is true that the positive votes by far outweigh the negative votes. The ratio for all 3 attitude questions amounts to 5.24 : 1, but the ratio of the "undecided" group to the negative group is nearly as strong. The total mean value consequently expresses a noticeably neutral tendency.

Actions

In spite of the lack of information, a strong minority of the educational authorities interviewed is ready to consider the acquisition of a medium size planetarium for a school region (and adult education). Many are undecided and only a few "disagreed". One of the reasons mentioned by this group and those "undecided" becomes apparent in question 9, namely transport problems. Other reasons were not investigated.

Technicalities

The strong majority of the educational authorities believe that schools have no place to install a planetarium. Many schools have confirmed this in the framework of the school main survey.

Summary, Conclusion and Implication:

The total score figure amounts to 56.65%. This result numerically interprets the unfavourable tendency prevailing for the idea of the school planetarium in the eyes of the educational authorities.

The results of the survey allow the conclusion that lack of knowledge about the school planetarium, fears as to the amount of financial demands, and reservations as to available place in the potential localities are the predominant factors that prevent the more widespread use of the planetarium as far as educational authorities are concerned, rather than unfavourable attitudes towards the planetarium. The presence of a favourable attitude towards the planetarium, however, does not mean that this medium is to be preferred to alternatives.
As most of the educational authorities interviewed do not know about their ministries' positive recommendations as to the use of school planetariums, one of the strongest initiatives for either promoting or tolerating the installation of school planetariums remains inactive.

The results of the survey have refuted the operational hypothesis and support the general hypothesis stating that planetariums are underused in education and that a number of reasons are responsible for this. Reasons lying within the responsibility of educational authorities have been mentioned.

Implication:

The number of positive votes is much too low to speak of a positive climate for the school planetarium. As, however, there is only a small fraction professing a negative attitude (question 2), but as on the other hand cheaper alternatives are preferred (questions 10 and 12), and as schools omissions to approach authorities for school planetariums (question 6) also play their role, it might be possible that some kind of active promotion for the school planetarium could change the present unfavourable state of affairs prevailing with educational authorities.

The next survey investigates the question of finance as a possible source for the underuse of the planetarium in education.
"LACK OF FINANCE MAY PREVENT THE INSTALLATION OF MORE SCHOOL PLANETARIUMS"

A Survey conducted with the Finance Departments of several Ministries of Education in West Germany

1. Theme and Purpose:

The theme of this survey is an investigation of the financial status existing for schools in West Germany. The purpose of this survey is to determine whether or not the financial conditions prevailing for schools in West Germany might be a factor preventing the installation of more planetariums in schools of West Germany. The study, though guided by the above operational hypothesis, also attempts to point to the possible utilisation of funds that may potentially be available.

2. Population:

The population for this survey is the finance departments of the Ministries of Education in West Germany including West Berlin, and a suitable sample size of 3 has been drawn from the population of N = 11, i.e. West Berlin, Baden-Württemberg and Rheinland-Pfalz. Additionally, the prices of school planetariums were obtained from 3 prominent manufacturers.

The first two states were chosen as they recommend the school planetarium, the latter was chosen as it had been included in the survey on the "Educational Value of the Planetarium", see programme II/4. An additional reason for the selection of the 3 states is the fact that West Berlin is relatively "rich", as far as the science budget for schools is concerned, Baden-Württemberg is an "average" state in that respect, and Rheinland-Pfalz is relatively "poor". It is therefore believed that the sample is representative. The author believes, according to his experience and observation, that expanding the sample size would not supply new findings.
3. **Methodology:**

An explanatory survey has been conducted inasmuch as cause (finance) and effect (possibility of buying planetariums) are investigated as independent and dependent variables. **Reliability and validity** are self-evident for this survey, as we are dealing with public data.

4. **Procedure:**

As ministries are rather large and complex institutions with time-consuming ways and means of internal communication, it would have been of little advantage to have included questions of finance in the earlier survey conducted with the same population. This earlier survey was conducted with the educational and curriculum departments in order to collect information related to astronomy as a school discipline.

It did also not seem expedient to ask the schools directly for the size of their science budgets, as a great reluctance to answer such questions was observed during the verbal interviews conducted in the framework of the preceding school surveys. Therefore the Ministries of Education had to be approached for the relevant information.

It is relatively easy to obtain information of the city-state *government* budgets from the finance departments in the respective ministries. These figures are openly available to the interested public. This holds true for West Berlin where the budget is centrally administrated.

For the larger "Bundesländer", figures are less precise as statistics are kept on a more general level and as the administration is much more diversified. Still, information is readily given by the various departments, as far as such information is available at all.

**Telephone interviews** were conducted with the budget departments and the related statistical bureaus in West Berlin, Baden-Württemberg and Rheinland-Pfalz. These 3 cases are sufficient for our purpose as they show variations in the sizes of their budgets and thus seem to illuminate the situation fully.

*) Footnote: City-states in West Germany are West Berlin, Hamburg, and Bremen.
5. **Rationale of the Questions:**

Ministries were asked for the budget shares allotted to the science disciplines of the schools. This is explained by the fact that this is the smallest subdivision given in the budget plans anywhere. In some cases this smallest subdivision has to be estimated from larger categories. To derive the final physics budget from these figures, which is the ultimate goal, a standard procedure is followed.

6. **Limitations:**

When studying the possibilities of buying schools planetariums, as far as this may be permitted by available budgets, it will hardly be possible to suggest ideal solutions. Too many variables of unknown size, character and effect are involved with one another, teachers initiative or inertia and committees' voting preferences being some of these. The author has hence limited the study to estimations of the possibilities offered by these budgets and it is expected that this will suffice to indicate possible tendencies in the 3 West German states chosen. The study starts from a point where the planetarium is considered to be desirable for schools and is hence influenced by this premise.

7. **Findings:**

7.1 **The Budget Distribution**

Based on observation, experience, and several informal discussions held with school headmasters, the average distribution of the science budget allocated to an individual school is as follows:

- Physics - Chemistry - Biology each 25% = 75%
- Mathematics and Geography each 12.5% = 25%
- total = 100%

It seems safe to assume, when based on the few curricula available in West Germany for the school subject of astronomy, that the physics department would have to provide any apparatus needed for teaching astronomy, whilst star globes and some of very basic cheaper material, e.g. pictures of the solar system, are also found in geography departments. The size of the budget-share that
may go in this way to the physics department of a school is thus
the main one to focus on when assessing the chances for the ac-
quision of a school planetarium.

7.2 Previous Findings in this Thesis related to the Question of
Finance

Many teachers were afraid that a large proportion of the budget
could not be made available for the benefit of only one discipline
(157 out of N = 186).

School authorities thought the same (40 out of N = 61).

Teachers feared that the price for a school planetarium would be
too high (127 out of N = 156).

Many teachers - though being interested in the planetarium as an
educational tool - did not want to earmark the necessary funds for
buying one (58 in N = 132).

On the other hand, only 7 out of N = 61 budgetary authorities
stated that they had ever received an application for a school
planetarium. The exact reasons for this are not exactly known but
are amply implied in many of the other causes found for the under-
use of the planetarium. Lack of information and inertia on the
side of the teachers may be two of them.

From the above summary, it became obvious that financial conside-
rations - though unspecified in the absence of sufficient informa-
tion on school planetariums - tend to be a strong factor impeding
the more widespread installation of school planetariums.

The surveys conducted so far have dealt with the financial situ-
ation of schools only in general terms but have not yet provided
an actual insight into the financial status of the schools. This
is the purpose of this survey.
7.3 Choice of Planetarium Equipment

Some Typical Examples

A school wanting to have an individual planetarium or a group of schools wanting a central planetarium would receive the following typical range of price information from various manufacturers. There are several choices open in each class of instrumentation; the instruments named are hence not the only ones available of a particular size:

**TABLE 28**

PRICES FOR BASIC PLANETARIUM EQUIPMENT & DOMES

A) Individual School Planetariums
B) Central School Planetariums

<table>
<thead>
<tr>
<th>Manufacturer</th>
<th>Type</th>
<th>Number of Stars</th>
<th>Dome $\phi$</th>
<th>Seating</th>
<th>Seats</th>
<th>Price DM</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>A)</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1.GOTO</td>
<td>EX-3</td>
<td>500</td>
<td>3 m</td>
<td>circular</td>
<td>20</td>
<td>3.500,</td>
</tr>
<tr>
<td>2.SPITZ</td>
<td>373</td>
<td>1000</td>
<td>4 m</td>
<td>circular</td>
<td>25</td>
<td>42.000,</td>
</tr>
<tr>
<td>3.GALILEO</td>
<td>Mod. III</td>
<td>1100</td>
<td>5 m</td>
<td>circular</td>
<td>40</td>
<td>125.000Q,</td>
</tr>
<tr>
<td>4.GOTO</td>
<td>GE 6</td>
<td>2800</td>
<td>6.5 m</td>
<td>circular</td>
<td>55</td>
<td>175.000Q,</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>B)</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5.SPITZ</td>
<td>A3P</td>
<td>3500</td>
<td>8 m</td>
<td>uni-dir.</td>
<td>65</td>
<td>246.000Q,</td>
</tr>
<tr>
<td>6.GOTO</td>
<td>GX10S</td>
<td>6500</td>
<td>10 m</td>
<td>uni-dir.</td>
<td>90</td>
<td>440.000Q,</td>
</tr>
<tr>
<td>7.SPITZ</td>
<td>512</td>
<td>4100</td>
<td>13.4 m</td>
<td>uni-dir.</td>
<td>110</td>
<td>450.000Q,</td>
</tr>
</tbody>
</table>

The number of seats given in this list represents an average arrangement.

The dividing line between A) and B) is drawn from observation and experience. Whereas the smaller individual school planetariums may fit into an existing hall, the larger planetariums above 8 m $\phi$ will almost certainly require a separate building.
While in the first three planetariums in the above list circular seating is the rule, the others allow uni-directional as well as circular seating in the auditorium.

Uni-directional seating allows for a multi-media installation, i.e. the classroom planetarium. This arrangement gives the teacher the possibility of combining routine blackboard-supported lecturing, experimentation on the teacher's demonstration desk (e.g. use of a mechanical-type planetary system or a prism-arrangement for spectrum projection) and the star spectacle demonstration by the planetarium projector and its accessories.

The advantages are obvious, as all types of media-use become applicable under one roof (except, of course, telescope and other direct sky observations).

7.4 High-School Budgets for Science Equipment

As far as possible, the budget figures for the last 3 years were taken and averaged. It is believed that this allows a more reliable extrapolation for the estimation of future trends.

The budget distribution for West Berlin is as follows:

<table>
<thead>
<tr>
<th>Title</th>
<th>Year</th>
<th>Sums DM</th>
<th>Mean,p.a.</th>
<th>25% for Physics</th>
<th>N Schools</th>
</tr>
</thead>
<tbody>
<tr>
<td>Routine Apparatus and Material</td>
<td>1978</td>
<td>2.440.000,-</td>
<td>2.440.000,-</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>1979</td>
<td>2.600.000,-</td>
<td>2.600.000,-</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>1980</td>
<td>3.095.000,-</td>
<td>3.095.000,-</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Special Apparatus above DM 10.000,-</td>
<td>1978</td>
<td>1.382.000,-</td>
<td>1.382.000,-</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>1979</td>
<td>1.873.000,-</td>
<td>1.873.000,-</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>1980</td>
<td>804.000,-</td>
<td>804.000,-</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*) This is the mathematical average for the last three years for the average physics department of the average school resulting in a mean value of DM 14.943,- p.a. In reality, the distribution is
unequal, depending on school type (e.g. science- or language-preference), number of students in the school and justifications for demands made. Deducting 10% for other needs results in a more realistic average of DM 13.449,- p.a.

The School Budget of Rheinland-Pfalz:

In this state it is the municipalities who are responsible for the schools' budget but their allocations are supplemented by the Ministry of Education's central budget, roughly at a ratio of 75% for the municipalities to 25% for the state. The figures obtained for the respective school expenditure from the Ministry and from the General Statistical Bureau of Rheinland-Pfalz amounts to:

approx. DM 1.000.000,- for 1977.

Later figures were not yet available.

This sum is to cover the needs of 135 high schools. Assuming an even distribution, this means DM 1.000.000,- : 135 schools = DM 7.407,- for each school; 25% of this sum leaves DM 1.852,- to the average physics department.

As to the exactness of this sum, the same reservations have to be made as were provided for the West Berlin school budget and an additional estimated 10% as a safety margin will have to be deducted, as other needs of the schools are invisibly included in this sum. The actual annual average sum amounts hence to

DM 1.667,- p.a.

The School Budget of Baden-Württemberg:

It proved too difficult to obtain even approximately relevant figures for the municipality-owned high schools in Baden-Württemberg, as statistical entries are insufficiently sub-divided. Those for the 10 high schools owned by the state were readily available from the Ministry of Education.
Limiting this part of the survey to the state-owned schools in Baden-Württemberg results in an illuminating case study. As it seems safe to assume that the average budgets of all schools in one state are more or less of the same order and that only a very few schools may be actually rich, an estimate can be made which should approximate the total physics budget for all the high schools in this state. It will be shown that a school would have to be very rich indeed if its budget were to allow expenditures on a planetarium being beyond the reach of other schools. The following table summarizes the exact figures for the state schools:

<table>
<thead>
<tr>
<th>Title</th>
<th>Year</th>
<th>Sum DM</th>
<th>Mean,p.a.</th>
<th>25% for Physics</th>
<th>N - Schools</th>
<th>Mean,p.a.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Apparatus</td>
<td>1980</td>
<td>234.100,-</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Equipment</td>
<td>1979</td>
<td>199.500,-</td>
<td>200.900,-</td>
<td>50.225,-</td>
<td>10</td>
<td>5.022,-</td>
</tr>
<tr>
<td></td>
<td>1978</td>
<td>169.100,-</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

From this amount of DM 5.022,- for the average physics department of the average school, an estimated 10% has to be deducted for other needs of the school which are invisibly included in the above figure.

The resulting average amounts to

\[ \text{DM 4.520,- p.a.} \]

As to the actual distribution, the same reservation has to be made as is provided for the West Berlin figures treated above.

Assuming that DM 4.500,- were also to be the annual physics budget for the municipality owned high schools and also for those of other ownership, the total amount for the remaining 451 high schools in the state would amount to \[ \text{DM 2.029.000,- p.a.} \].
7.5 Extra-Ordinary Budgets

There is evidence that throughout West Germany extra-ordinary funds have been made available from time to time for special public projects*, and a planetarium could easily be counted in that category. Such funds are frequently invisibly hidden in the primary general budget propositions. Especially as they cannot be recognized as such at the primary projection, a look at the total budget figures available in West Germany and their per capita distribution would be interesting at this stage.

Money seems to be there. The following figures indicate this.

Total Expenditure on Schools and Universities in West Germany:

- 1952 - DM 3 006 Mill., e.g. per head DM 59,--
- 1976 - DM 52 555 Mill., e.g. per head DM 854,--

Total Expenditure on Cultural Affairs in West Germany:

- 1952 - DM 443 Mill., e.g. per head DM 9,--
- 1976 - DM 4 055 Mill., e.g. per head DM 66,--

The latest figures on the West German Governments' budgets for the above two groups combined read:

  State Governments DM 49 618 Mill.
  State Governments DM 52 665 Mill. **

These amounts are total sums and not detailed any further, but it is obvious that in a population of about 60 000 000 more than DM 1,000,- per head has been projected for 1979. This should allow many plans and speculations by interested parties to be realised, including perhaps projects to build planetariums.

*) e.g. Opera houses, museums, sports facilities and the like.

The growth of the budget over the years is quite impressive. Total expenditure has grown by a factor of approximately 15 times while the price of major planetarium equipment rose only by the factor of approximately 5 times. The pure figures, apart from any other considerations, look therefore more promising today than they did in earlier days.

8. Discussions:

The budgets studied lie between DM 1.667,- p.a. and DM 13.449,- p.a. Large as this span may be, it is still in one and the same order in terms of allowing the financing of a school planetarium, though the higher the individual sum the better seem to be the chances of success for the combined efforts of several schools, if such could be organized.

West Berlin

Considering the annual budget figure of DM 13.449,-, it seems obvious that from their own annual physics budgets schools in West Berlin could only consider buying the rather simple and cheap midget-planetarium (DM 3.500,-). It seems that the Ministry of Education in West Berlin could consider erecting one modern central multi-media medium-size (110 seats) planetarium (equipment and building of 15 x 15 m = DM 900.000,-) every 3 years using roughly one third of the normal total physics budget for that period.*

A minimum of 6 central planetariums would be needed to satisfy each of the 6 school administrative areas of West Berlin, a scheme which would hence require 18 years to complete. To do more or to complete that scheme in a shorter period would require extra-ordinary budget allocations.

*) Considerations of cost-effectiveness render the 110 seat planetarium more desirable for central installations as 1 teacher can lecture 110 students at the same time instead of any smaller number determined by the planetarium's size. Also other costs are spread over a greater number of pupils.
The assumptions can hold true only under the conditions that all other interplaying variables were favourably disposed.*

Other speculations seem also to be reasonable, such as to recommend that 3 schools should combine their budgets for a small 4 m planetarium in just 1 year and let other disciplines (geography) participate, or all the others sacrifice a bit to make up for the small price difference in the calculation.** On the whole, it looks as if extra-ordinary budget allocations would best help schools in West Berlin to come into the possession of (a) school planetarium(s).

Having 6 medium size central planetariums would lift the available planetarium seat capacity by a factor of approximately 3 times for West Berlin.

Baden-Württemberg

Also the state schools of Baden-Württemberg could, it seems, consider only the acquisition of the cheapest type of midget projection planetariums for individual schools. From the normal central budget, the government would hardly be able to consider a central planetarium even in many years, if the budget were to remain at its present level. This consideration is separate from other considerations, such as that of the practicability of such an endeavour. The state-owned schools are widely dispersed and could therefore scarcely be reasonably united in such a common enterprise. Extra-ordinary budget allocations seem the only solution if the aim is to provide state schools with even only a small size (e.g. 4 m Ø) better type of a school planetarium. A really rich school in an exceptionally generous community would need for this purpose 9 times the sum which seems to form the average physics budget of the average school in Baden-Württemberg. It is not known if such schools exist. — For municipality schools the estimates look more favourable.

*) Teachers verbally interviewed on the subject during the school surveys believed that 1/3 of the physics budget could reasonably go to astronomy, at least for some period of time.

***) 3 x 13.500 = DM 40.500,- Price for the SPITZ 373 = DM 42.000,- Difference = DM 1.500,-
In speculating on possibilities for providing schools with planetariums, it is easier to operate with the total of the individual sums and to leave organizational problems out of consideration. These need not be dealt with at this stage.

Assuming that 1/3 of the budget (e.g. DM 676,500,-) could be justified as being a reasonable proportion to be spent for planetariums, then either 16 schools could receive a 4 m planetarium in each year, if other things remained equal, or a central 110 seat planetarium could be installed in every 1 1/2 years. This would result in 12 central planetariums in 18 years. Other planning models are also conceivable, of course. This applies for the 451 municipality schools.

**Rheinland-Pfalz**

This is a typical relatively "poor" state in West Germany. There are several others.

The individual schools there would have to let other disciplines sacrifice part of their budgets if they wanted to acquire even a cheap midget planetarium within one year's budget period, or spread the costs over two years, using up nearly all of the budget.

One medium-sized central planetarium of the 110 seat type would cost nearly the total annual budget for all the science disciplines in the high schools of this state. Still, with 110 places for the 112,266 high school students of this state it might perhaps be made justifiable if, with enough pressure, it were bought from a 3 years' even spread of the funds required. In this way, one would have to forego in each year 1/3 of the funds for other science needs. This might be an audacious plan, but it would allow 10 visits to the average high school student during his 13 years in school.*

*) A capacity-utilisation calculation will support this statement: 110 seats x 4 daily performances in 200 days = 88,000 seats p.a. This results in 1 visit per student every 1.27 years = 10 visits during his 13 years in school. The total German average is 1 to 2 times in 13 years.
In the calculation made 4 performances are estimated to be the daily rate which seems to be feasible if the planetarium is owned by the schools and operated like the schools.

If instead an 8 m Ø planetarium with 65 seats were to be chosen for only half the price, the financial burden would be eased proportionally and the visitors' rate would still be about 5 times per 13 school years for the average high school student. The cost-efficiency rate would be lower, but this would most probably be an element for a different department to worry about.

Other finance models are also conceivable for this "poor" state, such as the combination of several schools for the acquisition of a model 2 planetarium from table 28. 25 schools could share in one central planetarium. Duplications of the above model plans for a larger planetarium are thinkable when attacking the budgets of all schools including the intermediate and primary schools.

The chances of succeeding with major plans seem to be rather marginal when thinking of the normal budget, especially as astronomy is neither offered at a full course level in this state, nor is the acquisition of school planetariums recommended anywhere in the curriculum. The application for extra-ordinary funds may prove to be a more promising way.

**Tapping Extra-Ordinary Funds**

If a planetarium lobby did exist at all and if it were sufficiently strong and efficient, extra-ordinary sources for obtaining the necessary funds could be found and tapped. The art consists of convincing town-council committee members to adopt the idea of a planetarium and to furnish them with such a battery of convincing arguments that they would be enabled in turn to also gain the support of the opposition for the project(s).

In addition to the possible contributions from school budgets and to any extra-ordinary allocations to the school budget for a planetarium, there is the separate budget for cultural affairs which could be mobilized under the combined heading "School- and Adult-Education".

*) This would result into 10 planetarium days p.a. for each school.
Support would have to be mobilized and organized at the level of political decision-making in order to channel some of these funds to the planetarium sector. This is, however, a time-consuming and difficult undertaking with many problems to be overcome, such as vested interests and still stronger lobbying from different quarters. A teacher's total involvement with the project would be required to ensure success.

The above methodology of mobilizing funds is known to the author from both observation and experience and from discussions with manufacturers. In this context the statement can be made that many a public cultural institution including several planetariums have come into being in the manner outlined above.

Comparison with other Major School Expenditure

The planetarium is not the only costly single item in the range of modern educational tools. Other major expenditures for educational purposes are known to have been made for language laboratories, video centers, for computer training facilities and for astronomical telescopes.

3 case studies with schools concerning the acquisition of language labs were undertaken by the author in the framework of an earlier paper ("The Teacher and his Media", 1977). In each of these 3 cases the schools had successfully applied for extra-ordinary budget allotments, each time in the order of DM 100.000.-.

The central school administration of the city of Frankfurt installed several years ago an expensive TV-video-studio for the production of video cassettes for school science and sociology courses. This was possible only through the utilisation of extra-ordinary funds, as newspapers reported at the time.

A good quality astronomical telescope costs about twice as much as a midget planetarium and could (in analogy to the results of this study) be acquired only as a result of extra-ordinary efforts. Several schools own astronomical telescopes as the survey conducted with schools reveals.
The list of extra-ordinary expenditures could probably be prolonged considerably if a respective survey with schools were undertaken, and it may be advisable to fund-seeking teachers to point to such cases when claiming "their share" when the time seems ripe to ask for a planetarium.

9. Summary and Evaluation:

Chances for the Acquisition of Midget Planetariums

If classifying the schools of the 3 states studied in the three finance-categories of "rich" (West Berlin DM 13.500,- p.a.), "average" (Baden-Württemberg DM 4.500,- p.a.) and "poor" (Rheinland-Pfalz DM 1.650,- p.a.) then:

A "rich" school system could easily finance 1 midget planetarium for all schools.

An "average" school system could likewise, though less easily, finance 1 midget planetarium for all schools.

A "poor" school system could not do so, unless a special decision was taken to involve the budgets of other disciplines for the benefit of astronomy.

The above is valid for the one year standard budget period.

Chances for the Acquisition of Medium-Size Central Planetariums

"Rich" school systems could consider the installation of 1 or several central medium-size planetariums without undue cuts in the budget at the expense of other needs of physics, if say 1/3 of the physics budget were to go to the planetarium over some period of time.

"Average" school systems, in a state with many schools and hence a sufficiently large total sum, could think of 1 central medium-size planetarium within a comparatively short time, if - as above- 1/3 of the physics budget were to go to the planetarium.
"Poor" school systems even with many schools in the state would have to go to great pains if they wanted to erect a medium-size central planetarium with a good cost-efficiency rate (e.g. 110 seats). A medium-small size planetarium (e.g. 65 seats) might have a better chance of success due to its more favourable price.

A few finance models have been discussed in this study and these may suffice to illustrate the overall situation.

Acquisition of larger individual school planetariums or more planetariums of any size above the midget planetarium in any period of time would require the tapping of extra-ordinary funds, which could - it seems - be made available.

There are, as the tendencies established show, chances of obtaining funds for school planetariums of various sizes as far as purely financial considerations are concerned. Actually wanting a planetarium is, of course, the indispensable prerequisite.

10. Conclusion:

The results of this survey have established the existence of favourable possibilities in the finance systems of the schools which tends to refute the operational hypothesis, though it cannot be conclusively rejected in total, as too many decisive variables even inside the finance system itself had to remain unaccounted for in this survey.

The survey had basically no other aim than to establish tendencies.

The results of the survey support that part of the general hypothesis saying that planetariums are underused in education by pointing to the unfavourable channelling of potentially available funds for planetariums as a possible reason for the insufficient number of planetariums and hence their underuse.
11. Implications:

It seems that money as such is available. It must therefore - from the point of view of planetarium acquisition - either not be favourably channelled by the responsible authorities, or the possible final recipients of such funds must have refrained from making efforts to have these allocated to them for the purpose of buying a planetarium.

As other surveys of this thesis show, both of the above implications seem to be true.

12. Comparison to Lobbyism in the USA:

The president of the International Planetarium Society, Mr. James A. Hooks of Lumberton USA gives an example of how the planetarium community can become active in soliciting funds for more planetariums. He writes in his newsletter no. 2/1980:

"Your President on May 16, 1980, met and testified before the Senate Sub-Committee on Appropriations. I was asking for monies to be appropriated to the Institute of Museum Services or the National Science Foundation to be used specifically for Planetariums. It was an experience. I fought for what I believed in, that is, making sure that they are aware that we are a vital part of our society."

The following 2 reports describe manufacturers' activities in promoting the more widespread use of planetariums.
III/8

"PLANETARIUMS ARE UNDERUSED IN EDUCATION FOR REASONS WHICH CAN HARDLY LIE WITHIN THE RESPONSIBILITY OF MANUFACTURERS"

A Survey Conducted with Manufacturers of Planetariums

1. Theme, Justification and Purpose:

The theme of this survey is an investigation into the manufacturers' actions, omissions and attitudes that might be partly or totally responsible for the obvious underuse of the planetarium in the school system of West Germany. The fact that such an underuse exists has been conclusively proved in earlier surveys.

It is realized that the operational hypothesis, printed as the heading of this section, which guides this survey may give a paradoxical impression as it implies that manufacturers of the equipment might be responsible for the underuse of the planetarium; the very group one would rate off-hand as being beyond any such suspicion. And yet, the school pilot survey and the school main survey both point towards such a possibility by having demonstrated that most of the teachers interviewed have never received any information material from manufacturers. This survey seems therefore to be justified.

The purpose of this survey is to seek a test for the operational hypothesis and in doing so, support is sought for that part of the general hypothesis saying that planetariums are underused in education.

2. Population:

The population for this survey are the manufacturers of planetariums. Reference will also be made to the schools in West Germany who took part in the school pilot survey and in the school main survey.
The planetarium manufacturers are:

- **CARL ZEISS, West Germany** - produce only 1 large planetarium model

- **CARL ZEISS, East Germany** - produce 1 large planetarium model and 2 medium size planetariums

- **GOTO, Japan** - produce several school planetarium models and medium size planetariums besides large planetariums

- **MINOLTA, Japan** - produce several school planetarium models, medium planetarium models and large planetariums

- **GALILEO, Italy** - produce 2 small school planetarium models

- **SPITZ, USA** - produce 1 small school planetarium model, 2 medium size planetarium models, and 2 large planetarium models.

A full description on their products is summarized in chapter 1 of this thesis.

3. **Methodology:**

Interviews and correspondence were conducted with several of the manufacturers. Through his professional connections the author could double-check all information, and thus guarantee reliability, i.e. the correctness of all information used in this survey.

**Type of Survey:**

A descriptive survey has been conducted, predominantly aimed at learning only facts related to actions, omissions and attitudes without hoping to completely explore the possible spectrum of variables, as manufacturers show reluctance in fully disclosing their affairs. Of the likely range of causes responsible for the underuse of the planetarium, which lie within the sphere of responsibility of the manufacturers, only several have surfaced
during this survey conducted with the target group of manufacturers. Such reasons are mentioned briefly under paragraph 6, "Findings".

4. Rationale of the Questions:

Validity has been ensured by clearly covering the subject with direct questions in the interviews conducted. A list of pre-prepared questions was used as an "Aide Memoire" and was supplemented by freely posed additional questions during the interviews. A sample of a questionnaire is reproduced in the appendix exhibit 67. The correspondence conducted with manufacturers dealt only with their involvement in the German market.

5. Procedure:

Informal interviews had been conducted throughout a longer period, even during the very first general preparatory pilot survey. A more methodical survey was conducted by personal interviews and correspondence during 1978/79. The results reproduced here reflect the status prevailing in May 1980.

6. Findings:

6.1 Planetarium Manufacturing Programme Suitable for Schools:

At this stage of the thesis, planetarium models will only be listed according to their price range. There are 3 price ranges and 15 different school planetarium models to choose from:

Price range I: DM 3,000,- to 80,000,- = 7 different models
Price range II: DM 80,000,- to 180,000,- = 3 different models
Price range III: DM 180,000,- to 400,000,- = 5 different models

Reference is made to table no. 28, survey III/7 where a price list of available school planetariums is reproduced. The above list shows that there is no lack of planetarium models on the educational equipment market.

6.2 Marketing in West Germany

Commercial Representations

Of the various manufacturers for school planetariums only ZEISS, East Germany, has been represented in West Germany at all.
GOTO and SPITZ have only recently appointed a representative.

The other manufacturers do not have a representative in West Germany.

Prospective Clients' Familiarity with the Product

ZEISS, in both East and West Germany, are generally known as planetarium manufacturers. Their broad spectrum manufacturing range of optical goods has made their trademark generally well-known and their invention of the projection planetarium some 50 years ago is common knowledge. As the pilot surveys revealed, the planetarium manufacturer ZEISS is known in the schools. Knowledge about the particular medium-size planetarium is less widespread as previous surveys have shown. Prospective customers for the East German ZEISS medium-size planetarium are found among astronomical societies and navigational schools rather than in the general schools of West Germany as this class of planetarium projector is, broadly speaking, outside the range of the schools' budgets.

The other manufacturers seem to be virtually unknown in the schools of West Germany with the exception of GOTO, who have sold a few small school planetariums in West Germany. All planetarium manufacturers are better known to astronomical societies and groups of amateur astronomers.

Marketing Activities

ZEISS East Germany have participated in various trade fairs of the educational industry. SPITZ participated in one USA trade show held in Frankfurt, West Germany, some 12 years ago. This is all the relevant activity that the author could trace.

Advertising

It seems that none of the manufacturers have approached the prospective German school clientele by any form of direct advertising from their home centres or through advertising agencies.

Advertising in School Magazines

A telephone inquiry with the four leading publishers of school magazines
ended negatively. None of the advertising managers could recall having printed any advertisements of any of the projection planetarium manufacturers in recent times.

7. Discussion and Evaluation:

7.1 Reasons for the Manufacturers' Omission to deal actively with the German Market:

Out of the possible spectrum of reasons for the manufacturers' omission to deal more actively with the German market, a few of them became apparent during the discussions held with manufacturers. These reasons are:

- Preoccupation with the home market
- Lack of qualified staff that could conduct correspondence in the German Language
- Unfamiliarity with market conditions
- A sales system that did not allow the build-up of a network of dealers
- Lack of inquiries coming from the German market for school projection planetariums. This was considered as a sign that there was virtually no market.
- Existence of a pricing system which did not allow for an attractive commission to prospective representatives and/or dealers in West Germany.

In the author's professional experience none of the manufacturers includes any kind of sales commission for a prospective dealer, but would leave price policies to the prospective local dealers. These in turn find themselves outpriced if any prospective client should ask for a direct offer from the manufacturer. This perhaps is one of the strongest reasons which have prevented the development of a system of representatives such as is customary in the educational market. Foreign manufacturers maintain representatives and a system of appointed dealers to market their products in West Germany. The planetarium industry may be the only one that has exempted itself from this rule.
An additional reason may be the fact that the planetarium business is highly technical, requires much special knowledge and is financially not attractive to dealers. The fact that there are only a few planetariums in existence in the schools of West Germany may be proof enough to dealers that there is no promising market in which they could invest. Experience shows that selling planetariums is a time and energy consuming enterprise for which the customary commercial motivations such as ready sale and good profits are definitely not prevalent. *)

7.2 Market Situation:

The school planetarium market in West Germany is virgin land. Manufacturers have almost completely neglected this market and left the schools uninformed about their products. There has been virtually no attempt from the manufacturers' side to create a market for their planetariums, nor is there any trace of an effort by the manufacturers to expand on the very small nucleus that exists in the form of the few school planetariums in use in West Germany.

8. Conclusion

Manufacturers have utterly neglected the German educational market. Nevertheless, because there are so many other variables which hinder the spread of school planetariums, it cannot be predicted with any certainty whether or not the sole factor of manufacturers' advertising could remedy the unfortunate situation for the school planetarium in West Germany.

The results of the survey refute the operational hypothesis printed as the heading of this section and thus support that part of the general hypothesis saying that planetariums are underused in education for a variety of reasons by naming reasons which lie within the responsibility of the manufacturers.

The following survey, III/9, investigates in a case study the effect of actual commercial planetarium advertising on a great number of schools in West Germany.

*) Footnote: Some examples for extremely long negotiation times for planetarium sales are quoted here: Buenos Aires, Argentina: 32 years; Bangkok, Thailand: 8 years; Riyadh, Saudi Arabia: 10 years; Kuwait: pending but imminent since 15 years.
"ADVERTISING WILL PROMOTE THE MORE WIDESPREAD INSTALLATION OF PLANETARIUMS BY VIRTUE OF THE INFORMATION SUPPLIED IN THIS WAY"

An Ultimate Test - An Advertising Campaign

1. Theme and Purpose:
The theme of this survey is an investigation of whether or not schools would react towards industry's advertising. The purpose of this survey is to seek support on the school level for that part of the general hypothesis saying that the planetarium is underused in education and that a number of various reasons are responsible for this underuse.

2. Methodology, Procedure and Population:
A case study survey has been made by studying and evaluating a special advertising campaign undertaken by a scientific equipment trading company in West Germany. On the invitation of the author, this company carried out an advertising campaign in 1979/1980 in order to interest school teachers in the school planetarium.

The company bought from an advertising agency 2300 addresses ready-printed on slips usable for postage. The list encompassed all high schools in the areas of Baden-Württemberg and Nordrhein-Westfalen. From their own archive the company added 120 addresses in West Berlin.

The company printed an advertising letter intended to arouse an interest in the school planetarium and to solicit inquiries from schools for school planetariums. Additionally, a two-page prospectus was printed and the price of the cheapest school planetarium (DM 3400,-) was mentioned. The 2420 advertising letters were sent at a special reduced rate. Additionally 2 advertisements appeared in teachers' journals.

3. Findings:
The company spent approximately DM 2400,- (=£ 600.-) for the action. The action met with a nearly complete failure. Of 2420 recipients only one reply was received by telephone from Berlin. A school asked whether the smallest planetarium would exactly reproduce the retrograde movement
of the planet Mars. No inquiry for a quotation was made by that school.

At the end of it the company has had to write off the advertising campaign as a total loss.

4. Discussion:

While the survey number II/5 produced evidence of a teacher's interest in the planetarium as an educational tool, which was interpreted as showing a demand for this medium, the findings of these surveys were put to the test by the survey number III/5. Teachers' seeming interest was queried by questioning their readiness to provide necessary funds and of foregoing the alternative of buying an astronomical telescope.

This survey tests the influence of available information on teacher's readiness to undertake the acquisition of a school planetarium. It had been argued in earlier surveys that teachers utterly lacked information on school planetariums and it had likewise been argued that industry had failed to do anything to remedy this situation. Both were believed to be decisive reasons for the underuse of the planetarium.

It has become obvious that the supply of information on school planetariums has yielded no immediate reaction from teachers and that the trading company who undertook the advertising campaign had not received any encouragement from the schools to further pursue marketing efforts in West German schools.

It is customary for a company to use replies to advertising campaigns as a lead towards business prospects. Mostly on the grounds of such commercial inquiries will a company send their representatives to pay personal visits to prospective clients. It is much too expensive for a company to send representatives on either systematic or random calls in a market area without having any preliminary data in their hands.

5. Conclusion and Implications:

As teachers have claimed in the earlier surveys never to have overlooked any planetarium advertisement, it could be safely assumed that the material sent by the company actually reached their hands. It is not known exactly why there was no reaction to the advertising campaign.
It is suspected that teacher's inertia is responsible for this. For the company, this implies the necessity of intensifying their advertising efforts by approaching teachers more intensively, and perhaps also more frequently and in different manner, e.g. a public exhibition.

In view of the many other variables which exert their influence on the situation of the school planetarium in West Germany, the sole action of one commercial advertising campaign was evidently not a sufficiently strong incentive for teachers to convert their alleged interest in planetariums into positive action. It seems that for this purpose the full spectrum of variables which hinder the more widespread installation of school planetariums must be dealt with, which may be beyond the scope of a commercial company.

The results of this survey do not support the operational hypothesis printed on the head of this report. The results of this survey support that part of the general hypothesis saying that planetariums are underused in education by pointing towards teachers inertia as a possible cause for the underuse of the planetarium in education.

This survey is supported by copies of the company's relevant advertising material, which is filed as exhibits nos. 68 - 71 in the appendix. Trade names have been erased from this material.

This survey closes the investigations on the underuse of the planetarium. The next section offers a total summary of the surveys described in chapter III.
SUMMARY CHAPTER III

"FOR A VARIETY OF REASONS PLANETARIUMS ARE UNDERUSED IN EDUCATION"

Summary of the Surveys and Studies undertaken to determine the Under-use of the Planetarium and some of the Reasons responsible for it

1. Theme and Purpose:
Of the work undertaken in Chapter III of this thesis a summary is presented in the above title. The target area is West Germany but some of the findings are highlighted by comparing them to conditions prevailing in the USA.

2. Population:
N = 73 is the number of new subjects involved in the 9 research programmes of chapter III, in addition to those participating in the earlier surveys which are described in chapter II. *)
The participants were:
- Planetarium Directors
- Representative samples of the General Public,
  School Teachers, Government Officials in
  School Councils
- Planetarium Manufacturers
- A Commercial Company
- Social Researchers.

3. Methodology:
Telephone interviews, personal interviews and postal questionnaires were the methods of data collection employed. Operational hypotheses were devised which guided the individual research programmes.

4. Quantification:
An attempt was made to quantify the data collected in order to facilitate the analysis of findings.

*) Added to the figure of N=73 must be 2420 schools subjected to an exploratory advertising campaign described in survey III/7.
5. **Findings:**

5.1 The opinion poll on the number of planetariums available resulted in the conclusion that this number is not sufficient. Planetariums are not evenly distributed throughout West Germany.

5.2 Planetariums are not used as routine teaching tools even where they exist and the visit to the planetarium is the exception for a school class rather than the rule. Pupils cannot expect to see more than perhaps 3 planetarium performances in their entire school life even at places where a planetarium exists.

5.3 There is practically no helpful literature that could assist a school or educational authority in the installation of a planetarium and the selection of suitable equipment.

5.4 The planetarium is underused in education in the sense that only a few schools own a planetarium or have easy access to one, while there exists a wide spread interest in its use. Lack of information, lack of funds and teachers inertia have been confirmed as reasons for not having more planetariums at the school level; schools also have more pressing needs and lack space for the installation of planetariums.

5.5 Teachers' fears and biases of many sorts have been established as other reasons for the non-installation of planetariums in the schools. Considerations of low cost-effectiveness and possible technical problems, rather than considerations of didactic evaluation were the main misgivings entertained by teachers.

While in earlier surveys most teachers confessed their enthusiasm for the planetarium, their number shrunk considerably when it came to the question of finance and shrunk still further when it came to the question of an alternative choice, e.g. a telescope.
5.6 **Budgetary authorities** have no information about school planetariums, fear financial difficulties, have no budget applications for planetariums, are largely unaware of their Ministries' recommendation to install school planetariums, and only a few have ever considered the installation of planetariums. Although many confess to having a positive attitude towards the planetarium, a large number is undecided. It seems that much ought to be done to set the administrative machinery into motion to aid the acquisition of school planetariums.

5.7 **Planetarium Manufacturers** have utterly omitted to develop a market for their products in West Germany.

5.8 The cultural interests of the general public seem to support the planetarium to the same extent as they seem to support theatres and concert halls. There seems, therefore, little excuse for authorities to refuse the installation of public planetariums on the grounds of an assumed disinterest on the part of the general public.

5.9 Advertising for the school planetarium, as undertaken by a company through newspaper and direct mailing campaigns, did not meet with an immediate success. It seems, therefore, necessary to deal with the full spectrum of variables responsible for the underuse of the planetarium in education, if more planetariums are the goal.

5.10 Finance for culture and for education has been found to be available in principle but it is obviously not channeled in the interest of potential planetarium owners.

The next section represents a total summary and evaluation of all work described in this thesis. Final conclusions and implications are drawn and recommendations are offered.
1. Summary

27 surveys and 5 practical experiments in the planetarium have been conducted to test the hypothesis stating that

"PLANETARIUMS ARE BELIEVED TO BE EDUCATIONALLY VALUABLE TEACHING TOOLS AND THERE SEEMS TO EXISTS A DEMAND FOR THEM; BUT FOR A VARIETY OF REASONS PLANETARIUMS ARE UNDERUSED IN EDUCATION."

Chapter I of this thesis provides an introduction to the research theme and sets the scene with two essays, one on the science of astronomy and one on the planetarium.

Chapter II covers some initial exploratory surveys: the target group and the target area for the research theme are defined as being the school system of West Germany. Investigations into the educational value of the planetarium have been conducted by an investigation of the planetarium's intrinsic value, by opinion polls and by experiments. The results support the relevant part of the general hypothesis.

Furthermore, the problem of the demand for planetariums is investigated in chapter II. Actual and potential demand for planetariums do exist in the educational system of West Germany, according to the findings established. Manufacturers neither realize the existence of this demand nor have they tried to develop a market for their products in West Germany. The results of the surveys conducted support that part of the general hypothesis dealing with demand.

Educational research on the planetarium has not produced any consistent results. General literature on the planetarium is consistently positive.

Chapter III of the thesis investigates the underuse of the planetarium in the educational system of West Germany. The results of the surveys conducted support the relevant part of the hypothesis. Planetariums
are underused in the sense that there are not sufficient planetariums available in West Germany to satisfy demand for performances and, even where planetariums exist, students cannot expect to see more than 2 or 3 performances in their entire school life. Schools do not press for more performances.

Reasons for the insufficient number of planetariums in West Germany are to be found in the inactivity of budgetary authorities, lack of information, and inertia among teachers, their biases and misgivings as to the financial and technical sides of the installation of school planetariums, their other pressing needs, lack of space in the schools and other media preferences of the schools and the authorities.

Manufacturers' omissions to work the West German school market also contribute to the underuse of the planetarium.
2. Originality of the Work

The author claims originality for his work in the following domains:

2.1 This thesis is the first research work on the planetarium ever performed in the country of the origin of the projection planetarium. (Holding true for both Germanys.)

2.2 It is the first broad-spectrum survey on the planetarium done anywhere under the inclusion of all those circles dealing with or affected by the planetarium in one capacity or other.

2.3 It is the first survey ever done on the underuse of the planetarium, demand for the planetarium and general estimation of the planetarium's educational value.

2.4 The affective domain of student's learning in the planetarium is treated and the author has developed an effective test instrument for the purpose.

2.5 The influence of students' attitude towards the planetarium performance has been correlated to their achievement in the cognitive domain.

2.6 The thesis is the first work which includes a report on a commercial firm's activity. It describes the firm's (vain) attempts to advertise for the school planetarium by a mailing campaign conducted with 2420 schools and by newspaper advertisements.

2.7 It is the first thesis attempting to compile a comprehensive bibliography on the planetarium.

2.8 The thesis introduces the "relative percentage system" of scoring as a means of compensating for unequal N-number participation in the various questions of a questionnaire. The "relative percentage score" as a percentage fraction of the maximum possible score that could have been obtained at a full N-number participation, allows the computation of a just rank order succession, which could not have been obtained by using the absolute score figures. (This may, however, be an example of the re-invention of the wheel.)

2.9 It is the first thesis comparing the new space age planetarium version to the classical projection planetarium system, and to compare the two competing projection systems.
3. The Product of the Research

At the end of these texts it seems to be expedient to summarize the facts to be learned from the research work undertaken.

3.1 Astronomy as a School Subject

The surveys conducted produced an overall picture of to what extent astronomy is being taught in the schools of the 11 states of West Germany and West Berlin. It was found that in several states astronomy or astrophysics is taught as a high school subject and that selected astronomical themes are taught subordinated to physics and/or geography in many schools of the remaining states. Themes of at least very basic astronomy, e.g. the solar system, are being taught in practically every normal curriculum school.

3.2 A Planetarium Census

A census has been made of all existing planetariums, i.e. 1319. While it is not claimed that this census is complete on the international scale, it seems to be complete for West Germany (20). The census has allowed the calculation of the number of possible planetarium visits that can be provided to the average school student during his school life, i.e. two or three times at the few places where planetariums are available. It has been established in this way that the planetarium is not a routine teaching tool even where it exists, and that this teaching tool is utterly underused in the school system of West Germany.

3.3 The Planetarium's Educational Value and Justification for its Use

Educational value in a medium has been defined as its effectiveness as a teaching tool. The planetarium's intrinsic value was revealed by a study of its potentials and functions in the fulfillment of curriculum requirements. Results of media research in West Germany would potentially support the planetarium, but continuing disputes about school system philosophies could in the long run prove detrimental. Opinion polls on the planetarium's value produced widely positive results, which lack, however, an adequate scientific basis. Observation and experience, imagination and intuition were found to be the only fundamentals on which such convictions were based in most of the groups interviewed. Only planetarium directors and planetarium manufacturers proved to be aware of existing research
literature, but both groups have tended to ignore the negative conclusions presented by some of the few reports on educational experimentation performed in the planetarium on isolated teaching themes.

3.4 Research Literature on the Planetarium

By the evaluation of 13 research papers produced by other authors on the educational potential and the educational value of the planetarium, it has been established that the conclusions derived from educational experimentation in the planetarium are inconsistent. Some deny the planetarium's superiority over the classroom.

3.5 Experimentation in the Planetarium

The author's own experimentation, arranged with 5 student groups of different ages and different school backgrounds, produced widely consistent results and delivered evidence of the planetarium's high effectiveness in teaching a given subject and in inducing a strongly positive attitude in the students. The planetarium's high educational value in both the cognitive and the affective domains seems to be confirmed by this set of tests in the planetarium.

3.6 Demand for Planetariums and the Underuse of the Planetarium on the School Level

The surveys conducted confirmed, at first sight, the teachers pronounced interest in the planetarium as a teaching tool for schools. This was interpreted as a manifestation of an existing demand for school planetariums. Teachers and astronomers saw educational potential and educational value in the planetarium. Many teachers rated the planetarium as being superior to conventional media. The remaining respondents to the relevant question thought it to be at least a good supplement, and nobody judged it as being inferior.

While this result looked favourable, it was soon revealed that the number of those showing enthusiasm for the planetarium shrank considerably when they were faced with the question of finance and were given an alternative choice, i.e. the choice of a telescope.

*)Footnote: This is in accordance with the author's personal experience gained in numerous discussions with members of both groups.
Still, a solid group of teachers maintained their firm interest in the planetarium throughout all the cross examination questions. The majority of teachers, however, felt - when probing deeper into their conceptions - that many obstacles tend to prevent the installation of school planetariums.

Lack of funds, lack of information, lack of space for the installation of school planetariums and also teachers' inertia were established as being actual reasons responsible for the underuse of the planetarium on the school level.

From the results of the surveys conducted, it seems safe to assume that the vast majority of teachers would readily accept the school planetarium, if all actual obstacles hindering the installation of school planetariums could be removed for them, and if all likely obstacles could be explained away for them.

Actual demand is expressed by those teachers who stood firm throughout all tests, and potential demand is expressed by all those teachers who have merely revealed an interest in the planetarium and who became uncertain when proceeding further in the tests.

3.7 Demand for Planetariums and the Underuse of Planetariums investigated at the Level of Educational Authorities

As 10 out of 11 Ministries of Education confirmed that astronomy is taught in their areas at some level*, it follows that at least a potential demand must exist for planetariums at the school level in West Germany. 3 of these Ministries have confirmed actual demand.

It has been established by the relevant surveys that the Ministries of Education can only recommend the installation of school planetariums, but cannot make the apparently financially autonomous school budgetary authorities actually buy planetariums.

It has been established by the survey conducted with a representative sample of the schools' budgetary authorities that no impetus for the installation of school planetariums is to be expected from

*) Footnote: Using supplementary sources of information, it has been ascertained that astronomy is taught at least at the elementary level in all normal curriculum schools in West Germany and West Berlin.
these authorities. It seems, therefore, safe to assume that a school would have to invest some effort in convincing these authorities before any funds for the acquisition of a planetarium could be hoped for.

3.8 Public Support for the Planetarium

According to the surveys conducted, it seems that the public planetarium is patronized by a similar fraction of the general population, i.e. approximately 5%, to that which supports theatres and concert halls, though the planetariums seem to be less elititarian than other cultural places and tend to attract their audiences from all walks of life. Planetarium directors believe that advertising could increase the size of their clientele.

3.9 Demand for School Planetariums and the Underuse of the Planetarium investigated on the Manufacturers' Level

The surveys conducted produced evidence of the manufacturers' neglect in developing a market for school planetariums in West Germany. This fact makes them partly responsible for the existing underuse of the planetarium in West Germany.

The only large-scale advertising campaign ever undertaken for the school planetarium in West Germany involved 2420 schools and met with a complete failure for the school equipment company which undertook the campaign, so did their efforts of newspaper advertising.

3.10 Helpful Literature

Scanning the scene of planetarium literature in the pursuance of the research task set for this thesis produced evidence of only one work on the doctorate level (N.J. Dean, 1971, op.cit.) offering advice in instrument selection to prospective planetarium owners. The author found the work to be of only limited value, and no other helpful literature could be traced for the selection and installation of school planetariums. Besides, planetarium research literature published in the USA has remained unnoticed and unobserved at the school level in West Germany.

3.11 Finance

Potentially available funds could possibly be mobilized by an efficient lobby.
3.12 The "Mystic Effect"

The "mystic effect" has been recognized by Ridky (op.cit.) as well as by the author as being a phenomenon influencing and affecting the attitudes of planetarium visitors. The direction of the influence and its origin, character and strength have not been investigated by the author. The author is, however, inclined to assume that the influence is predominantly positive in character.

3.13 More favourable Conditions for the Planetarium in the USA

Comparisons to Conditions in the USA

While several of the findings made in West Germany were highlighted by comparing them to conditions prevailing in the USA, it remains to be demonstrated why the USA is evidently so much more favoured with regard to the use of the planetarium as an educational tool.

The density of planetariums in the USA is 1 planetarium for 235,926 people. In West Germany the ratio is 1 planetarium for 3,032,530 people.* Educational standards and goals are comparable in both countries, but there are differences in the school system. West Germany keeps students longer in the high schools, but provides no colleges, and in the USA many of the school planetariums are owned by colleges. Their environment frequently represents a "learning village" which may produce a favourable climate for installing such an extraordinary institution for learning and erudite entertainment.

Astronomy is an undergraduate subject in the colleges and universities in the USA with a large student clientele, which provides a priori for a wide field of application for the planetarium at the level of higher education. This is not the case in West Germany. Astronomy is not taught at that level, which excludes the universities as prospective customers for the planetarium industry. The very limited number of postgraduate students of astronomy is a further strong factor preventing the installation of university planetariums in West Germany.

*) Footnote: USA population (1974) 211,390,000 : Planetariums 896 = 235,926
West German " (1970) 60,650,600 : " 20 = 3,032,530
Also, many high schools in the USA own a planetarium. At the high school level West Germany is an underdeveloped country as regarding the application of the planetarium as educational tool.

In the USA education seems to be less conservative in its attitude towards educational media when compared to West Germany. Education there seems to be more open to experimental undertakings; the pioneering spirit seems to be more strongly pronounced, a more favourable state of awareness and more openmindedness towards the unusual seems to prevail, and educational authorities have in many instances promoted the installation of school planetariums. The educational system in the state of Pennsylvania is a good example of this. Funds also seem to flow more easily in the USA, and donations made to education are not seldom. In fact, most large planetariums in the USA came into being by the generosity of benevolent donors.

The planetarium idea has received a strong boost by the "SPUTNIK-Syndrome" influencing USA education in the fifties. All the above argumentation has provided much better preconditions for the installation of school planetariums in the USA in comparison to West Germany, which largely lacks the above group of favourable elements as an impetus.

There are also retarding elements for the planetarium idea produced by certain educational movements in the USA, but their exact effect is not known.

*) Footnote: "SPUTNIK-Syndromé" is a term used to describe the shock that America's educational system received after Russia had launched the first man-made satellite in 1957. Spending on education rose significantly in the USA as a consequence of that event.
4. Conclusions

Astronomy is widely taught in the school system of West Germany, but the planetarium is very far from being a routine tool for teaching astronomy, although teachers do rate it highly as a teaching tool.

The results of the research work undertaken as described in chapter II of this thesis support that part of the general hypothesis pertaining to the planetarium's educational value. A study of the planetarium's intrinsic value was made, opinion polls and practical experiments in the planetarium were undertaken. There exists a potential and actual demand for school planetariums as has likewise been established by the results of all but one of the surveys described in chapter II. General literature on the planetarium is without exception positive, research literature is found to be partly critical. The results of the research work undertaken as described in chapter III of this thesis support that part of the general hypothesis saying that planetariums are underused in education for a number of different reasons.

There are not sufficient planetariums in operation, and the existing planetariums are unevenly distributed. Even in their places of location their capacity does not allow the pupil more than two or three planetarium performances during his entire school life. Prospective planetarium owners find no helpful literature as a source of information and guidance. While the educational value of the planetarium seems to be taken for granted in the schools of West Germany, little support for its installation has been found at the level of the educational authorities though funds are potentially available. Media research in West Germany is potentially favorable to the planetarium and the confessed opinions of all groups concerned with the planetarium would promote its more widespread use if an effective lobby could be organized. Manufacturers have neglected to develop a market for school planetariums in West Germany. Advertising for school planetariums, which has only started very recently, has neither been done effectively nor to a sufficient extent. Schools have generally made no efforts to acquire a planetarium.

The author found the position of the school planetarium in West Germany to be in a desolate state.
5. Implications and Recommendations

In the course of the surveys and studies undertaken, the author gained the firm conviction that the planetarium represents a particularly valuable teaching tool as it not only allows a lesson to be taught very effectively, but also produces a noticeably positive attitude in an audience.

If the planetarium's striking underuse is to be abolished, then from the results of the research work certain implications can be derived and certain recommendations can be made to the groups involved.

5.1 Teachers
Teachers will have to invest a lot of effort in collecting information on school planetariums and study ways in which their wish to own, co-own or simply use a planetarium can be implemented.

5.2 Astronomers
Astronomers should try to establish contacts with schools to interest them more strongly in the science of astronomy, and they should offer guidance to the schools and help in the selection and procurement of teaching media for the subject of astronomy, including recommendations for the use of school planetariums.

5.3 Educational Authorities
Ministries of Education should not only recommend the use of planetariums and publish curricula for the school subject of astronomy, but they should also show ways in which schools could come into the possession of school planetariums. Budgetary authorities should install or expand existing media committees and include studies on how schools could come into the possession of school planetariums in their activities.

5.4 Planetarium Directors
Planetarium directors should approach schools more intensively and directly and - knowing that their facility is too limited to become a routine teaching institute* - should offer their advice on how schools could come into the possession of school planetariums.

*) Footnote: "Routine teaching institute" is defined as a teaching place available to a given class routinely, i.e. at frequent intervals, and not only once or twice in 10 to 13 school years.
5.5 **Educationalists**

Educationalists can be recommended to uncover the neglected field of the planetarium in education, and to make efforts in promoting a valuable but strikingly underused teaching medium. The "Recommendations for further Research" listed in the following section advocate the above suggestion in some practical detail.

5.6 **Industry**

The impetus for the more widespread use of the school planetarium can - realistically - only be created by judicious advertising by industry. Joint efforts by the various manufacturers are to be recommended in order to develop West Germany from a potential market into an actual market. Manufacturers seem to be afraid that competitive interlopers could benefit from their individual expensive advertising efforts. A cartel of some sort may therefore be recommendable.

5.7 **Interested Parties**

Interested individuals or groups should try to form a lobby for an active planetarium propaganda and for mobilizing the necessary funds by various means and from various sources.

5.8 **Planetarium Committees**

Intending planetarium owners should consider the installation of a multi-media classroom planetarium as the most likely best solution for different teaching approaches.
6. Recommendations for further Research

The author would like to propose the following recommendations for further research:

6.1 The development of better methods of educational research which would allow more consistent results to be produced when dealing with the planetarium's educational potential and educational value.

6.2 Curriculum research for the school subject of astronomy with the objective of determining:
   a) which particular themes should be taught in the planetarium,
   b) which particular themes should be taught in the classroom,
   c) how both teaching environments can supplement one another,
   d) if the classroom-type planetarium can successfully combine both teaching methods,
   e) to what extent practical astronomical telescope observation or other forms of practical astronomical observation should supplement a), b), c), and d).

6.3 A study of the "Mystic Effect", its existence and manifestations, its positive or negative influence on attitudes towards the planetarium performance and on learning in the planetarium. The effective utilisation of any positive influence it may exert and the elimination of any negative influence it may exert.

6.4 A study of elements that could promote a more widespread application of the planetarium in the schools.

6.5 A study offering a guideline to prospective planetarium owners for the erection of a school planetarium and the selection of suitable equipment.
6.6 A study of the cost-effectiveness of the school planetarium with the objective of
   a) establishing a justifiable ratio of the frequency of use of the planetarium chamber and the costs of a school planetarium,
   b) this should lead to the recommendation of an "economic size" for a single-school planetarium or for a central school planetarium intended for a number of schools.

6.7 A study of a curriculum and means for its practical implementation for the training of teachers as planetarium operators and for routine maintenance of the equipment.

6.8 A study into the possibility of using the "Mobile Planetarium", developed in the USSR and USA, to overcome the shortage of school planetariums in West Germany.

6.9 A study of the relationship between Attitude-Motivation-Learning and Retention in the Planetarium.

It is expected that more research on the planetarium will promote

THE APPLICATION OF THE PLANETARIUM

AS AN EDUCATIONAL TOOL
<table>
<thead>
<tr>
<th></th>
<th>Author</th>
<th>Title</th>
<th>Publisher</th>
<th>Year</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Bates, A.W.</td>
<td>&quot;Obstacles to the Effective Use of Communication Media in a Learning System&quot;</td>
<td>Keynote address to the International APLET Conference, Liverpool, 1974</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>Cronbach, L.J.</td>
<td>&quot;Educational Psychology&quot;</td>
<td>Ruperthart Davis, London, 1970</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>Diederichsen, U.</td>
<td>&quot;Einführung in das wissenschaftliche Denken&quot;</td>
<td>Werner Verlag, Düsseldorf, 1972</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>Entwistle, N.J. &amp; Nisbet, J.D.</td>
<td>&quot;Educational Psychology&quot;</td>
<td>Hodder &amp; Stoughton, 1976</td>
<td></td>
</tr>
<tr>
<td>9</td>
<td>Peters, R.S.</td>
<td>&quot;Ethics and Education&quot;</td>
<td>George Allen &amp; Unwin Ltd., London 1971</td>
<td></td>
</tr>
<tr>
<td>10</td>
<td>Romiszowski, A.J.</td>
<td>&quot;The Selection and Use of Instructional Media&quot;</td>
<td>Kogan Page, 1976</td>
<td></td>
</tr>
<tr>
<td>13</td>
<td>Standop, Ewald</td>
<td>&quot;Die Form der wissenschaftlichen Arbeit&quot;</td>
<td>UTB, Quelle &amp; Meyer, Heidelberg 1975</td>
<td></td>
</tr>
</tbody>
</table>
15. Vester, Frederic

"Denken, Lernen, Vergessen"
(Thinking, Learning, Forgetting)
Deutsche Verlagsanstalt, Stuttgart, 1975

16. The Open University
Milton Keynes, England

"Methods of Educational Research"
E 341, Blocks 1 - 6.
1. ANON. "Lehrplan für das Fach Astronomie" Kultusministerium Baden-Württemberg, 1976
2. ANON. "Entwurf zum Curriculum Leistungskurs Physik" Kultusministerium Rheinland-Pfalz
3. ANON. "Euro Data" Marplan, Offenbach 1975
4. ANON. "Statistisches Jahrbuch 1976 für die BRD" Kohlhammer Verlag
5. ANON. Denkschrift "Planetenforschung", Harald Boldt Verlag KG, Boppard 1977
6. ANON. List on World Planetariums outside the U.S.A. Michigan State University, ABRAMS Planetarium, 1977
7. ANON. International Astronomical Union, Symposium No. 37, held in Rome May 8 - 10, 1969
8. ANON. European Southern Observatory, various Bulletins
9. ANON. "I.P.S. Newsletter" International Planetarium Society, Abrams Planetarium, Michigan State University, East Lansing, Michigan 48824
11. ATYEO, Henry C. "The Excursion as a Teaching Technique" Columbia University, Teachers College, New York, May 1939
12. BOLOGNESE, Caroline "Schools' Planetarium Really a Laboratory" Article in "TODAY'S POST", USA, June 14, 1977
<table>
<thead>
<tr>
<th>No.</th>
<th>Author(s)</th>
<th>Title</th>
<th>Source</th>
</tr>
</thead>
</table>
| 15. | CHAMBERLAIN, Joseph Miles | "The Development of the Planetarium in the United States"  
| 16. | CHAMBERLAIN, Joseph Miles | "The Administration of a Planetarium as an Educational Institution"  
| 17. | CRONHOLM, Lewis C. | "What are the Educational Values in Planned Field Trips?"  
| 18. | DAVIS, Louise | "Motivating Teachers for more Direct Educational Use of the Planetarium"  
Cranbrook Institute of Science, Bulletin 38/1959 |
| 19. | DEAN, Norman Jack | "Guidelines in the Selection of Planetarium Instruments"  
Ed.D.-Dissertation, University of Maryland, 1971 |
| 20. | DEGANI, Meir H. | "The Educational Task of the Planetarium"  
Cranbrook Institute of Science, Bulletin 38/1959 |
4th edition R 1969, MacMillan |
| 22. | EMMONS, Richard H. | "A Report on a School Planetarium: its Design, its Development as a Group Project, its Utility as an Instructional Aid; and its Program in School Community Relations"  
Master's Thesis, Kent State University, Kent, Ohio, 1950 |
| 23. | ENGELHARD, Karl | "Medien im Lernprozess"  
Praxis Geographie, 2. April 1980 |
| 24. | EVANS, Hawthorne C. Jr. | "An Experiment in the Development and Use of Educational Field Trips"  
Ed.D.-Dissertation, University of Tennessee, 1958 |
| 25. | FIRNISS, Kurt | "The Teacher and His Media", 1977 |
| 26. | FOHRBERG, Karla | "Kulturszene Bremen"  
Zentrum für Kulturforschung Hamburg, 1979 |
| 27. | GINZEL, Hannes | "Medienverband-Begriff und Zielsetzung"  
Praxis Geographie, 1. April 1980 |
28. GRATTON, L. (ed)  "Non-Solar X- and Gamma-Ray Astronomy"
    Dudley Observatory, Albany, N.Y. USA

29. HAGAR, Charles F.  "The Philosophy and Environmental Relationship of the Planetarium"
    Astronomisches Büro, Wien, 1969

30. HAVELBERG, Gerhard  "Medien als unterrichts-technologische Innovation"
    Praxis Geographie, 2. April 1980

31. HEY, J.S.  "The Radio Universe"
    Pergamon International Popular Science Series 1971

32. HEYWARD, Robert Ross  "The Development and Field Testing of an Instrument using the Planetarium to evaluate the Attainment of the Concept of Annual Motion"
    Ph.D.-Thesis, Georgia State University, 1975

33. JENZANO, A.F.  "Training America's Astronauts ..."
    Sternwarte der Stadt Bochum, 1968

34. JONES, Roland A.  "Teaching Navigation in a Planetarium"
    Cleveland Museum of Natural History, 1960

35. KELLER, Hans-Ulrich  "Zur Didaktik von Planetariumsvorführungen"
    Bochum 1976

36. KELLER, Hans-Ulrich  "Himmelsuhrwerk Planetarium"
    Bilder der Wissenschaft, May 1977

37. KOSOLSKI, John E.  "Establishing a Space Science Curriculum"
    Cleveland Museum of Natural History, Planetariums and their Use for Education, August 1960

38. KÜSTER, Jürgen  "Untersuchungen zur Wirksamkeit von audiovisuellen Hochschulunterrichtsmitteln im Prozess der Festigung des Wissens, durchgeführt im Forschungsbereich Methodik des Physikunterrichts"
    Dr.-Thesis, Erfurt 1976

39. KRAUSE, Arthur  "Himmelskunde für Jedermann"
    Franckesche Verlagshandlung, Stuttgart 1954

40. KUNERT, A.  "The Economical Conditions of a Planetarium and Publicity"
    Sternwarte der Stadt Bochum, 1968

41. LEVITT, I.M.  "The Planetarium in the Space Age"
    Sternwarte der Stadt Bochum, 1968

42. MARTYNOV, Dimitrij  "The Planetarium and Space Age"
    Sternwarte der Stadt Bochum, 1968
<table>
<thead>
<tr>
<th></th>
<th>Name</th>
<th>Title</th>
<th>Author Institution and Date</th>
</tr>
</thead>
<tbody>
<tr>
<td>43.</td>
<td>MILLER, Freeman</td>
<td>&quot;The Use of the Planetarium for College and University Classes&quot;</td>
<td>Cranbrook Institute of Science, Bulletin 38/1959</td>
</tr>
<tr>
<td>44.</td>
<td>MUCKE, H.</td>
<td>&quot;Addendum for Newcomers&quot;</td>
<td>Astronomisches Büro Wien, 1969</td>
</tr>
<tr>
<td>45.</td>
<td>NASSAU, J.J.</td>
<td>&quot;Exploring the Universe&quot;</td>
<td>Cleveland Museum of Natural History, 1960</td>
</tr>
<tr>
<td>46.</td>
<td>NICHOLSON, Thomas</td>
<td>&quot;The Planetarium and the School&quot;</td>
<td>Sternwarte der Stadt Bochum, 1968</td>
</tr>
<tr>
<td>47.</td>
<td>NOBLE, Margret</td>
<td>&quot;A Survey of Planetarium Programs&quot;</td>
<td>Cleveland Museum of Natural History, 1960</td>
</tr>
<tr>
<td>49.</td>
<td>PERLIK, Alfons</td>
<td>&quot;Astronomie in der Schule&quot;</td>
<td>Blick in das Weltall, City of Bochum 1964</td>
</tr>
<tr>
<td>51.</td>
<td>RAPF, Horst</td>
<td>&quot;Das moderne Projektionsplanetarium&quot;</td>
<td>Carl Zeiss Publication, 1969</td>
</tr>
<tr>
<td>53.</td>
<td>RIDKY, Robert William</td>
<td>&quot;A Study of the Planetarium's Effectiveness on Student Achievement, Perceptions and Retention&quot;</td>
<td>Ph.D.-Thesis, Syracuse University, USA, 1973</td>
</tr>
<tr>
<td>54.</td>
<td>ROBINSON, Claudia</td>
<td>&quot;The Planetarium and Adult Education&quot;</td>
<td>Cranbrook Institute of Science, Bulletin 38/1959</td>
</tr>
<tr>
<td>57.</td>
<td>SACHS, Lothar</td>
<td>&quot;Statistische Auswertungsmethoden&quot;</td>
<td>Springer Verlag</td>
</tr>
</tbody>
</table>
58. RUTTER, Michael et.al.  "Fifteen Thousand Hours, Secondary Schools and their Effects on Children"  
Open Books, London 1979  
Review by "Der Spiegel"

59. SMITH, Billy Arthur  "An Experimental Comparison of 2 Techniques (Planetarium Lecture-Demonstration and Classroom Lecture-Demonstration) of Teaching Selected Astronomical Concepts to 6th Grade Students"  

60. SMITH, Theodore Victor  "A Study of the Effectiveness of the Planetarium and the Classroom in Teaching of Constellations"  
Ph.D.-Thesis, Nova University, 1974

61. SNOW, Dan  "Approaches to Public Programs"  
Cleveland Museum of Natural History, 1960

62. SPERLING, Norman (ed)  List of "North American Planetaria"  
Duncan Planetarium, Princeton, N.J., 1973

63. SPIEGEL, Der  Investigation of the Schools Systems in West Germany  
"Gesamtschulen in der Bundesrepublik" (III) 17/34, 1980

64. SPITZ, Armand N.  "Pre-School Children in the Planetarium"  
Cleveland Museum of Natural History, 1960

65. SULLIVAN, Michael  "Planetariums Flip Their Lids"  
Museum News, San Diego, California, USA, 1972

66. TUTTLE, Donald E.  "Elgin's Planetarium Curriculum Research Project"  

67. WERNER, Helmut  "From the Aratus to the Zeiss Planetarium"  
Verlag Gustav Fischer, Stuttgart 1957

68. WIESER, Sig  "The Automated Show"  
IPS "Planetarian" Vol.8, No.1, 1979

69. WILDER, Charles G.  "The Planetarium as a Community Service"  
Cranbrook Institute of Science, Bulletin 38/1959

70. WINKELMANN, Helmut  "Shows for Children"  
Astronomisches Büro Wien, 1969

72. YATES, F. "Statistical Tables for Biological and Medical Research" Oliver & Boyd Ltd., Edinburgh, 1963

73. YEE, Albert H. BAER, Joyce M. HOLT, Douglas K. "An Evaluation of the Effectiveness of School Planetarium Experiences" University of Wisconsin and Madison Public Schools, 1968

74. YOUNG, Arthur "Quantitative Measurements and Demonstrations in the Planetarium" San Diego College, Calif. USA

75. Catalogs of: CARL ZEISS, West Germany CARL ZEISS, East Germany SPITZ SPACE SYSTEMS INC., USA MINOLTA, Japan GOTO OPTICAL MFG, Japan BAADER PLANETARIUM KG, West Germany FARQUHAR COMP., USA OFFICINE GALILEO, Italy

76. Prospectus of several planetariums.
LIST OF PLANETARIUM LITERATURE

The author faced some initial difficulties in finding research literature on the planetarium. Only a very few references, even on general planetarium literature, could be traced in a number of libraries.

The author thought it therefore expedient and helpful to others to present a collection of all relevant titles for which references were found throughout the total period of study. (i.e. 1977 - 1980)

The list does not claim to be exhaustive but it certainly contains more titles than are to be found in any of the sources consulted. Certain inconsistencies in presentation were unavoidable due to unclear references.
<table>
<thead>
<tr>
<th>No.</th>
<th>Author</th>
<th>Title</th>
<th>Source</th>
</tr>
</thead>
</table>

**YEAR: 1397**

<table>
<thead>
<tr>
<th>No.</th>
<th>Author</th>
<th>Title</th>
<th>Source</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>VALLEMON, Pierre le Lorraine, Abbé de (1649-1721)</td>
<td>La sphère du monde, selon l'hypothèse de Copernic, présentée au Roy.</td>
<td>Paris, P.Marchand 1707</td>
</tr>
<tr>
<td>No.</td>
<td>Author</td>
<td>Title</td>
<td>Source</td>
</tr>
<tr>
<td>-----</td>
<td>-------------------------</td>
<td>-----------------------------------------------</td>
<td>--------------------------------------------------</td>
</tr>
<tr>
<td>1</td>
<td>HUYGENS, Christian 1629-1695</td>
<td>Opuscula posthum.</td>
<td>Amstelodami, apud Janssonio-Waesbergios, 1728 Descriptio automati planetarii</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>No.</th>
<th>Author</th>
<th>Title</th>
<th>Source</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>JANVIER, Antide 1751-1835</td>
<td>Des revolutions des corps celestes par le mecanisme des rouages.</td>
<td>Paris, Imprimerie Didot, 1812</td>
</tr>
<tr>
<td>No.</td>
<td>Author</td>
<td>Title</td>
<td>Source</td>
</tr>
<tr>
<td>-----</td>
<td>----------------</td>
<td>--------------------------------------------------------</td>
<td>--------------</td>
</tr>
<tr>
<td>1</td>
<td>FIORINI, M.</td>
<td>Erd- und Himmelsgloben, ihre Geschichte und Konstruktion.</td>
<td>Leipzig 1895</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>No.</th>
<th>Author</th>
<th>Title</th>
<th>Source</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>THIELE, G.</td>
<td>Antike Himmelsbilder.</td>
<td>Berlin 1898</td>
</tr>
<tr>
<td>No.</td>
<td>Author</td>
<td>Title</td>
<td>Source</td>
</tr>
<tr>
<td>-----</td>
<td>---------------</td>
<td>--------------------------------------------</td>
<td>---------------------------------------------</td>
</tr>
</tbody>
</table>

**YEAR: 1922**

<table>
<thead>
<tr>
<th>No.</th>
<th>Author</th>
<th>Title</th>
<th>Source</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>DRECHSLER, A.</td>
<td>Der arabische Himmelsglobus des Mohamed ben Muyid el-'Ordhi vom Jahre 1279.</td>
<td>Dresden 1922</td>
</tr>
<tr>
<td>No.</td>
<td>Author</td>
<td>Title</td>
<td>Source</td>
</tr>
<tr>
<td>-----</td>
<td>-----------------</td>
<td>----------------------------------------------------------------------</td>
<td>---------------------------------------------</td>
</tr>
<tr>
<td>1</td>
<td>BAUERSFELD, W.</td>
<td>Das Projektions-Planetarium des Deutschen Museums, München.</td>
<td>Zeitschrift für Feinmechanik, 32</td>
</tr>
<tr>
<td>2</td>
<td>BAUERSFELD, W.</td>
<td>Das Projektions-Planetarium des Deutschen Museums in München.</td>
<td>Zeitschrift des VDI, 68</td>
</tr>
<tr>
<td>3</td>
<td>MORISON, G.H.</td>
<td>Die Geheimnisse der Sterne.</td>
<td>Westermanns Monatshefte, 69</td>
</tr>
<tr>
<td>5</td>
<td>CARL ZEISS, Jena</td>
<td>Das Zeiss-Planetarium, ein riesenhaftes Weltbildgerät und Anschauungsmittel.</td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>ANON.</td>
<td>The Optical Planetarium at Munich.</td>
<td>Nature 114</td>
</tr>
<tr>
<td>No.</td>
<td>Author</td>
<td>Title</td>
<td>Source</td>
</tr>
<tr>
<td>-----</td>
<td>-------------------------</td>
<td>----------------------------------------------------------------------</td>
<td>--------------------------------------------------</td>
</tr>
<tr>
<td>2</td>
<td>CARRASCO, P.</td>
<td>El mundo anda como queremos (Die Welt läuft, wie wir wollen).</td>
<td>El Sol, Madrid, 2. Januar 1925</td>
</tr>
<tr>
<td>3</td>
<td>DISCHINGER, F.</td>
<td>Fortschritte im Bau von Massivkuppeln.</td>
<td>Deutsche Bauzeitung, 59</td>
</tr>
<tr>
<td>4</td>
<td>FUCHS, F.</td>
<td>Physik und Astronomie im Deutschen Museum.</td>
<td>Kosmos, 22</td>
</tr>
<tr>
<td>5</td>
<td>FUCHS, F.</td>
<td>Das Deutsche Museum und seine naturwissenschaftlichen Sammlungen.</td>
<td>Die Umschau, 29</td>
</tr>
<tr>
<td>6</td>
<td>KAUFMANN, A.</td>
<td>Das Zeiss-Planetarium.</td>
<td>Schweizerische Techniker-Zeitung Nr. 42</td>
</tr>
<tr>
<td>7</td>
<td>MEYER, F.A.</td>
<td>Das mechanische Planetarium des Deutschen Museums.</td>
<td>Zeitschrift des VDI, 69</td>
</tr>
<tr>
<td>8</td>
<td>MORISON, G.H.</td>
<td>Heavens Built of Concrete.</td>
<td>Scientific American, 132</td>
</tr>
<tr>
<td>9</td>
<td>TODD, D.</td>
<td>A new optical projection Planetarium for visualizing the motions of the celestial bodies, as seen by the naked eye, from the earth.</td>
<td>Popular Astronomy, 33</td>
</tr>
<tr>
<td>10</td>
<td>CARL ZEISS, Jena</td>
<td>Vorrichtung zum Projizieren von Gestirnen auf eine kugelförmige Projektionswand. Deutsches Reichspatent, Klasse 42 h, Gruppe 23, Nr. 391 036 vom 17.10.1922 Nr. 436 087 vom 30.7.1925 Nr. 439 981 vom 30.7.1925</td>
<td></td>
</tr>
<tr>
<td>No.</td>
<td>Author</td>
<td>Title</td>
<td>Source</td>
</tr>
<tr>
<td>-----</td>
<td>--------------------</td>
<td>-------------------------------------------------</td>
<td>-------------------------------</td>
</tr>
<tr>
<td>1</td>
<td>BUTLER, Howard Russel</td>
<td>An Ideal Astronomic Hall.</td>
<td>Nat. Hist. July-August</td>
</tr>
<tr>
<td>2</td>
<td>DEXEL, W.</td>
<td>Planetarium und Planetariumsbauten.</td>
<td>Universum</td>
</tr>
<tr>
<td>3</td>
<td>FISHER, C.</td>
<td>Popular Astronomic Education in Europe.</td>
<td>Science, 63</td>
</tr>
<tr>
<td>4</td>
<td>FISHER, C.</td>
<td>The New Projection Planetarium.</td>
<td>Natural History, 26</td>
</tr>
<tr>
<td>5</td>
<td>KOERBER, F.</td>
<td>Planetarien.</td>
<td>Der Naturforscher, 3</td>
</tr>
<tr>
<td>6</td>
<td>KRAUS, H.-J.</td>
<td>The Planetarium at Düsseldorf.</td>
<td>Deutsche Bauzeit. 60, 35</td>
</tr>
<tr>
<td>7</td>
<td>MATZDORFF</td>
<td>Planetarium der Stadt Berlin.</td>
<td>Centralblatt der Bauverwaltung, 47</td>
</tr>
<tr>
<td>8</td>
<td>MEYER, F.A.</td>
<td>Mechanisches Planetarium des Deutschen Museums in München</td>
<td>Zeitschrift für Feinmechanik, 34</td>
</tr>
<tr>
<td>9</td>
<td>VILLIGER, W.</td>
<td>Das Zeiss-Planetarium.</td>
<td>Verlag B. Vopelius, Jena 1926</td>
</tr>
<tr>
<td>10</td>
<td>VILLIGER, W.</td>
<td>Planetarium in Berlin.</td>
<td>Nachrichten-Zeitung des VDI, 6, Nr. 47</td>
</tr>
<tr>
<td>11</td>
<td>VILLIGER, W.</td>
<td>The Zeiss Planetarium</td>
<td>pp. 14-17 London</td>
</tr>
<tr>
<td>12</td>
<td>ANON.</td>
<td>Neuerungen am Zeiss-Planetarium.</td>
<td>Zeitschrift des VDI, 70</td>
</tr>
<tr>
<td>13</td>
<td>ANON.</td>
<td>The Weingarten Planetarium.</td>
<td>Isis, 8, 26</td>
</tr>
<tr>
<td>No.</td>
<td>Author</td>
<td>Title</td>
<td>Source</td>
</tr>
<tr>
<td>-----</td>
<td>--------</td>
<td>-------</td>
<td>--------</td>
</tr>
<tr>
<td>1</td>
<td>BAUERSFELD, W.</td>
<td>Device for projecting stars.</td>
<td>United States Patent, No. 1,616,736, February 8, 1927</td>
</tr>
<tr>
<td>5</td>
<td>KLÜBER, H. von</td>
<td>Das Zeiss-Planetarium.</td>
<td>Die Naturwissenschaften, 15</td>
</tr>
<tr>
<td>6</td>
<td>LUYTEN, W.J.</td>
<td>The New Projection Planetarium.</td>
<td>Natural History, 27</td>
</tr>
<tr>
<td>7</td>
<td>MÜLLER, B.</td>
<td>The Planetarium at Mannheim.</td>
<td>Deutsche Bauzeit.</td>
</tr>
<tr>
<td>8</td>
<td>RITTER, H.</td>
<td>Neubau des Planetariums in Leipzig.</td>
<td>Der Neubau, 9</td>
</tr>
<tr>
<td>9</td>
<td>SCHLACHTER, A.</td>
<td>Der Globus, seine Entstehung und Verwendung in der Antike.</td>
<td>Stoicheia VIII. Leipzig und Berlin</td>
</tr>
<tr>
<td>10</td>
<td>STEIN, G.</td>
<td>Deutsche Planetarien.</td>
<td>Der Neubau, 9</td>
</tr>
<tr>
<td>11</td>
<td>STRÖMGREN, E.</td>
<td>Zweite Sammlung astronominischer Miniaturen.</td>
<td>Berlin 1927 Das Wunder in Jena</td>
</tr>
<tr>
<td>12</td>
<td>VILLIGER, W.</td>
<td>Das Zeiss-Planetarium, ein Himmelstheater für alle Erdbewohner.</td>
<td>Natur, 18</td>
</tr>
<tr>
<td>13</td>
<td>VILLIGER, W.</td>
<td>Der Aufbau des Zeiss-Planetariums.</td>
<td>Nachrichten-Zeitung des Vereines Deutscher Ingenieure, 7, Nr. 32</td>
</tr>
<tr>
<td>14</td>
<td>WOLF, P.</td>
<td>Neubau des Planetariums in Dresden.</td>
<td>Der Neubau, 9</td>
</tr>
<tr>
<td>15</td>
<td>ANON.</td>
<td>Planetarium in Liegnitz anlässlich der &quot;Gugali&quot;.</td>
<td>Liegnitz 1927</td>
</tr>
<tr>
<td>No.</td>
<td>Author</td>
<td>Title</td>
<td>Source</td>
</tr>
<tr>
<td>-----</td>
<td>---------</td>
<td>----------------------------------------------------------------------</td>
<td>------------------------------------------------------------------------</td>
</tr>
</tbody>
</table>
| 1   | AUERBACH, F. | Planetarien.  
Das Meyersche mechanische Planetarium. | Handbuch der physikalischen und technischen Mechanik, II |
| 2   | AUERBACH, F. | Planetarien.  
Das Bauersfeldsche Projek- tionsplanetarium. | Handbuch der physikalischen und technischen Mechanik, II |
| 3   | BIANCHI, E. | Il "Planetarium". | Le Vie d'Italia |
| 4   | KAEMPFFERT, W. | Now America will have a Planetarium. | New York Times Magazine, June 24, 1928 |
| 5   | KRAUS, H.J.  
| 6   | MEHMEI, F. | New Building for Hanover Daily Newspaper. | Bauingen., 9  
(Planetarium dome) |
| 7   | STOCKLEY, J. | Where the stars stand still. | A radio talk delivered from Station WMAL Washington, and from WOO, Philadelphia. |
| 8   | VILLIGER, W.  
| 9   | VILLIGER, W. | Etwas vom Aufbau des Planetariums. | Schweizerische Jugendblätter,  
(November) |
| 10  | VILLIGER, W. | Vom Aufbau des Zeiss-Planetariums. | Carl Zeiss, Jena 1928 |
| 11  | VILLIGER, W. | Das Zeiss-Planetarium. | 7. Auflage  
Jena, ohne Jahr |
<p>| 12  | ANON. | Planetariumsbock - Eise Eisinga. | Arnhem 1928 |</p>
<table>
<thead>
<tr>
<th>No.</th>
<th>Author</th>
<th>Title</th>
<th>Source</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>GARNIER, E.</td>
<td>A Proposito des Planetario.</td>
<td>Il Politecnico, Milano, Nr. 12</td>
</tr>
<tr>
<td>3</td>
<td>HENNIG, R.</td>
<td>Der homerische Sternenhimmel</td>
<td>Die Himmelswelt, 39</td>
</tr>
<tr>
<td>4</td>
<td>INGALLS, A.G.</td>
<td>Canned Astronomy.</td>
<td>Scientific American, 141</td>
</tr>
<tr>
<td>5</td>
<td>MALONEY, J.A.</td>
<td>Chicago builds first Planetarium in the United States.</td>
<td>Armour Engr., 21</td>
</tr>
<tr>
<td>6</td>
<td>MEYER, F.A.</td>
<td>Mechanisches Planetarium des Deutschen Museums in München.</td>
<td>Deutsche Optische Wochenschrift, 12</td>
</tr>
<tr>
<td>7</td>
<td>RIESMANN, D.</td>
<td>The Zeiss Planetarium.</td>
<td>The General Magazine and Historical Chronicle, University of Pennsylvania (January)</td>
</tr>
<tr>
<td>8</td>
<td>SEITZ, H.</td>
<td>Das Zeiss-Planetarium und seine Bedeutung für die Schule.</td>
<td>Württembergische Schulwarte, 5</td>
</tr>
<tr>
<td>9</td>
<td>SIMON, H.</td>
<td>Design of the Zeiss Planetarium.</td>
<td>American Machinist, 73</td>
</tr>
<tr>
<td>10</td>
<td>SIMON, H.</td>
<td>Production Operations on the Planetarium.</td>
<td>American Machinist, 73</td>
</tr>
<tr>
<td>11</td>
<td>ANON.</td>
<td>Adler Planetarium and Astronomical Museum. (Chicago)</td>
<td>Science, N.S. 70</td>
</tr>
<tr>
<td>No.</td>
<td>Author</td>
<td>Title</td>
<td>Source</td>
</tr>
<tr>
<td>-----</td>
<td>--------------</td>
<td>----------------------------------------------------------------------</td>
<td>---------------------------------------------</td>
</tr>
<tr>
<td>1</td>
<td>BECKER, F.J.</td>
<td>Zeiss-Projektionsplanetarium</td>
<td>Natur und Kultur, Wien, 27</td>
</tr>
<tr>
<td>2</td>
<td>FIESELER, F.</td>
<td>Erstes Zeiss-Planetarium in USA. (Chicago)</td>
<td>Deutsche Optische Wochenschrift, 16</td>
</tr>
<tr>
<td>3</td>
<td>FOX, P.</td>
<td>The Planetarium as a Computing Device</td>
<td>Popular Astronomy, 38</td>
</tr>
<tr>
<td>4</td>
<td>LOMBARDI, C.</td>
<td>Il Planetario di Milano</td>
<td>Milano Rivista Mensile del Comune, 46</td>
</tr>
<tr>
<td>5</td>
<td>NORDENMARK, N.V.E.</td>
<td>Om Zeiss' Planetarium och stellarium.</td>
<td>Populär Astronomisk Tidskrift, Stockholm, 11</td>
</tr>
<tr>
<td>6</td>
<td>PÄTTELE, O.</td>
<td>Das Zeiss-Planetarium als Anschauungsmittel im Unterricht.</td>
<td>Unterrichtsblätter für Mathematik und Naturwissenschaften, 36</td>
</tr>
<tr>
<td>7</td>
<td>RAYMOND, F.</td>
<td>La Merveille d'Jena ou le Planétaire Zeiss.</td>
<td>Vu, 3, No. 138</td>
</tr>
<tr>
<td>9</td>
<td>VILLIGER, W.</td>
<td>Aufbau des Zeiss-Planetariums.</td>
<td>Centralzeitung für Optik und Mechanik 51</td>
</tr>
<tr>
<td>10</td>
<td>ANON.</td>
<td>Chicago's Planetarium</td>
<td>Heating and Ventilating, New York, 27</td>
</tr>
<tr>
<td>11</td>
<td>ANON.</td>
<td>Zeiss-Planetariet og stellariet i Stockholm.</td>
<td>Nordisk Astronomisk Tidskrift, Kopenhagen, 11</td>
</tr>
<tr>
<td>No.</td>
<td>Author</td>
<td>Title</td>
<td>Source</td>
</tr>
<tr>
<td>-----</td>
<td>-----------------</td>
<td>------------------------------------------------------</td>
<td>------------------------------------------------------------------------</td>
</tr>
<tr>
<td>1</td>
<td>BONACINI, C.</td>
<td>A Proposito del Planetarium Zeiss.</td>
<td>Atti Memorie, Serie IV, 3</td>
</tr>
<tr>
<td>2</td>
<td>BONACINI, C.</td>
<td>Il Planetarium Zeiss nella storia dello strumentario celeste.</td>
<td>Coelum, 1</td>
</tr>
<tr>
<td>3</td>
<td>FISHER, C.</td>
<td>The drama of the skies.</td>
<td>The Journal of the American Museum of Natural History, 32</td>
</tr>
<tr>
<td>6</td>
<td>MICHEL, E.</td>
<td>Planetariumsbau und Raumakustik.</td>
<td>Deutsche Bauzeitung Beilage: Konstruktion</td>
</tr>
<tr>
<td>7</td>
<td>MOORE, S.P.</td>
<td>Chicago Planetarium.</td>
<td>Elec.Specifications</td>
</tr>
<tr>
<td>8</td>
<td>RADICKE, K.</td>
<td>Das Zeiss-Planetarium.</td>
<td>Optische Rundschau 22</td>
</tr>
<tr>
<td>9</td>
<td>STOCKLEY, J.</td>
<td>Making the stars stand still.</td>
<td>A radio talk presented December 26, 1930, through stations of the Columbia Broadcasting System.</td>
</tr>
<tr>
<td>10</td>
<td>UNGERER, A.</td>
<td>Les horloges astronomiques et monumentales les plus remarquables de l'antiquité jusqu'à nos jours.</td>
<td>Strasbourg 1931</td>
</tr>
<tr>
<td>11</td>
<td>ANON.</td>
<td>Le planetarium de Bruxelles.</td>
<td>Gazette astronom. 24</td>
</tr>
<tr>
<td>12</td>
<td>ANON.</td>
<td>The Adler Planetarium and Astronomical Museum (Chicago)</td>
<td>The Observatory, London, 54</td>
</tr>
<tr>
<td>13</td>
<td>ANON.</td>
<td>The Zeiss Planetarium.</td>
<td>The American Monthly, 24</td>
</tr>
<tr>
<td>14</td>
<td>ANON.</td>
<td>Planetariumet i Chicago.</td>
<td>Nordisk Astronomisk Tidsskrift, Copenhagen, 12</td>
</tr>
<tr>
<td>No.</td>
<td>Author</td>
<td>Title</td>
<td>Source</td>
</tr>
<tr>
<td>-----</td>
<td>----------------</td>
<td>----------------------------------------------------------------------</td>
<td>---------------------------------------------</td>
</tr>
<tr>
<td>1</td>
<td>BROWN, B.</td>
<td>Astronomical Atlases, Maps, and Charts.</td>
<td>London 1932</td>
</tr>
<tr>
<td>2</td>
<td>BUSSOLINI, J.A.</td>
<td>El Planetario. Una Maravilla de la tecnica.</td>
<td>Revista Astronomica, Buenos Aires, 4</td>
</tr>
<tr>
<td>3</td>
<td>FIESELER, F.</td>
<td>Über die Entstehung und die kulturelle Bedeutung des Zeiss-Planetaryums.</td>
<td>Optische Rundschau und Photo-Optiker, 23</td>
</tr>
<tr>
<td>6</td>
<td>ANON.</td>
<td>Himmelsblau im Zeiss-Planetarium in Jena.</td>
<td>Optische Rundschau, 23</td>
</tr>
</tbody>
</table>

**YEAR: 1933**

<table>
<thead>
<tr>
<th>No.</th>
<th>Author</th>
<th>Title</th>
<th>Source</th>
</tr>
</thead>
<tbody>
<tr>
<td>2</td>
<td>NORDENMARK, N.V.E.</td>
<td>Stockholms utstallningons Zeiss-Planetarium.</td>
<td>Popular Astronomisk Tidsskrift, 14</td>
</tr>
<tr>
<td>4</td>
<td>STOCKLEY, J.</td>
<td>Benjamin Franklin Memorial and the Franklin Institute. Opening of the Fels Planetarium.</td>
<td>Popular Astronomy, 41</td>
</tr>
<tr>
<td>5</td>
<td>CARL ZEISS, Jena</td>
<td>Gerät zur Projektion heller Linien und Punkte auf dunklem Grunde. Deutsches Reichs- patent Nr. 577 285, Klasse 42 h, Gruppe 23, vom 29.5.33</td>
<td></td>
</tr>
<tr>
<td>No.</td>
<td>Author</td>
<td>Title</td>
<td>Source</td>
</tr>
<tr>
<td>-----</td>
<td>----------------</td>
<td>------------------------------------------------------------------------</td>
<td>-----------------------------</td>
</tr>
<tr>
<td>1</td>
<td>FISHER, C.</td>
<td>The Hayden Planetarium of the American Museum of Natural History.</td>
<td>Popular Astronomy, 42</td>
</tr>
<tr>
<td>2</td>
<td>FISHER, C.</td>
<td>The Hayden Planetarium.</td>
<td>Natural History, 34</td>
</tr>
<tr>
<td>3</td>
<td>LOBUIZEN, T. van</td>
<td>Het Zeiss-Planetarium te s' Gravenhage geopend.</td>
<td>Hemel en Dampkring, 32</td>
</tr>
<tr>
<td>4</td>
<td>RAYMOND, J.J. Jr.</td>
<td>Het Zeiss-Planetarium Haagsche Courant.</td>
<td>De Ingenieur, Utrecht, 49</td>
</tr>
<tr>
<td>5</td>
<td>SIXMA, H.</td>
<td>The Franeker Planetarium.</td>
<td>Popular Astronomy, 42</td>
</tr>
<tr>
<td>6</td>
<td>ANON.</td>
<td>Project of a Planetarium at Osaka.</td>
<td>Kyoto Bulletin 4, No. 304</td>
</tr>
<tr>
<td>7</td>
<td>ANON.</td>
<td>Astronomische Reise durch zwei Jahrtausende. Erlebnis mit einer Maschine.</td>
<td>Das Werk, Monatsblätter der Siemens-Rheinelbe-Schuckert-Union, Düsseldorf, 14</td>
</tr>
<tr>
<td>No.</td>
<td>Author</td>
<td>Title</td>
<td>Source</td>
</tr>
<tr>
<td>-----</td>
<td>----------------</td>
<td>----------------------------------------------------</td>
<td>---------------------------------------------</td>
</tr>
<tr>
<td>1</td>
<td>OHMES, R.</td>
<td>Cooling System in New Planetarium.</td>
<td>Refrig. Eng., 31, 3</td>
</tr>
<tr>
<td>2</td>
<td>KUMENZEW, G.A.</td>
<td>Das Moskauer Planetarium.</td>
<td>Moskau 1936</td>
</tr>
<tr>
<td>3</td>
<td>VILLIGER, W.</td>
<td>Zum zehnten Geburtstag des Planetariums Berlin.</td>
<td>Das Weltall, 36</td>
</tr>
<tr>
<td>4</td>
<td>VOGEL, O.</td>
<td>Das Planetarium zu Franeker und sein Erbauer Eise Eisinga.</td>
<td>Rundschau Technischer Arbeit (VDI-Nachrichten)</td>
</tr>
<tr>
<td>5</td>
<td>WERNER, H.</td>
<td>Neues über das Zeiss-Planetarium. (Russisch)</td>
<td>Mirovedenie (Weltkunde), 25</td>
</tr>
<tr>
<td>6</td>
<td>ANON.</td>
<td>Osaka-Planetarium.</td>
<td>Kyoto Bulletin, 4, Nr. 326</td>
</tr>
<tr>
<td>7</td>
<td>ANON.</td>
<td>Das Hayden-Planetarium in New York.</td>
<td>Zeitschrift des österreichischen Ingenieur- und Architektenvereins 38</td>
</tr>
<tr>
<td>No.</td>
<td>Author</td>
<td>Title</td>
<td>Source</td>
</tr>
<tr>
<td>-----</td>
<td>----------------</td>
<td>----------------------------------------------------------------------</td>
<td>------------------------------------------------------------------------</td>
</tr>
<tr>
<td>1</td>
<td>DOUBLET, E.</td>
<td>Le Planétaire de l'Exposition de 1937.</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>KRONZKOV, N.</td>
<td>Planetarium.</td>
<td>Pravda, 150</td>
</tr>
<tr>
<td>4</td>
<td>PAPE, P.F.</td>
<td>Thin Concrete Shell Dome for New York planetarium.</td>
<td>Engineering News Record, 115 II</td>
</tr>
<tr>
<td>5</td>
<td>PUIG, J.</td>
<td>El Planetario Zeiss.</td>
<td>Biblioteca científica del Observatorio San Miguel (Argentina)</td>
</tr>
<tr>
<td>6</td>
<td>REMACLE, G.</td>
<td>Les Planétaires.</td>
<td>La Nature, Paris 651</td>
</tr>
<tr>
<td>7</td>
<td>RYWOSCH, A.</td>
<td>L'ossature du Planetarium a l'Exposition Internationale de Paris.</td>
<td>Travaux, 21, 56</td>
</tr>
<tr>
<td>8</td>
<td>SCHISTOVSKY, K.N.</td>
<td>Neue Leistungen der Technik im Moskauer Planetarium.</td>
<td>Mirovendenie, 26</td>
</tr>
<tr>
<td>9</td>
<td>SIMONET, R.</td>
<td>Paris possède enfin un &quot;Planétaire&quot;.</td>
<td>La Science et la Vie, 66</td>
</tr>
<tr>
<td>10</td>
<td>STOCKLEY, J.</td>
<td>Planetarium Operation.</td>
<td>The Scientific Monthly, 45</td>
</tr>
<tr>
<td>11</td>
<td>VILLIGER, W.</td>
<td>Zeiss-Planetarien im Fernen Osten.</td>
<td>Ostasiatische Rundschau, 18</td>
</tr>
<tr>
<td>12</td>
<td>ANON.</td>
<td>New American Planetarium for Springfield, Massachusetts.</td>
<td>Popular Astronomy 45</td>
</tr>
<tr>
<td>14</td>
<td>ANON.</td>
<td>Le Planétarium de Bruxelles.</td>
<td>Gazette Astronomique, 24</td>
</tr>
<tr>
<td>No.</td>
<td>Author</td>
<td>Title</td>
<td>Source</td>
</tr>
<tr>
<td>-----</td>
<td>-------------------------</td>
<td>----------------------------------------------------------------------</td>
<td>-------------------------------------------------------------</td>
</tr>
<tr>
<td>1</td>
<td>ALTER, D.</td>
<td>Planetarium as a Public School Laboratory.</td>
<td>The Sky, 2, Nr. 10</td>
</tr>
<tr>
<td>2</td>
<td>ATWOOD, W.W.</td>
<td>Giant Celestial Sphere. A Forerunner of later Planetariums.</td>
<td>The Sky, 2, Nr. 6</td>
</tr>
<tr>
<td>3</td>
<td>ATYEO, Henry C.</td>
<td>The Excursion as A Teaching Technique.</td>
<td>Contributions to Education, no. 761 New York: Teachers College, Columbia University, 1938</td>
</tr>
<tr>
<td>4</td>
<td>GRESSITT, F.</td>
<td>Tokyo's Planetarium is Newest and Most Spectacular Feature.</td>
<td>Far Eastern Review Shanghai, 35</td>
</tr>
<tr>
<td>5</td>
<td>VILLIGER, W.</td>
<td>Der Zeiss-Sonnensystemprojektor, ein Zusatzgerät zum Zeiss-Planetarium.</td>
<td>Das Weltall, 38</td>
</tr>
<tr>
<td>6</td>
<td>WERNER, H.</td>
<td>Schein und Sein im Wandel der Planeten.</td>
<td>Carl Zeiss, Jena 1938 and 1939</td>
</tr>
<tr>
<td>No.</td>
<td>Author</td>
<td>Title</td>
<td>Source</td>
</tr>
<tr>
<td>-----</td>
<td>-------------------</td>
<td>----------------------------------------------------------------------------------------</td>
<td>---------------------------------------------</td>
</tr>
<tr>
<td>1</td>
<td>BOK, B.J.</td>
<td>Report on Astronomy.</td>
<td>Popular Astronomy</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>47, No. 7</td>
</tr>
<tr>
<td>2</td>
<td>LEWIS, Charles F.</td>
<td>Address at dedication of the Buhl Planetarium and Institute of Popular Science.</td>
<td>Program of the Dedication Ceremony, Pittsburgh, Oct. 24</td>
</tr>
<tr>
<td>3</td>
<td>LÜBKE, A.</td>
<td>Astronomische Monumentuhren.</td>
<td>Die Himmelswelt, 49</td>
</tr>
<tr>
<td>4</td>
<td>McELLROY, G.S.</td>
<td>Heating and Air Conditioning Pittsburgh's Buhl Planetarium.</td>
<td>Heating, piping and air conditioning, 11, 6</td>
</tr>
<tr>
<td></td>
<td>ROCKWELL, T.F.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>RAUDENBUSCH, H.</td>
<td>Sonnensystemprojektor und Siriusparallaxen- und aberrationsprojektor, zwei neue Zusatzgeräte zum Zeiss Planetarium.</td>
<td>Die Naturwissenschaften, 27</td>
</tr>
<tr>
<td>6</td>
<td>SOMMER, R.</td>
<td>Siegeszug der Planetarien.</td>
<td>Das Weltall, 39</td>
</tr>
<tr>
<td>7</td>
<td>STOCKLEY, J.</td>
<td>America's fifth Planetarium.</td>
<td>The Sky, 3, No. 12</td>
</tr>
<tr>
<td>8</td>
<td>ANON.</td>
<td>The Zeiss-Optical Planetarium.</td>
<td>The Griffith Observer, 3</td>
</tr>
<tr>
<td>9</td>
<td>ANON.</td>
<td>Planetarier.</td>
<td>Nordisk Astronomisk Tidsskrift, 20</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>107 und 21</td>
</tr>
<tr>
<td>No.</td>
<td>Author</td>
<td>Title</td>
<td>Source</td>
</tr>
<tr>
<td>-----</td>
<td>--------</td>
<td>-------</td>
<td>--------</td>
</tr>
<tr>
<td>1</td>
<td>BARNARD, W.T.</td>
<td>Test on Grade X Science - The Heavens.</td>
<td>Education (Secondary Edition)XXVIII (March)</td>
</tr>
<tr>
<td>2</td>
<td>BRANDT, R.</td>
<td>Neues vom Zeiss-Planetarium.</td>
<td>Die Himmelswelt, 50</td>
</tr>
<tr>
<td>3</td>
<td>GILLINGHAM, H.E.</td>
<td>The First Orreries in America.</td>
<td>Journal of the Franklin Institute 229</td>
</tr>
<tr>
<td>4</td>
<td>HILTON, Wallace A.</td>
<td>A Planispheric Planetarium for the Astronomy Club.</td>
<td>School Science and Mathematics, XL (February)</td>
</tr>
<tr>
<td>6</td>
<td>STEMPELL, G. von</td>
<td>Das Zeiss-Planetarium und seine Zusatzgeräte.</td>
<td>Deutsche Optische Wochenschrift und Centralzeitung für Optik und Mechanik 61</td>
</tr>
<tr>
<td>7</td>
<td>STOCKLEY, J.</td>
<td>Opening of the Buhl Planetarium and Institute of Popular Science in Pittsburgh.</td>
<td>Scientific Monthly 50</td>
</tr>
<tr>
<td>8</td>
<td>WERNER, H.</td>
<td>Die Entwicklung des Zeiss-Planetariums.</td>
<td>Die Sterne, 20 1940</td>
</tr>
<tr>
<td>9</td>
<td>ANON.</td>
<td>The Hayden Planetarium.</td>
<td>Popular Astronomy, 48</td>
</tr>
<tr>
<td>10</td>
<td>ANON.</td>
<td>Senkbühne und Hebeprojektor sind einzigartige Neuerungen im Buhl-Planetarium zu Pittsburgh.</td>
<td>The Sky 4, No. 3</td>
</tr>
<tr>
<td>No.</td>
<td>Author</td>
<td>Title</td>
<td>Source</td>
</tr>
<tr>
<td>-----</td>
<td>----------------</td>
<td>--------------------------------------</td>
<td>---------------------------------------------</td>
</tr>
</tbody>
</table>

YEAR: 1942

<table>
<thead>
<tr>
<th>No.</th>
<th>Author</th>
<th>Title</th>
<th>Source</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>ALLISON, W.</td>
<td>The People's Observatory of the Buhl Planetarium and Institute of Popular Science</td>
<td>Popular Astronomy, 50</td>
</tr>
<tr>
<td>No.</td>
<td>Author</td>
<td>Title</td>
<td>Source</td>
</tr>
<tr>
<td>-----</td>
<td>----------------</td>
<td>--------------------------------------------</td>
<td>-------------------------------</td>
</tr>
<tr>
<td>1</td>
<td>KAISER, E.</td>
<td>Zu Goethes Himmelsbeobachtungen.</td>
<td>Das Weltall, 43</td>
</tr>
<tr>
<td>2</td>
<td>WHITNEY, R. L.</td>
<td>Schoolroom Planetarium.</td>
<td>Grade Teacher, (January)</td>
</tr>
</tbody>
</table>

YEAR: 1944

<table>
<thead>
<tr>
<th>No.</th>
<th>Author</th>
<th>Title</th>
<th>Source</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>ANON.</td>
<td>Das Planetarium der Schwedischen Astronomischen Gesellschaft wird nach Göteborg verlegt.</td>
<td>Populär Astronomisk Tidskrift, 25</td>
</tr>
<tr>
<td>No.</td>
<td>Author</td>
<td>Title</td>
<td>Source</td>
</tr>
<tr>
<td>-----</td>
<td>------------------</td>
<td>--------------------------------------------------------</td>
<td>----------------------------</td>
</tr>
<tr>
<td>1</td>
<td>WERNER, H.</td>
<td>Vom Polarstern bis zum Kreuz des Südens.</td>
<td>2. Auflage. Jena 46</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>BERGH, S. van den</td>
<td>On the Observation of Meteors in a Zeiss Planetarium.</td>
<td>Popular Astronomy, 55</td>
</tr>
<tr>
<td>No.</td>
<td>Author</td>
<td>Title</td>
<td>Source</td>
</tr>
<tr>
<td>-----</td>
<td>---------------</td>
<td>-----------------------------------------------------------------------</td>
<td>-------------------------------</td>
</tr>
<tr>
<td>1</td>
<td>DIECKVOSS, W.</td>
<td>Die Gottorper Weltkugel.</td>
<td>Die Himmelswelt, 55</td>
</tr>
<tr>
<td>2</td>
<td>GABB, G.H.</td>
<td>An Early Orrery by Thomas Tompion and George Graham.</td>
<td>The Connoisseur, 122(September)</td>
</tr>
<tr>
<td>3</td>
<td>KRAUSE, A.</td>
<td>Himmelskunde für jedermann.</td>
<td>Stuttgart 1948</td>
</tr>
<tr>
<td>4</td>
<td>WERNER, H.</td>
<td>Das ptolemäische und kopernikanische Weltsystem und das Zeiss-Planetarium.</td>
<td>Naturwissenschaftliche Rundschau, 1</td>
</tr>
<tr>
<td>5</td>
<td>WERNER, H.</td>
<td>Der Werdegang des Zeiss-Planetariums.</td>
<td>Die Himmelswelt, 55</td>
</tr>
<tr>
<td>6</td>
<td>WERNER, H.</td>
<td>Neue Zusatzeinrichtungen zum Zeiss-Planetarium zur Darstellung des Nautischen Dreiecks und anderer Elemente der Sphärischen Astronomie.</td>
<td>Optik, 4 (1948/49)</td>
</tr>
<tr>
<td>No.</td>
<td>Author</td>
<td>Title</td>
<td>Source</td>
</tr>
<tr>
<td>-----</td>
<td>----------------</td>
<td>---------------------------------------------------------</td>
<td>------------------------------------------------------------------------</td>
</tr>
<tr>
<td>1</td>
<td>BALSS, H.</td>
<td>Antike Astronomie.</td>
<td>München 1949</td>
</tr>
<tr>
<td>2</td>
<td>BRANDT, R.</td>
<td>25 Jahre Zeiss-Planetarium.</td>
<td>Orion, Zeitschrift der Schweizerischen Astronomischen Gesellschaft, 3</td>
</tr>
<tr>
<td>4</td>
<td>HARTWIG, G.</td>
<td>Zeiss-Planetarien in aller Welt.</td>
<td>Die Sterne, 25</td>
</tr>
<tr>
<td>5</td>
<td>HEILAND, F.</td>
<td>Das Zeiss-Planetarium.</td>
<td>Deutsche Optische Wochenschrift, 66</td>
</tr>
<tr>
<td>8</td>
<td>ZINNER, E.</td>
<td>Quellen zur Geschichte der Sternkunde.</td>
<td>Sternenwelt 1</td>
</tr>
<tr>
<td>9</td>
<td>WERNER, H.</td>
<td>Die Bedeutung der klassischen Sternbeobachtungen für die Lösung astronomischer Probleme.</td>
<td>Naturwissenschaftliche Rundschau, 2</td>
</tr>
<tr>
<td>No.</td>
<td>Author</td>
<td>Title</td>
<td>Source</td>
</tr>
<tr>
<td>-----</td>
<td>---------------</td>
<td>-----------------------------------------------------------------------</td>
<td>---------------------------------------------</td>
</tr>
<tr>
<td>1</td>
<td>DEGENHARDT, A.H.</td>
<td>The Zeiss-Planetarium.</td>
<td>Vision, 4</td>
</tr>
<tr>
<td>3</td>
<td>WATSON, F.G.</td>
<td>Tin Can Planetarium.</td>
<td>The Science Teacher (November)</td>
</tr>
<tr>
<td>4</td>
<td>WERNER, H.</td>
<td>Nachbildungen des Sternenhimmels.</td>
<td>Sternenwelt, 2</td>
</tr>
<tr>
<td>5</td>
<td>ANON.</td>
<td>The sixth Planetarium in the U.S.A. (Chapel Hill).</td>
<td>Journal of the British Astronomical Assoc., 60</td>
</tr>
</tbody>
</table>

**YEAR: 1951**

<table>
<thead>
<tr>
<th>No.</th>
<th>Author</th>
<th>Title</th>
<th>Source</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>BUNTON, G.W.</td>
<td>A Universe Indoors.</td>
<td>Astronomical Society of the Pacific, Leaflet, no. 262</td>
</tr>
<tr>
<td>2</td>
<td>WERNER, H.</td>
<td>Die Dramatisierung der Astronomie im Zeiss-Planetarium.</td>
<td>Sternenwelt, 3</td>
</tr>
<tr>
<td>No.</td>
<td>Author</td>
<td>Title</td>
<td>Source</td>
</tr>
<tr>
<td>-----</td>
<td>-------------------------</td>
<td>----------------------------------------------------------------------</td>
<td>---------------------------------------------</td>
</tr>
<tr>
<td>1</td>
<td>BOMIO, R.</td>
<td>Le Planétarium. Un théâtre dont les acteurs sont les astres.</td>
<td>Science et Vie, 81</td>
</tr>
<tr>
<td>2</td>
<td>COUDERC, P.</td>
<td>Le Planétarium du Palais de la Découverte.</td>
<td>Paris 1952</td>
</tr>
<tr>
<td>3</td>
<td>HAMON, A.</td>
<td>Le Planétarium.</td>
<td>L'Astronomie, 66</td>
</tr>
<tr>
<td>4</td>
<td>KOREY, Ruth A.</td>
<td>Making a Planetarium: A Unit on the Sky.</td>
<td>Grade Teacher (December)</td>
</tr>
<tr>
<td>5</td>
<td>MILLER, Robert Cunningham</td>
<td>Galaxy by the Golden Gate.</td>
<td>Pacific Discovery, Special Morrison Planetarium number, (December)</td>
</tr>
<tr>
<td>7</td>
<td>SCHOMERUS, F.</td>
<td>Geschichte des Jenaer Zeiss-werkes 1846 bis 1946.</td>
<td>Stuttgart 1952</td>
</tr>
<tr>
<td>8</td>
<td>WERNER, H.</td>
<td>Orientierung im Gelände nach Gestirnen.</td>
<td>4. Auflage Stuttgart 1952</td>
</tr>
<tr>
<td>9</td>
<td>WERNER, H.</td>
<td>Die Verstirnung von Motiven des Osiris-Mythos.</td>
<td>Internationales Archiv für Ethnographie, 46</td>
</tr>
<tr>
<td>10</td>
<td>ZEISS-OPTON, Oberkochen</td>
<td>Einrichtung zur Darstellung der Eigenbewegung von Fixsternen in Verbindung mit Projektionsplanetarien.</td>
<td>Zum Deutschen Bundespatent eingereicht unter dem Aktenzeichen Z 2786, IX a, Klasse 42 h, Gruppe 23, am 2.7.1952</td>
</tr>
<tr>
<td>No.</td>
<td>Author</td>
<td>Title</td>
<td>Source</td>
</tr>
<tr>
<td>-----</td>
<td>------------</td>
<td>------------------------------------------------------------</td>
<td>------------------------------------------------------------------------</td>
</tr>
<tr>
<td>1</td>
<td>AUER, H.</td>
<td>Bericht aus dem Deutschen Museum.</td>
<td>Deutsches Museum, Abhandlungen und Berichte, 21, Heft 1</td>
</tr>
<tr>
<td>2</td>
<td>LATSCH, Heinz</td>
<td>Das Zeiss-Planetarium.</td>
<td>3. erweiterte Aufl Jena, G. Fischer in Kommission</td>
</tr>
<tr>
<td>3</td>
<td>WERNER, H.</td>
<td>Die Sterne dürften ihr verschwenden.</td>
<td>Verlag Gustav Fischer, Stuttgart</td>
</tr>
<tr>
<td>4</td>
<td>ANON.</td>
<td>Das Planetarium der Firma Zeiss in Sao Paulo.</td>
<td>Intercambio, Revista Cultural, 11</td>
</tr>
<tr>
<td>No.</td>
<td>Author</td>
<td>Title</td>
<td>Source</td>
</tr>
<tr>
<td>-----</td>
<td>-------------------------</td>
<td>--------------------------------------------</td>
<td>---------------------------------------</td>
</tr>
<tr>
<td>2</td>
<td>SPENCER, Steven M.</td>
<td>The Stars are His Playthings</td>
<td>Saturday Eve. Post Vol.226 (April,24)</td>
</tr>
</tbody>
</table>

**YEAR: 1955**

<table>
<thead>
<tr>
<th>No.</th>
<th>Author</th>
<th>Title</th>
<th>Source</th>
</tr>
</thead>
<tbody>
<tr>
<td>2</td>
<td>LETSCH, H.</td>
<td>Das ZEISS-Planetarium.</td>
<td>Jena 1955, VEB Fischer</td>
</tr>
<tr>
<td>No.</td>
<td>Author</td>
<td>Title</td>
<td>Source</td>
</tr>
<tr>
<td>-----</td>
<td>----------------------</td>
<td>-------------------------------------------------</td>
<td>------------------------------------------------------------------------</td>
</tr>
<tr>
<td>1</td>
<td>CROMMELIN, C.A.</td>
<td>Planetaria.</td>
<td>Bulletin of the National Assoc. of Watch and Clock Collectors, Inc. VII, No. 3 (April)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>WERNER, Helmut</td>
<td>From the Aratus Globe to the Zeiss Planetarium.</td>
<td>Stuttgart</td>
</tr>
<tr>
<td>No.</td>
<td>Author</td>
<td>Title</td>
<td>Source</td>
</tr>
<tr>
<td>-----</td>
<td>-----------------------------</td>
<td>-----------------------------------------------</td>
<td>---------------------------------------------</td>
</tr>
<tr>
<td>1</td>
<td>BERTELE, H. von</td>
<td>Clocwork Globes and Orreries.</td>
<td>Horological Journal, Saint Duns-</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>tans House, Carey Lane, London, 1958</td>
</tr>
<tr>
<td>2</td>
<td>BLITZ, Theodore F.</td>
<td>Let the Stars Get in Their Eyes.</td>
<td>Grade Teacher, (November)</td>
</tr>
<tr>
<td>3</td>
<td>CHAMBERLAIN, Joseph Miles</td>
<td>The Development of the Planetarium in the United States.</td>
<td>Washington, D.C. Smithsonian Institution</td>
</tr>
<tr>
<td>4</td>
<td>COLE, M.</td>
<td>Make an Oatmeal Box Planetarium.</td>
<td>Grade Teacher, (September)</td>
</tr>
<tr>
<td>6</td>
<td>KING, Henry O.</td>
<td>London's new Planetarium.</td>
<td>Sky &amp; Telescope no. 9, July</td>
</tr>
<tr>
<td>No.</td>
<td>Author</td>
<td>Title</td>
<td>Source</td>
</tr>
<tr>
<td>-----</td>
<td>-----------------------------</td>
<td>----------------------------------------------------------------------</td>
<td>-----------------------------------------------------------------------</td>
</tr>
<tr>
<td>1</td>
<td>DAVIS, Louise</td>
<td>Motivating Teachers for More Direct Educational Use of the Planetarium.</td>
<td>Cranbrook Institute of Science, Bulletin 38</td>
</tr>
<tr>
<td>2</td>
<td>DEGANI, Meir H.</td>
<td>The Educational Task of a Planetarium.</td>
<td>Cranbrook Institute of Science, Bulletin 38</td>
</tr>
<tr>
<td>3</td>
<td>HOWE, Ray J.</td>
<td>The Planetarium Program and the School Curriculum.</td>
<td>Planetaria and Their Use for Education. Bloomfield Hills, Michigan: Cranbrook Institute of Science</td>
</tr>
<tr>
<td>4</td>
<td>JAGGER, Miriam ed.</td>
<td>Planetaria and Their Use for Education.</td>
<td>Cranbrook Institute of Science, Bulletin 38</td>
</tr>
<tr>
<td>5</td>
<td>KING, Henry C.</td>
<td>Development of the Planetarium.</td>
<td>The Journal of the British Astronomical Assoc., Vol. 70 no. 1 (January)</td>
</tr>
<tr>
<td>6</td>
<td>KING, Henry C.</td>
<td>The Planetarium.</td>
<td>In Endeavour, London 1959</td>
</tr>
<tr>
<td>8</td>
<td>MILLER, Freeman</td>
<td>The Use of the Planetarium for College and University Classes.</td>
<td>Cranbrook Institute of Science, Bulletin 38</td>
</tr>
<tr>
<td>10</td>
<td>ROBINSON, Claudia</td>
<td>The Planetarium and Adult Education.</td>
<td>Cranbrook Institute of Science, Bulletin 38</td>
</tr>
<tr>
<td>11</td>
<td>ROSEENERGY, John C.</td>
<td>The Use of the Planetarium in Secondary Schools.</td>
<td>Cranbrook Institute of Science, Bulletin 38</td>
</tr>
<tr>
<td>12</td>
<td>de SULLA PRICE, Derek</td>
<td>An Ancient Greek Computer.</td>
<td>Scientific American (June)</td>
</tr>
<tr>
<td>13</td>
<td>SPITZ, A.N.</td>
<td>Planetarium, an Analysis of Opportunities and obligations.</td>
<td>Griffith Observer</td>
</tr>
<tr>
<td>14</td>
<td>STARRETT, C.V.</td>
<td>Integrating the Planetarium Program with General Science and Special Subject Interests.</td>
<td>Cranbrook Institute of Science, Bulletin 38</td>
</tr>
<tr>
<td>No.</td>
<td>Author</td>
<td>Title</td>
<td>Source</td>
</tr>
<tr>
<td>-----</td>
<td>-------------------------</td>
<td>-------------------------------------------------------</td>
<td>---------------------------------------------</td>
</tr>
<tr>
<td>15</td>
<td>STEIN, Raymond J.</td>
<td>Planetarium Programs for the Handicapped.</td>
<td>Cranbrook Institute of Science, Bulletin 38</td>
</tr>
<tr>
<td>16</td>
<td>WILDER, Charles G.</td>
<td>The Planetarium as a Community Service.</td>
<td>Cranbrook Institute of Science, Bulletin 38</td>
</tr>
<tr>
<td>No.</td>
<td>Author</td>
<td>Title</td>
<td>Source</td>
</tr>
<tr>
<td>-----</td>
<td>----------------</td>
<td>--------------------------------------------------------</td>
<td>---------------------------------------------</td>
</tr>
<tr>
<td>1</td>
<td>BEECHER, W.J.</td>
<td>Academy Completes Star Dome Exhibit.</td>
<td>Museum Activities No. 10 (April, S)</td>
</tr>
<tr>
<td>4</td>
<td>HAGAR, C.F.</td>
<td>Eine ausgewählte Liste von Planetariums-Untermalungs-</td>
<td>Planetariums-Mitteilungen 2(60) 50(Oberkochen)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>musik.</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>HEILAND, Fritz</td>
<td>Astronomie im Zeiss-Planetarium.</td>
<td>VEB Gustav Fischer Verlag, Jena, 1960</td>
</tr>
<tr>
<td>7</td>
<td>NOBLE, Margaret</td>
<td>A Survey of Planetarium Programs.</td>
<td>same as above</td>
</tr>
<tr>
<td>No.</td>
<td>Author</td>
<td>Title</td>
<td>Source</td>
</tr>
<tr>
<td>-----</td>
<td>----------------</td>
<td>------------------------------------------------------------</td>
<td>---------------------------------------------</td>
</tr>
<tr>
<td>1</td>
<td>ATKIN, J. Myron</td>
<td>Teaching Concepts of Modern Astronomy to Elementary School Children.</td>
<td>Science Education XLV (February)</td>
</tr>
<tr>
<td>2</td>
<td>BERLAND, Theodore</td>
<td>Classroom for the Space Age.</td>
<td>Science Digest XLIX (January)</td>
</tr>
<tr>
<td>3</td>
<td>ENGLE, A.</td>
<td>How Far Can Fifth Graders Go in a Space Study?</td>
<td>The Instructor, (December)</td>
</tr>
<tr>
<td>4</td>
<td>PRICE, Roger W.</td>
<td>Improvement of Astronomy Education (K-16) through a State Wide Program.</td>
<td>Science Education XLV (October)</td>
</tr>
<tr>
<td>5</td>
<td>THWAITES, W.M.</td>
<td>Inexpensive Planetarium Dome.</td>
<td>The Science Teacher (May)</td>
</tr>
<tr>
<td>No.</td>
<td>Author</td>
<td>Title</td>
<td>Source</td>
</tr>
<tr>
<td>-----</td>
<td>-----------------</td>
<td>------------------------------------------------------------</td>
<td>---------------------------------------------</td>
</tr>
<tr>
<td>2</td>
<td>ANON.</td>
<td>Das Zeiss-Planetarium im Lauf der Entwicklung bis zur Gegenwart.</td>
<td>Jenaer Rundschau 1962/4</td>
</tr>
<tr>
<td>No.</td>
<td>Author</td>
<td>Title</td>
<td>Source</td>
</tr>
<tr>
<td>-----</td>
<td>-------------------------</td>
<td>----------------------------------------------------------------------</td>
<td>------------------------------------------------------------------------</td>
</tr>
<tr>
<td>1</td>
<td>BARKER, G.</td>
<td>Die Astronomie in Schule und Universitat der Sowjetunion.</td>
<td>Sterne und Welt- raum 2(63)86</td>
</tr>
<tr>
<td>2</td>
<td>CROSS, Whitman, II.</td>
<td>Using a Planetarium.</td>
<td>Science Teacher XXX (Dec.1963)</td>
</tr>
<tr>
<td>3</td>
<td>HAARSTICK, Maxine B.</td>
<td>How to Succeed in the Planetarium.</td>
<td>Museum News, 43 (Dec.)</td>
</tr>
<tr>
<td>4</td>
<td>HALL, Donald A.</td>
<td>Elements of astronomy and physical geography; an introduction to astronomy and physical geography, incl. directions for using the Trippensee planetarium and a supplement on the Elementary planetarium.</td>
<td>Saginaw, Mich. Trippensee Planetarium Co., 1963</td>
</tr>
<tr>
<td>6</td>
<td>KRENICK, Donald</td>
<td>Science Facilities: A Planetarium Your School Can Afford.</td>
<td>School Management (June 1963)</td>
</tr>
<tr>
<td>7</td>
<td>McGIRR, Clint</td>
<td>Planetarium at Oak Creek High School.</td>
<td>American School Board Journal, (April 1963)</td>
</tr>
<tr>
<td>8</td>
<td>RICKER, Kenneth Scott</td>
<td>Guidelines for Effective Selection of Science Equipment for Elementary Schools and a survey of the Utilization of Science Equipment in Elementary Schools in the State of Maryland.</td>
<td></td>
</tr>
<tr>
<td>No.</td>
<td>Author</td>
<td>Title</td>
<td>Source</td>
</tr>
<tr>
<td>-----</td>
<td>--------</td>
<td>-------</td>
<td>--------</td>
</tr>
<tr>
<td>No.</td>
<td>Author</td>
<td>Title</td>
<td>Source</td>
</tr>
<tr>
<td>-----</td>
<td>-------------------</td>
<td>----------------------------------------------------------------------</td>
<td>------------------------------------------------------</td>
</tr>
<tr>
<td>1</td>
<td>BRANLEY, Franklyn M.</td>
<td>Planetariums - An Evaluation</td>
<td>Science Teacher XXXI (Oct. 1964)</td>
</tr>
<tr>
<td>3</td>
<td>FUNDERBURK, E.C.</td>
<td>Planetarium Opens New World of Science to Students in Fairfax County.</td>
<td>Virginia Journal of Education, May 1964</td>
</tr>
<tr>
<td>5</td>
<td>GARDNER, Marjorie H.</td>
<td>The Planetarium as an Educational Tool.</td>
<td>The Science Teacher, Washington 1964</td>
</tr>
<tr>
<td>6</td>
<td>JOHNSON, Robert I.</td>
<td>The Astrologer's Point of View.</td>
<td>Museum News, 43 (Dec.)</td>
</tr>
<tr>
<td>7</td>
<td>MATHEWS, William H.</td>
<td>Planetarium, Observatories, and Earth Science Exhibits.</td>
<td>Research Series no. 6, Earth Science Curriculum Project Boulder, Colorado</td>
</tr>
<tr>
<td>8</td>
<td>MUCKE, Hermann</td>
<td>Das methodische Programm des Wiener Planetariums.</td>
<td>Der Sternenbote, Wien, 1964</td>
</tr>
<tr>
<td>9</td>
<td>NOBLE, Margaret</td>
<td>The Planetarium and Space Science in the Elementary School.</td>
<td>Science Education XLVIII, 1964</td>
</tr>
<tr>
<td>10</td>
<td>RÖSENER, Richard</td>
<td>Das Wiener Planetarium und seine Geschichte.</td>
<td>ZEISS-Informationen 54, 1964</td>
</tr>
<tr>
<td>11</td>
<td>ROHR, Hans</td>
<td>Das Planetarium.</td>
<td>Schweizer Journal 8, 1964</td>
</tr>
<tr>
<td>12</td>
<td>SAMPLES, Robert E.</td>
<td>Extending the Planetarium Program.</td>
<td>The Science Teacher, Oct. 1964</td>
</tr>
<tr>
<td>14</td>
<td>SPITZ, Armand</td>
<td>The Philosopher's Point of View.</td>
<td>Museum News, 43 (Dec.)</td>
</tr>
<tr>
<td>15</td>
<td>THOMPSON, Orrin G.</td>
<td>Stars in Their Skies.</td>
<td>Illinois Education LII (March 1964)</td>
</tr>
<tr>
<td>16</td>
<td>TREJO, Paul E.</td>
<td>Space Education and the Foothill Planetarium.</td>
<td>Sky and Telescope XXVIII (Sept. 1964)</td>
</tr>
<tr>
<td>No.</td>
<td>Author</td>
<td>Title</td>
<td>Source</td>
</tr>
<tr>
<td>-----</td>
<td>-----------------------</td>
<td>-----------------------------------------------------</td>
<td>------------------------------------------------------------------------</td>
</tr>
<tr>
<td>17</td>
<td>VANCE, John B.</td>
<td>A Community Uses the Planetarium.</td>
<td>The Science Teacher, Oct. 1964</td>
</tr>
<tr>
<td>18</td>
<td>WARNEKING, Glenn E.</td>
<td>Earth and Space Science Laboratory.</td>
<td>The Science Teacher, Oct. 1964</td>
</tr>
<tr>
<td>19</td>
<td>ANON.</td>
<td>The Star of Bethlehem.</td>
<td>Space Frontiers, The Chicago Planetarium Society (79, West Monroe St, Chicago) 1964</td>
</tr>
<tr>
<td>20</td>
<td>ANON.</td>
<td>Architect Manual For Space Science Classroom.</td>
<td>(Sli-Spitz Laboratories, Inc., Yorklyn, Delaware)</td>
</tr>
<tr>
<td>21</td>
<td>ANON.</td>
<td>Blick in das Weltall.</td>
<td>Kulturamt der Stadt Bochum, 1964</td>
</tr>
<tr>
<td>No.</td>
<td>Author</td>
<td>Title</td>
<td>Source</td>
</tr>
<tr>
<td>-----</td>
<td>--------</td>
<td>-------</td>
<td>--------</td>
</tr>
<tr>
<td>1</td>
<td>CROSS, Whitman, II.</td>
<td>Planetarium Projectors and Equipment.</td>
<td>The Science Teacher Oct. 1965</td>
</tr>
<tr>
<td>2</td>
<td>GILBERT, Rose Bennett</td>
<td>Space Age Education.</td>
<td>Museum News, 44</td>
</tr>
<tr>
<td>3</td>
<td>HALL, Donald S.</td>
<td>The Morehead Planetarium.</td>
<td>University of North Carolina, Chapel Hill, 1965</td>
</tr>
<tr>
<td>5</td>
<td>MEYER, Hans Gerhard</td>
<td>Himmelswunder made in Germany.</td>
<td>Westermann-Hefte, 3, 1965</td>
</tr>
<tr>
<td>7</td>
<td>PREVOST, Roland</td>
<td>Un grand planétarium pour Montréal.</td>
<td>Montreal, 2, 1965</td>
</tr>
<tr>
<td>9</td>
<td>TAFLER, David</td>
<td>Dow Planetarium - a new landmark.</td>
<td>Montreal, 2, 1965</td>
</tr>
<tr>
<td>11</td>
<td>ANON.</td>
<td>Neubau des Planetariums in Berlin-Schöneberg aus Stahlbetonfertigteilen.</td>
<td>Dywidag-Berichte, 2, 1965</td>
</tr>
<tr>
<td>12</td>
<td>ANON.</td>
<td>40 Jahre Bau von Projektionskuppeln nach der Schalenbauweise Zeiss-Dywidag.</td>
<td>Dywidag-Berichte, 2, 1965</td>
</tr>
<tr>
<td>13</td>
<td>ANON.</td>
<td>Zeiss Planetarium der Wilhelm-Forster-Sternwarte Berlin.</td>
<td>Wilhelm-Forster-Sternwarte, 1 Berlin 41, Münsterdamm 90</td>
</tr>
<tr>
<td>14</td>
<td>ANON.</td>
<td>Planetarien</td>
<td>Sterne und Weltraum 4(65)123</td>
</tr>
<tr>
<td>No.</td>
<td>Author</td>
<td>Title</td>
<td>Source</td>
</tr>
<tr>
<td>-----</td>
<td>--------</td>
<td>-------</td>
<td>--------</td>
</tr>
<tr>
<td>15</td>
<td>ANON.</td>
<td>The Planetarium.</td>
<td>University of the Witwatersrand, Johannesburg, South Africa</td>
</tr>
<tr>
<td>16</td>
<td>ANON.</td>
<td>Astronomy at the ADLER-Planetarium.</td>
<td>Sky and Telescope 30(65)221</td>
</tr>
<tr>
<td>No.</td>
<td>Author</td>
<td>Title</td>
<td>Source</td>
</tr>
<tr>
<td>-----</td>
<td>--------</td>
<td>----------------------------------------------------------------------</td>
<td>-----------------------------------------------------------------------</td>
</tr>
<tr>
<td>1</td>
<td>BEDINI, Silvio A. MADDISON, Francis R.</td>
<td>Mechanical Universe; the astratium of Giovanni de' Dondi.</td>
<td>Philadelphia, American Philosophical Society, 66</td>
</tr>
<tr>
<td>3</td>
<td>CLERAUX, Pierre</td>
<td>Le Planetarium: Voyage comfortable parmi les étoiles.</td>
<td>Actualité, Montréal Fe. 1966</td>
</tr>
<tr>
<td>4</td>
<td>DAVIS, Donald D.</td>
<td>New Skies for a New City.</td>
<td>Sky and Telescope 4, 1966</td>
</tr>
<tr>
<td>7</td>
<td>GIUSTI, Orestes</td>
<td>Identification de Estrellas.</td>
<td>Planetario Humboldt Venezuela, 1966</td>
</tr>
<tr>
<td>9</td>
<td>HALL, Donald S.</td>
<td>What's 'Up' in Space.</td>
<td>Popular Astronomy, 60 (May-June)</td>
</tr>
<tr>
<td>11</td>
<td>MUCKE, Hermann</td>
<td>Unter dem Himmel längst versunkener Zeiten.</td>
<td>Der Sternenbote, Wien, 9, 1966</td>
</tr>
<tr>
<td>12</td>
<td>NOBLE, Margaret K.</td>
<td>Astronomy Coordinated with the Planetarium.</td>
<td>Washington, D.C. Public School Planetarium, 1966</td>
</tr>
<tr>
<td>13</td>
<td>RAFF, Horst</td>
<td>Das Planetarium, seine Möglichkeiten und seine Bedeutung.</td>
<td>Neue Züricher Zeitung, 30.11.66</td>
</tr>
<tr>
<td>14</td>
<td>ROURA RADA, Vicente</td>
<td>Memoria 1966.</td>
<td>Planetario Humboldt Venezuela, 1966</td>
</tr>
<tr>
<td>15</td>
<td>SMITH, Billy A.</td>
<td>An Experimental Comparison of Two Techniques (Planetarium Lecture-Demonstration and Classroom Lecture-Demonstration) of Teaching Selected Astronomical Concepts to Sixth Grade Students.</td>
<td>Unpublished Doctoral Dissertation, Arizona State University, 1966</td>
</tr>
<tr>
<td>No.</td>
<td>Author</td>
<td>Title</td>
<td>Source</td>
</tr>
<tr>
<td>-----</td>
<td>----------------</td>
<td>---------------------------------------------------------</td>
<td>------------------------------------------------------------------------</td>
</tr>
<tr>
<td>17</td>
<td>VOLKMANN, Harald</td>
<td>Aufbau und Leitung des ZEISS Planetariums.</td>
<td>Zeiss-Informationen 59, 1966</td>
</tr>
<tr>
<td>19</td>
<td>ANON.</td>
<td>What you should know about Astronaut Training at Morehead Planetarium.</td>
<td>University of North Carolina, Chapel Hill, 1966</td>
</tr>
<tr>
<td>No.</td>
<td>Author</td>
<td>Title</td>
<td>Source</td>
</tr>
<tr>
<td>-----</td>
<td>-------------------------</td>
<td>----------------------------------------------------------------------</td>
<td>------------------------------------------------------------------------</td>
</tr>
<tr>
<td>1</td>
<td>BOHRMANN, Alfred</td>
<td>Wie funktioniert ein Planetarium?</td>
<td>Sterne und Weltraum, 6, 1967</td>
</tr>
<tr>
<td>7</td>
<td>GRANT, Rafael</td>
<td>The way to the stars.</td>
<td>The Bangkok Post, July 30, 1967</td>
</tr>
<tr>
<td>9</td>
<td>MARTIN, Joel</td>
<td>Take Them on a Field Trip to the Stars.</td>
<td>Grade Teacher LXXXIV (Feb.1967)</td>
</tr>
<tr>
<td>10</td>
<td>MUCKE, Hermann</td>
<td>Das Planetarium als astronomische Analogrechenanlage.</td>
<td>Annalen der Universitäts-Sternwarte Wien,Band 27, 1Hefte Wien 1967</td>
</tr>
<tr>
<td>15</td>
<td>ROBERTS, Dayton</td>
<td>Education under the Stars.</td>
<td>Florida Schools, Dec.-Jan, 67-68</td>
</tr>
<tr>
<td>No.</td>
<td>Author</td>
<td>Title</td>
<td>Source</td>
</tr>
<tr>
<td>-----</td>
<td>--------</td>
<td>-------</td>
<td>--------</td>
</tr>
<tr>
<td>17</td>
<td>STEINBAUM, Martin J.</td>
<td>Young Artists in Orbit: Children's Art Project Sponsored by Hayden Planetarium.</td>
<td>School Arts Oct. 1967</td>
</tr>
<tr>
<td>21</td>
<td>TUTTLE, Donald E.</td>
<td>Elgin's Special Planetarium Class for the Academically Talented.</td>
<td>Projector, Great Lakes Planetarium Assoc., Oct. 1967</td>
</tr>
<tr>
<td>24</td>
<td>ANON.</td>
<td>Erweiterung des Verkehrshauses der Schweiz.</td>
<td>Hotel Revue 2.11.67</td>
</tr>
<tr>
<td>25</td>
<td>ANON.</td>
<td>4000 Besucher bei der historischen Reihe des Wiener Planetariums.</td>
<td>Der Sternenbote, Wien, 12, 1967</td>
</tr>
<tr>
<td>26</td>
<td>ANON.</td>
<td>Planetarium in Luzern: Grundstein gelegt.</td>
<td>Der Sternenbote Wien, 12, 1967</td>
</tr>
<tr>
<td>27</td>
<td>ANON.</td>
<td>Blick in das Weltall. Das Bochumer Planetarium.</td>
<td>Otto-Rundschau, Dez. 1967</td>
</tr>
<tr>
<td>28</td>
<td>ANON.</td>
<td>History and Development of Fernbank Science Center.</td>
<td>Fernbank Science Center, Atlanta</td>
</tr>
<tr>
<td>No.</td>
<td>Author</td>
<td>Title</td>
<td>Source</td>
</tr>
<tr>
<td>-----</td>
<td>--------------------------</td>
<td>----------------------------------------------------------------------</td>
<td>------------------------------------------------------------------------</td>
</tr>
<tr>
<td>3</td>
<td>CALDER, William A.</td>
<td>The Fernbank Science Center and Planetarium.</td>
<td>Sky and Telescope Aug. 68</td>
</tr>
<tr>
<td>6</td>
<td>KAMINSKI, H.</td>
<td>2nd International Planetarium Directors Conference 1966</td>
<td>Sternwarte der Stadt Bochum, Arbeitsbericht 68</td>
</tr>
<tr>
<td>7</td>
<td>KRATZ, R.N.</td>
<td>Planetarium Usage Looks Up.</td>
<td>Nation's Schools May 68</td>
</tr>
<tr>
<td>9</td>
<td>MANI, James D.</td>
<td>Barrington's K-12 Plan Avoids Reruns.</td>
<td>Nation's Schools (May)</td>
</tr>
<tr>
<td>11</td>
<td>McHUGH, Shirley, ed.</td>
<td>Planetarium Considerations: Administrative, Architectural, Instructional Survey and Report.</td>
<td>Middle Atlantic Planetarium Soc. Published by Chesapeake Public Schools, Virginia</td>
</tr>
<tr>
<td>13</td>
<td>NORTON, O.R.</td>
<td>The Planetarium and Atmospherium, an Indoor Universe</td>
<td>NATUREGRAPH PUB. HEALDSBURG, CALIF.</td>
</tr>
<tr>
<td>No.</td>
<td>Author</td>
<td>Title</td>
<td>Source</td>
</tr>
<tr>
<td>-----</td>
<td>----------------------</td>
<td>----------------------------------------------------------------------</td>
<td>---------------------------------------------</td>
</tr>
<tr>
<td>16</td>
<td>PITLUGA, George</td>
<td>Criteria for a Planetarium Presentation.</td>
<td>The Science Teacher, Dec. 68</td>
</tr>
<tr>
<td>18</td>
<td>ROBERTS, John M.</td>
<td>Valhalla via the Planetarium.</td>
<td>The Science Teacher, Dec. 68</td>
</tr>
<tr>
<td>21</td>
<td>STEINBAUM, Martin J.</td>
<td>Chosen: Planetarium Director</td>
<td>The Science Teacher, Jan. 68</td>
</tr>
<tr>
<td>22</td>
<td>STRAYER, Richard</td>
<td>Start-Up Problems More Imaginary than Real</td>
<td>Nation's Schools May 68</td>
</tr>
<tr>
<td>23</td>
<td>TROCONIS, Ing. En-rique Ginnari</td>
<td>Actividades en el Planetario Humboldt.</td>
<td>Sciencia al Dia, 1, 1968</td>
</tr>
<tr>
<td>25</td>
<td>YARIAN, Alton</td>
<td>Get to the Point for a Really Big Blowup.</td>
<td>The Science Teacher, Nov. 68</td>
</tr>
<tr>
<td>No.</td>
<td>Author</td>
<td>Title</td>
<td>Source</td>
</tr>
<tr>
<td>-----</td>
<td>---------------------</td>
<td>----------------------------------------------------------------------</td>
<td>------------------------------------------------------------------------</td>
</tr>
<tr>
<td>1</td>
<td>ASIMOV, I.</td>
<td>The Last Question</td>
<td>Reprint Strasenburg Planetarium, Rochester 1969</td>
</tr>
<tr>
<td>3</td>
<td>BISHOP, Jeanne E.</td>
<td>Portions of the Following are Transcribed.</td>
<td>Projector, Great Lakes Planetarium Assoc., Oct. 1969</td>
</tr>
<tr>
<td>7</td>
<td>ENGLE, Paul R.</td>
<td>Training of Instructors to Use and Make Use of the Planetarium.</td>
<td>Projector, Great Lakes Planetarium Assoc., Oct. 1969</td>
</tr>
<tr>
<td>8</td>
<td>FISCHER, L.</td>
<td>Das Planetarium LONGINES.</td>
<td>Verlag Verkehrshaus der Schweiz</td>
</tr>
<tr>
<td>11</td>
<td>JENZANO, A.F.</td>
<td>Celestial Training for US Spacemen in the ZEISS-Planetarium.</td>
<td>Planetarium International 2(69)</td>
</tr>
<tr>
<td>12</td>
<td>JETTNER, Frank C.</td>
<td>Degree Programs for Planetarium Operators.</td>
<td>Projector, Great Lakes Planetarium Assoc., Oct. 1969</td>
</tr>
<tr>
<td>14</td>
<td>KNAPP, Richard S.</td>
<td>A Major Advance in Planetarium Projectors, ZEISS Model VI.</td>
<td>Museum News, 48 (Nov.)</td>
</tr>
<tr>
<td>15</td>
<td>KRATZ, R.N.</td>
<td>Everyone Has a Sky</td>
<td>Clearing House (Feb. 1969)</td>
</tr>
<tr>
<td>No.</td>
<td>Author</td>
<td>Title</td>
<td>Source</td>
</tr>
<tr>
<td>-----</td>
<td>-------------------------</td>
<td>----------------------------------------------------------------------</td>
<td>---------------------------------------------</td>
</tr>
<tr>
<td>20</td>
<td>PITLUGA, George E.</td>
<td>Summer Institutes for Planetarium Directors.</td>
<td>Projector, Great Lakes Planetarium Assoc., Oct. 1969</td>
</tr>
<tr>
<td>21</td>
<td>RAFF, Horst</td>
<td>Das moderne Projektions-Planetarium.</td>
<td>Naturwissenschaften 56, 1969</td>
</tr>
<tr>
<td>22</td>
<td>RAFF, H. ÜBELACKER, E.</td>
<td>Die Darstellung von Raumfahrteffekten im ZEISS-Planetarium.</td>
<td>Planetarium International 1(69)</td>
</tr>
<tr>
<td>23</td>
<td>ANON.</td>
<td>ZEISS-Planetarium für Stuttgart.</td>
<td>Sterne und Weltraum 8(69) 210</td>
</tr>
<tr>
<td>26</td>
<td>ANON.</td>
<td>Science Studies Sprout in Outdoor Settings.</td>
<td>Nation's Schools, 83 (Feb. 1969)</td>
</tr>
<tr>
<td>No.</td>
<td>Author</td>
<td>Title</td>
<td>Source</td>
</tr>
<tr>
<td>-----</td>
<td>----------------------</td>
<td>----------------------------------------------------------------------</td>
<td>------------------------------------------------------------------------</td>
</tr>
<tr>
<td>1</td>
<td>ABELL, G.O.</td>
<td>Education in Astronomy and the AAS.</td>
<td>Bull. of A.A.S.</td>
</tr>
<tr>
<td>8</td>
<td>LUNETTA, Don</td>
<td>The Denver Space Transit Planetarium.</td>
<td>Museum News, 49 (May)</td>
</tr>
<tr>
<td>12</td>
<td>PORTSEVSKY, Konstantin A.</td>
<td>Moszkovszkij Planetarii Detjam i Mododezsu.</td>
<td>Znanyie, Moszkva 1970</td>
</tr>
<tr>
<td>No.</td>
<td>Author</td>
<td>Title</td>
<td>Source</td>
</tr>
<tr>
<td>-----</td>
<td>-----------------------</td>
<td>----------------------------------------------------------------------</td>
<td>----------------------------------------------</td>
</tr>
<tr>
<td>14</td>
<td>REED, George</td>
<td>Is the Planetarium a More Effective Teaching Device than the Combination of the Classroom Chalkboard and Celestial Globe?</td>
<td>School Science and Mathematics, June 1970</td>
</tr>
<tr>
<td>15</td>
<td>ROBERTS, John M.</td>
<td>The Planetarium as an Interdisciplinary Teaching Aid.</td>
<td>The Science Teacher 1970, XXXVII,</td>
</tr>
<tr>
<td>17</td>
<td>JETTNER, Frank</td>
<td>A Survey of Planetariums, Planetarium Instruments, and their Operators.</td>
<td>Duncan Planetarium Princeton Day School, Princeton, New Jersey</td>
</tr>
<tr>
<td>19</td>
<td>KILBURN, R.</td>
<td>Das ZEISS-Planetarium Model VI</td>
<td>Sterne und WeltRaum 9(70)92</td>
</tr>
<tr>
<td>21</td>
<td>WINTERS, Harold A.</td>
<td>Planetary - Stätten der Volksbildung</td>
<td>Sterne und WeltRaum 9(70)83</td>
</tr>
<tr>
<td>No.</td>
<td>Author</td>
<td>Title</td>
<td>Source</td>
</tr>
<tr>
<td>-----</td>
<td>-------------------------</td>
<td>----------------------------------------------------------------------</td>
<td>---------------------------------------------</td>
</tr>
<tr>
<td>1</td>
<td>BATTAGLINI, Dennis</td>
<td>An Experimental Study of the Science Curriculum Improvement Study Involving Fourth Graders' Ability to Understand Concepts of Relative Position and Motion Using the Planetarium as a Testing Device.</td>
<td>Michigan State University, Ph.D. Diss., 1971</td>
</tr>
<tr>
<td>2</td>
<td>BENNETT, Michael A.</td>
<td>Teaching with the Planetarium.</td>
<td>1971 Session Notes from the Spitz/McGraw-Hill Summer Institutes in Planetarium Education</td>
</tr>
<tr>
<td>5</td>
<td>JETTNER, F.C.</td>
<td>Unpublished Preceedings of the ISPE Constitutional Committee.</td>
<td></td>
</tr>
<tr>
<td>No.</td>
<td>Author</td>
<td>Title</td>
<td>Source</td>
</tr>
<tr>
<td>-----</td>
<td>--------------------------</td>
<td>----------------------------------------------------------------------</td>
<td>----------------------------------------------</td>
</tr>
<tr>
<td>1</td>
<td>ABELL, G.O.</td>
<td>And Now May I wish You All a Very Good Morning.</td>
<td>The Planetarian, 1 (Sept.)</td>
</tr>
<tr>
<td>2</td>
<td>ASIMOV, I.</td>
<td>Science and Communication.</td>
<td>The Planetarian, Vol.1 No.1 (72) 4</td>
</tr>
<tr>
<td>4</td>
<td>CHAMERLAIN Von Del</td>
<td>Planetarium Programming for the General Public.</td>
<td>The Planetarian, Vol.1 No.3 (72) 79</td>
</tr>
<tr>
<td>5</td>
<td>COBIA, Le Ron W.</td>
<td>Abrams Planetarium.</td>
<td>The Planetarian, 1 (June)</td>
</tr>
<tr>
<td>6</td>
<td>DICKSTEIN, Martin</td>
<td>Audio Visuals Under the Stars.</td>
<td>db The Sound Engineering Magazine, 6 (Oct.)</td>
</tr>
<tr>
<td>7</td>
<td>GUILBERT, Edward Hunt</td>
<td>A Standardized Test in Collegiate Descriptive Astronomy on Selected Concepts which can be Demonstrated in the Planetarium.</td>
<td>University of Southern Mississippi, unpublished Ed.D.Diss., 1972</td>
</tr>
<tr>
<td>8</td>
<td>HARRISON, Phillip</td>
<td>The Vanderbuilt Planetarium.</td>
<td>Sky &amp; Telescope 44 (Aug.)</td>
</tr>
<tr>
<td>9</td>
<td>JAMISON, Marion Merle</td>
<td>A Consideration of the Planetarium and the Lecturer as Agents to Effect Change in Administrators Regarding Social Attitudes in the School and Community.</td>
<td>University of Illinois at Urbana Champaign, Ph.D.Diss., 1972</td>
</tr>
<tr>
<td>10</td>
<td>KELLER, H.-U.</td>
<td>Erweiterung des Schulprogramms im Planetarium der Stadt Bochum.</td>
<td>Sterne und Weltbraum 11(72) 20</td>
</tr>
<tr>
<td>11</td>
<td>KNAPP, R.S. CHRISTIANSON, W.A.</td>
<td>A New Observatory at Chapel Hill.</td>
<td>Sky &amp; Telescope, 44 (Nov.), 288</td>
</tr>
<tr>
<td>12</td>
<td>KUNERT, A.</td>
<td>4.Internationale Planetariumsleitertagung in Kanada und USA.</td>
<td>Sterne und Weltbraum 11(72) 319</td>
</tr>
<tr>
<td>13</td>
<td>MORRIS, Marie N.</td>
<td>Mobile Planetariums.</td>
<td>The Science Teacher XXXVIII, 55-56</td>
</tr>
<tr>
<td>No.</td>
<td>Author</td>
<td>Title</td>
<td>Source</td>
</tr>
<tr>
<td>-----</td>
<td>------------------</td>
<td>----------------------------------------------------------------------</td>
<td>-----------------------------------------------</td>
</tr>
<tr>
<td>15</td>
<td>PITLUGA, George E.</td>
<td>The Planetarium Visit ... An Evaluation by Teachers.</td>
<td>Science Activities Vol. 6, 15-18</td>
</tr>
<tr>
<td>16</td>
<td>REED, George F.</td>
<td>A Bibliography for Planetarium Education.</td>
<td>International Society of Planetarium Educators</td>
</tr>
<tr>
<td>17</td>
<td>RICHARD-JONES, P.</td>
<td>The London Schools' Planetarium --- Its Use and Value.</td>
<td>Visual Education, (Dec) 13-17</td>
</tr>
<tr>
<td>18</td>
<td>STAMPLER, W. Robert</td>
<td>A Planetarium Program.</td>
<td>American Biology Teacher, 34 (Sep)</td>
</tr>
<tr>
<td>19</td>
<td>SULLIVAN, Michael</td>
<td>Planetariums Flip Their Lids.</td>
<td>Museum News, 51 (Nov)</td>
</tr>
<tr>
<td>20</td>
<td>WIESER, S.</td>
<td>The Calgary Centennial Planetarium.</td>
<td>The Planetarian, 1 (Sep)</td>
</tr>
<tr>
<td>21</td>
<td>ANON.</td>
<td>Stuttgart erhält ein Planetarium.</td>
<td>Sterne und Weltraum 11(72)103</td>
</tr>
<tr>
<td>22</td>
<td>ANON.</td>
<td>Planetariums of North America.</td>
<td>Sky &amp; Telescope, 43 (Jan.) 11</td>
</tr>
<tr>
<td>23</td>
<td>ANON.</td>
<td>Popular Astronomy in East Germany.</td>
<td>Sky &amp; Telescope, 43 (May) 282.</td>
</tr>
<tr>
<td>24</td>
<td>ANON.</td>
<td>The Indoor Solar System.</td>
<td>Science Activities 8 (Sept.) 39</td>
</tr>
<tr>
<td>25</td>
<td>ANON.</td>
<td>Boston Developer.</td>
<td>Sky &amp; Telescope, 43 (Jan.) 13</td>
</tr>
<tr>
<td>No.</td>
<td>Author</td>
<td>Title</td>
<td>Source</td>
</tr>
<tr>
<td>-----</td>
<td>--------</td>
<td>-------</td>
<td>--------</td>
</tr>
<tr>
<td>2</td>
<td>FRIEDMAN, Alan J.</td>
<td>Alternate Approaches to Planetarium Programs.</td>
<td>Mercury, 2 (Nov/Dec 1973) 12,18</td>
</tr>
<tr>
<td>4</td>
<td>KELLER, H.-U.</td>
<td>Das Planetarium der Sternwarte Bochum als Medium zur Weltraumkunde.</td>
<td>Sternwarte Bochum</td>
</tr>
<tr>
<td>5</td>
<td>MCDONALD, Donald</td>
<td>The Minolta Planetarium.</td>
<td>The Planetarian 2 pp. 14-15</td>
</tr>
<tr>
<td>7</td>
<td>REED, George</td>
<td>Design for a School Planetarium.</td>
<td>Science Activities 9 (May)</td>
</tr>
<tr>
<td>8</td>
<td>RIDKY, Robert William</td>
<td>A Study of Planetarium Effectiveness on Student Achievement, Perceptions and Retention.</td>
<td>Syracuse University (New York) Ph.D.Diss., 1973</td>
</tr>
<tr>
<td>9</td>
<td>SCHADE, Herbert C. BOYT, Richard</td>
<td>Construction of an Inexpensive Planetarium.</td>
<td>The Physics Teacher 11 (Sept.)</td>
</tr>
<tr>
<td>10</td>
<td>SCHULTZ, Ora Ann</td>
<td>Planetarium Astronomy for the Hearing Impaired.</td>
<td>The Science Teacher 40 (April)</td>
</tr>
<tr>
<td>13</td>
<td>SUNAL, Dennis Wayne</td>
<td>The Planetarium in Education: An Experimental Study of the Attainment of perceived Goals.</td>
<td>University of Michigan, Ph.D.Diss., 1973</td>
</tr>
<tr>
<td>14</td>
<td>YARIAN, Alton</td>
<td>Pointing's the Way - For Image Projection.</td>
<td>The Science Teacher 40 (May)</td>
</tr>
<tr>
<td>No.</td>
<td>Author</td>
<td>Title</td>
<td>Source</td>
</tr>
<tr>
<td>-----</td>
<td>--------</td>
<td>-------</td>
<td>--------</td>
</tr>
<tr>
<td>15</td>
<td>ANON.</td>
<td>Under Roof, Dome and Sky.</td>
<td>Middle Atlantic Planetarium Society and University of Maryland proposed in cooperation with associated school systems. 1973</td>
</tr>
<tr>
<td>17</td>
<td>ANON.</td>
<td>Semicentennial of the Zeiss-Planetarium.</td>
<td>OPTON Feintechnik GmbH, Oberkochen</td>
</tr>
<tr>
<td>18</td>
<td>ANON.</td>
<td>Planetarium Association</td>
<td>Sky &amp; Telescope 46 (Oct.1973) 231</td>
</tr>
<tr>
<td>19</td>
<td>ANON.</td>
<td>The London Schools Planetarium.</td>
<td>Physics Education, 8 (Nov)</td>
</tr>
<tr>
<td>20</td>
<td>ANON.</td>
<td>Constellation Figures</td>
<td>Sky &amp; Telescope,45 (June) 370,376-77</td>
</tr>
<tr>
<td>No.</td>
<td>Author</td>
<td>Title</td>
<td>Source</td>
</tr>
<tr>
<td>-----</td>
<td>-------------------------------</td>
<td>----------------------------------------------------------------------</td>
<td>------------------------------------------------------------------------</td>
</tr>
<tr>
<td>1</td>
<td>ARY, Max L.</td>
<td>The Third Stage of Planetarium Evolution.</td>
<td>The Planetarian, Vol.3, nos.1&amp;2(74)</td>
</tr>
<tr>
<td>2</td>
<td>BRANLEY, F.M.</td>
<td>Education in Major Planetariums.</td>
<td>Annals of the New York Academy of Science, Vol.198 (74)192</td>
</tr>
<tr>
<td>6</td>
<td>KELLER, H.-U.</td>
<td>Sternentheater Planetarium.</td>
<td>Verlag Faßbender, Bochum 1974</td>
</tr>
<tr>
<td>7</td>
<td>KELLER, H.-U.</td>
<td>50 Jahre ZEISS-Planetarium.</td>
<td>Sterne und Weltraum 13(74)16</td>
</tr>
<tr>
<td>8</td>
<td>KUNERT, A.</td>
<td>Medienverbund: Fernsehen im Planetarium.</td>
<td>Sterne und Weltraum 13(74)406</td>
</tr>
<tr>
<td>9</td>
<td>KULIKOV, K.A.</td>
<td>Kurz Szfericseszkoj Asztronomii Nauka.</td>
<td>Moszkva, 1974</td>
</tr>
<tr>
<td>12</td>
<td>NORTON, O. Richard</td>
<td>A Very Unusual Planetarium.</td>
<td>Mercury, 3(Nov/Dec)</td>
</tr>
<tr>
<td>13</td>
<td>SMITH, S.B.</td>
<td>An Inexpensive Home-Built Planetarium Projector.</td>
<td>Sky &amp; Telescope 48 (July)</td>
</tr>
<tr>
<td>14</td>
<td>SMITH, Theodore Victor</td>
<td>A Study of the Effectiveness of the Planetarium and the Classroom in the Teaching of Constellations.</td>
<td>Nova University (Florida) Ph.D.Diss., 1974</td>
</tr>
<tr>
<td>No.</td>
<td>Author</td>
<td>Title</td>
<td>Source</td>
</tr>
<tr>
<td>-----</td>
<td>--------------</td>
<td>-----------------------------------------------</td>
<td>---------------------------------------------</td>
</tr>
<tr>
<td>17</td>
<td>TAYLOR, Glenda</td>
<td>Spaceship San Diego - The only one like it in the World.</td>
<td></td>
</tr>
<tr>
<td>18</td>
<td>ANON.</td>
<td>Planetarium für Stuttgart.</td>
<td>Sterne und Weltraum 13(74)149</td>
</tr>
<tr>
<td>19</td>
<td>ANON.</td>
<td>Planetariums Meet.</td>
<td>Sky &amp; Telescope 47 (June, 1974) 386</td>
</tr>
<tr>
<td>No.</td>
<td>Author</td>
<td>Title</td>
<td>Source</td>
</tr>
<tr>
<td>-----</td>
<td>-------------------------------</td>
<td>----------------------------------------------------------------------</td>
<td>---------------------------------------------</td>
</tr>
<tr>
<td>2</td>
<td>DEAN, Norman J. LAUCK, Gregory M.</td>
<td>Effectiveness of the Planetarium in Teaching Navigation to Migratory Birds.</td>
<td>The Science Teacher 43 (Feb) 43</td>
</tr>
<tr>
<td>3</td>
<td>GYULA, S.</td>
<td>A Planetarium. Vom Himmelsglobus zum Weltraumtheater.</td>
<td>Gondolat Budapest 1975</td>
</tr>
<tr>
<td>4</td>
<td>HAYWARD, Robert Ross</td>
<td>The Developing and Field Testing of An Instrument Using the Planetarium to Evaluate the Attainment of the Concept of Annual Motion</td>
<td>Unpublished Doctoral Dissertation, Georgia State University, 1975</td>
</tr>
<tr>
<td>6</td>
<td>KESSLER, Sigrun</td>
<td>Optisches Museum zu Jena.</td>
<td>Supplement to Jena Review, 1975</td>
</tr>
<tr>
<td>7</td>
<td>LOVI, G.</td>
<td>Atlanta Planetarium Conference.</td>
<td>Sky &amp; Telescope 49 (Jan.) 26-27</td>
</tr>
<tr>
<td>8</td>
<td>MERGLER, Robert</td>
<td>The Planetarium in the Junior High School Curriculum.</td>
<td>School Science and Mathematics, 75 (Nov.) 591-92</td>
</tr>
<tr>
<td>11</td>
<td>PRIHODA, P.</td>
<td>A Story about the Sun.</td>
<td>Prag 1975</td>
</tr>
<tr>
<td>12</td>
<td>RIDKY, Robert W.</td>
<td>The Mystique Effect of the Planetarium.</td>
<td>School Science and Mathematics, 75 (Oct.)</td>
</tr>
<tr>
<td>15</td>
<td>ANON.</td>
<td>Museums and Planetariums with Permanent Aerospace Exhibits.</td>
<td>Journal of Aerospace Education 2</td>
</tr>
<tr>
<td>16</td>
<td>ANON.</td>
<td>District of Columbia Planetarium Projector.</td>
<td>Sky &amp; Telescope 50 (Nov.) 308</td>
</tr>
<tr>
<td>No.</td>
<td>Author</td>
<td>Title</td>
<td>Source</td>
</tr>
<tr>
<td>-----</td>
<td>--------</td>
<td>-------------------------------------------------</td>
<td>------------------------------------</td>
</tr>
<tr>
<td>17</td>
<td>ANON.</td>
<td>Among Much Else a Space Movie Envelopes the Audience; Grace Flandrau Planetarium, University of Arizona.</td>
<td>Sunset, 156 (Febr.) 28</td>
</tr>
<tr>
<td>18</td>
<td>ANON.</td>
<td>An Astronomical Mural at Flandrau Planetarium.</td>
<td>Sky &amp; Telescope, 51 (March) 156-68</td>
</tr>
<tr>
<td>19</td>
<td>ANON.</td>
<td>Planetarium Educators Meet in New Jersey.</td>
<td>Sky &amp; Telescope, 52 (July) 37-38</td>
</tr>
<tr>
<td>No.</td>
<td>Author</td>
<td>Title</td>
<td>Source</td>
</tr>
<tr>
<td>-----</td>
<td>------------------------</td>
<td>----------------------------------------------------------------------</td>
<td>------------------------------------------------------------------------</td>
</tr>
<tr>
<td>1</td>
<td>BECK, Hans Gerhard</td>
<td>Moscow Planetarium Centre of Public Instruction in Astronomy in the USSR.</td>
<td>Jena Review, 1976/3</td>
</tr>
<tr>
<td>2</td>
<td>BISHOP, Jeanne E.</td>
<td>Planetarium Methods Based on the Research of Jean Piaget.</td>
<td>Science and Children, 13 (May)</td>
</tr>
<tr>
<td>3</td>
<td>BURNETTE, Walter</td>
<td>Use of the Planetarium in Changing Attitudes and Achievement in Earth-Space Education.</td>
<td>Unpublished Doctoral Dissertation, University of Missouri-Columbia</td>
</tr>
<tr>
<td></td>
<td>Neal, Jr.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>COTTRIL, Phillip</td>
<td>A Study Comparing Achievement of Fourth-Grade Classes in Indirect and Direct Approaches to Planetarium Teaching.</td>
<td>University of Maryland, Ed.D.Diss., 1976</td>
</tr>
<tr>
<td></td>
<td>Kenneth</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Allen</td>
<td></td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>HAUSS, Deborah</td>
<td>Planetarium draws Pupil's Oohs and Aahs.</td>
<td>Compass, Dec.16,76</td>
</tr>
<tr>
<td>7</td>
<td>LOVI, G.</td>
<td>Planetariums Convene in Colorado.</td>
<td>Sky &amp; Telescope, 52 (Dec.) 422-24</td>
</tr>
<tr>
<td>9</td>
<td>PANKOW, Maria</td>
<td>The Silesian Planetarium in Chotzow.</td>
<td>Jena Review, 1976/3</td>
</tr>
<tr>
<td>10</td>
<td>SCHATZ, D.</td>
<td>Self Discovery in Astronomy for the Public.</td>
<td>Sky &amp; Telescope, 52 (Oct.) 254</td>
</tr>
<tr>
<td></td>
<td>FRIEDMAN, A.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>12</td>
<td>SWEEDY, Peter H.</td>
<td>Planetarium Shells.</td>
<td>The Physics Teacher 14 (Feb.) 110-12</td>
</tr>
<tr>
<td>14</td>
<td>ZIRPOLI, D.</td>
<td>Baltimore's New Davis Planetarium.</td>
<td>Sky &amp; Telescope, 32 (Sep.) 175-79</td>
</tr>
<tr>
<td>15</td>
<td>ANON.</td>
<td>50 Years Ago the ZEISS Planetarium opens at Jena.</td>
<td>Jena Review, 1976/3</td>
</tr>
<tr>
<td>16</td>
<td>ANON.</td>
<td>Learning Lab-Planetarium Innovation.</td>
<td>NALID Journal, 11 (Feb.) 24</td>
</tr>
<tr>
<td>No.</td>
<td>Author</td>
<td>Title</td>
<td>Source</td>
</tr>
<tr>
<td>-----</td>
<td>-------------------------</td>
<td>----------------------------------------------------------------------</td>
<td>--------------------------------------------------</td>
</tr>
<tr>
<td>1</td>
<td>BISHOP, Jeanne E.</td>
<td>United States Astronomy Education: Past, Present and Future.</td>
<td>Science Education 61 (March)</td>
</tr>
<tr>
<td>2</td>
<td>BOLOGNESE, Caroline</td>
<td>School's Planetarium really a Laboratory.</td>
<td>Today's Post Tuesday, June 14</td>
</tr>
<tr>
<td>3</td>
<td>FLETCHER, Jack</td>
<td>An Experimental Comparison of the Effectiveness of a Traditional Type Planetarium Program and a Participatory Type Planetarium Program.</td>
<td>Unpublished Doctoral Dissertation, University of Virginia, 1977</td>
</tr>
<tr>
<td>4</td>
<td>HILLEBRAND, R. RYAN, M.F.</td>
<td>Project Parsec Goes to Mars.</td>
<td>Sky &amp; Telescope, 54 (December)</td>
</tr>
<tr>
<td>5</td>
<td>KELLER, H.U.</td>
<td>A New West German Planetarium.</td>
<td>Sky &amp; Telescope, 54 (November)</td>
</tr>
<tr>
<td>6</td>
<td>NORTON, O.R.</td>
<td>Eight Feet of Solar Spectrum.</td>
<td>Sky &amp; Telescope, 54 (September)</td>
</tr>
<tr>
<td>7</td>
<td>SCHALK, Gyula</td>
<td>Planetarium és csillagászat Róka Gedeon emlékének.</td>
<td>Gondolat Kiadó Budapest 1977</td>
</tr>
<tr>
<td>8</td>
<td>SUNAL, Dennis W. SZYNANSKI SUNAL, Cynthia</td>
<td>The Planetarium in the American School Experience.</td>
<td>School Science and Mathematics, 77 (March)</td>
</tr>
<tr>
<td>No.</td>
<td>Author</td>
<td>Title</td>
<td>Source</td>
</tr>
<tr>
<td>-----</td>
<td>------------------</td>
<td>----------------------------------------------------------------------</td>
<td>-------------------------------------</td>
</tr>
<tr>
<td>1</td>
<td>HAMILTON, Thomas Wm.</td>
<td>A Somewhat Annotated Bibliography of References to Planetariums in Sky &amp; Telescope Magazine for the Years 1952 through 1978.</td>
<td>Wagner College Planetarium, USA</td>
</tr>
<tr>
<td>2</td>
<td>MILLIKEN, E.</td>
<td>New Hampshire's Student-Run Planetarium.</td>
<td>Sky &amp; Telescope, 55 (March)</td>
</tr>
<tr>
<td>3</td>
<td>RUSK, J.</td>
<td>Planetarium Design: A Winner Near Dallas.</td>
<td>Sky &amp; Telescope, 55 (June)</td>
</tr>
<tr>
<td>4</td>
<td>SCHALK, G.</td>
<td>Budapest Finally Gets Its Big Planetarium.</td>
<td>Sky &amp; Telescope, 55 (January)</td>
</tr>
</tbody>
</table>