This is to certify that the

thesis entitled

AN EXPERIMENTAL STUDY OF THE RELATIVE EDUCATIONAL IMPACTS OF FOUR INTRODUCTORY FORMATS TO A PUBLIC PLANETARIUM PROGRAM

presented by

Walter James Bisard

has been accepted towards fulfillment of the requirements for

Ph.D. degree in Education

George M. Van Deusen
Major professor

Date August 17, 1979

AN EXPERIMENTAL STUDY OF THE RELATIVE EDUCATIONAL IMPACTS OF FOUR INTRODUCTORY FORMATS TO A PUBLIC PLANETARIUM PROGRAM

By

Walter James Bisard

A DISSERTATION

Submitted to
Michigan State University
in partial fulfillment of the requirements
for the degree of

DOCTOR OF PHILOSOPHY

Department of Administration and Higher Education

1979

ABSTRACT

AN EXPERIMENTAL STUDY OF THE RELATIVE EDUCATIONAL IMPACTS OF FOUR INTRODUCTORY FORMATS TO A PUBLIC PLANETARIUM PROGRAM

By

Walter James Bisard

The need for rational evaluation and subsequent improvement of educational institutions and their programs is based upon the public's rightful and compounded demands of relevance and quality. The need for significant research in the field of planetarium education as it relates to science education is very well founded. There have been very few well-designed experiments in public planetarium programing.

Based upon these needs, this study was designed to investigate the effects of specific variables on the educational aspects of public planetarium programing as measured by an immediate post-test. The variable of most interest in this work was the type of introductory format to the program. The introductions compared in this research were a written program introduction, a personal introduction, a slide introduction, and a null introduction. One of these introductory treatments was randomly assigned to each of the presentations of the public program, The Last Question, across three distinct program times. These times were at 8:00 P.M. on Friday and Saturday evenings, 10:00 P.M. on Friday and Saturday evenings, and on Sunday afternoons at 2:00 P.M. and 4:00 P.M. A post-test given to randomly selected audience members estimated relative learning of the audiences and also collected demographic data. A two-factor analysis of covariance was performed on the experimental data.

The results demonstrate that valuable educational research can be conducted within the realm of public planetarium programing. The null introductory treatment was demonstrated to be inferior to the other three introductions of the experiment in facilitating learning by the audience patrons. Statistical contrasts of the relative learning by the audiences with individual introductory treatments were also conducted. The results also indicate that Sunday audiences learn significantly less than either the 8:00 P.M. or 10:00 P.M. audiences. Statistical contrasts of the relative learning by the audiences at the three different program times were also conducted as well as comparisons of their demographic traits. This study leads to several significant conclusions and implications for public planetarium and school planetarium programing as well as for museums, science centers, and the general classroom.

ACKNOWLEDGMENTS

Acknowledgment for inspiration, assistance, and guidance generously provided to me during the tenure of my research is given to my family, the staff and patrons of Abrams Planetarium, and the members of my Michigan State University doctoral committee, which consisted of Von Del Chamberlain and Lee Shapiro from Abrams Planetarium; Thomas Stoeckly from the Department of Astronomy and Astrophysics; William Schmidt from the Department of Educational Psychology; and George VanDusen from the College of Engineering, who served as Committee Chairperson.

TABLE OF CONTENTS

LIST OF TABLES

Table		Page

LIST OF FIGURES

CHAPTER I

THE PROBLEM AREA

Introduction to the Planetarium

The human search for order and place in the cosmos started with the age of reason. This recently accelerated and has been labeled "the space age" by some people with a commencement of October 1957 (Moore, 1965). As the ancient civilizations conceived a "celestial sphere" to contain the heavenly bodies and the more recent civilizations invented the "planetarium" or "sky theatre" to teach astronomical knowledge, this search still continues (Moore, 1965). One of the most important contemporary problems of the human race is whether nature, man, and man's technology can peacefully coexist. A partial solution to this problem must come through accurate interpretation of the sciences to the general public (Hurd, 1974).

The planetarium is formally defined as a building or a room designed to house an optical device to project various celestial images and effects. In contemporary practice, the planetarium serves as a popularizer and educator of astronomy to students at the elementary, secondary, and post-secondary levels of education as well as to the general public.

The primary purpose of the modern planetarium is educational in nature. The audiences usually consist of a very wide age range from children to senior citizens, while the range of topics is equally wide and ranges from the usual science-oriented topics in astronomy and related sciences to science fiction and multi-disciplinary programing. This is especially true with public audiences and programs as documented by many writers including Schafer (1975), Ary (1974), Nevelle (1975), Powers (1973), and others. These programs usually take place in organized school visits for students and public programs for the general public. While school programs concentrate on educational pedagogies and topics, public programs tend to be a mixture of educational, inspirational, and entertaining topics (V. D. Chamberlain, 1972a). In fact, this latter point is quite controversial with regard to emphasis in public programing. The exact mix of these three elements is dependent upon the planetarium director and staff and is certainly not a clearly resolved issue within the planetarium profession (Schafer, 1975).

From the earliest history of the planetarium regarding the celestial spheres of Eudoxes and Archimedes, the educational theme has certainly been paramount (King, 1970). Moore (1965) felt that Archimedes made the first tangible model of order in celestial motion in the second century B.C. The evolution of the planetarium may be traced from the ancient celestial globes in which the viewer is outside looking inward to that of an Earth-based observer in which the viewer is inside the universe looking outward. This evolution or transition is what Moore called the "Great Departure," and it took place in the seventeenth century. This was the "Gottrop Globe," and it consisted of a large hollow copper sphere weighing over three tons and was decorated on the inside with stars and constellations.

Provisions were made for ten persons and the operator to sit inside of it on a bench as the globe revolved around them (Moore, 1965).

The twentieth century saw the development of the modern planetarium projector at the Zeiss Works in Jena, Germany, by A. E. Bleksley (Moore, 1965). This invention of a projector to cast bright points of light onto a hemispherical ceiling might officially be labeled as the invention of the modern planetarium projector (Moore, 1965). The concept of optical projection on the fixed hemisphere was originated by Dr. W. Bauersfeld of Zeiss shortly after the close of the First World War and after five years of development, the projection idea became a reality in August of 1924 (Marshall, 1946).

After that momentous occasion in 1924, museums and public institutions sent representatives to inspect the first model. Fifteen large Zeiss planetariums in a period of five years were produced and installed in Europe before the first installation in the United States (Marshall, 1946). Zeiss produced several large projectors for planetariums in the United States such as the Adler Planetarium in Chicago (1930), the Fels Planetarium in Philadelphia (1933), the Griffith Planetarium in Los Angeles (1935), the Hayden Planetarium in New York City (1935), the Buhl Planetarium in Pittsburgh (1939), and following World War II, the Moorehead Planetarium at the University of North Carolina (1949). During this latter period, an American-based optical company, the Spitz Corporation, was starting to produce smaller educational planetariums for schools. Spitz later produced larger projectors for major planetariums such as the Longway Planetarium in Flint (1958), the USAF Planetarium in Denver (1959), and the Abrams Planetarium in East Lansing (1965) (Moore, 1965). During the time of the earliest American installations, Zeiss made several large projectors for Stockholm (1936), Milan (1936), Osaka (1937), Paris (1937), and Tokyo (1938) (Marshall, 1946). Opticians and scientists of the California Academy of Sciences designed and constructed a major planetarium instrument in San Francisco for the Morrison Planetarium (1952) and the Hayden Planetarium in Boston installed Korkosz instruments and 1937 and 1952 (Gallagher, 1970).

The last two decades have witnessed a tremendous growth in the number of new planetariums which has been fueled by the various national space exploration and research projects coupled with National Science Foundation educational grants. Compilations of the planetariums in North America by the International Society of Planetarium Educators (ISPE) (Sperling, 1973) and the world by Gallagher (1970) were attempts to list and describe all the facilities. Recently, Shapiro (1975) of Abrams Planetarium assembled a computerized list of all planetariums of North America and the world. This list was computerized so constant updating is relatively simple and accurate. Shapiro (1975) found the building of new planetariums peaked in 1970 and is slowly diminishing. As of 1975, there were approximately 1,430 planetariums in the world with 900 located in the United States, of which 500 were school-operated, 280 were college- or university-affiliated, and 120 were related to a public governing institution such as a museum or science center (Shapiro, 1975). It is obvious that the planetariums are reaching millions of people yearly.

The history of the growth of planetariums is quite deserving of a doctoral dissertation by itself because it is intertwined with the history of science, nations, societies, and especially, outstanding science educators. One of the most outstanding figures of this rich historical development was Armond Spitz, founder of the company which has produced the majority of planetarium projectors used in the United States at the present time. Many times in the promotion and encouragement of planetarium education, he utilized the following basis which is still valid at the present time:

> What justification do we have for the planetarium? In the technical world of the future, much of the responsibility for financial support for research, development, and education will fall directly on the shoulders of the taxpayers. It can categorically be said there is no type of organization better fitted than the planetarium to prepare the electorate to vote intelligently on the support of future scientific endeavors. The success of such ventures may well hinge on the effectiveness with which planetariums have played their individual and collective roles (Rush, 1977).

The importance of the planetarium to science popularization and interpretation to the general public via school programs and public programs remains as the primary justification for the planetarium's existence. On a global basis, a little progress has been made but John Sternig's statement of 1949 is still largely true: "The average inhabitant of our planet is still just as Earth-centered in his mental outlook as though Copernicus had never been born" (Sternig, 1949). Many people stress the advantage in transfer of knowledge from the technical facts to the popular interpretation of those facts using a unique and versatile tool such as the planetarium. Gerrit L. Verschuur (1975) is both a professional astronomer and science writer of popular astronomy articles, and elucidated this point when he said:

> A prime function of most planetariums, whether a school, university, or public facility, is to present astronomical knowledge to the community it serves. The science of astronomy is unique in having such a dramatic and fascinating tool to aid in public education, and planetariums hopefully strive to present the most accurate and up to date knowledge about the universe. They should also do so in a responsible and entertaining way.

Other writers in the science education field feel that not only facts of science must be popularized but the negative attitudes toward science, technology, and their effects on society need to be rectified and countered. Jane Geoghegan (1973) wrote about this situation in an article entitled "More on Understanding Science," in which she made the following point with regard to communication:

> We, as planetarians, must be genuinely involved with these concerns as anyone else, and in fact, we have a unique opportunity to use the planetarium concept to develop badly needed lines of communication between the scientific community and the public.

Paul DeHart Hurd is Professor Emeritus of Education at Stanford University and has received numerous awards and recognitions for his outstanding work in science education. In an address to the first biennial conference of the ISPE (1975), he discussed the society of the United States and its recent changes. He emphasized the implications of good science education and the part planetariums should play. Hurd's remarks further supported the evidence that communication must be improved between the people involved in science and technology with the public. "Technology which has maintained the strength of our economy for decades is now regarded as an enemy of our national environment and as a major force in the dehumanization of many." Scientists must have a means of communicating their research results in a positive manner to gain public confidence and social responsibility. Hurd concluded that "Science is thus on the defensive, characterized by an anti-science sentiment among the general public and student alike."

Certainly, planetariums fit into science education at all levels in a potentially large way since they can use their unique media combinations to arouse interest while learning takes place. Hurd called for the planetarium community to consider their educational goals with regard to the science education of the general citizen:

> In summary, what this all means is to react with a little more sensitivity to the nature of learning. Certainly keep programs to arouse interest, but unless they are reinforced with a specifically planned program built around a few concepts to extend learning, the interest goes for naught or for very little. . . . This I see as an educational function of the planetarium: present a sizable portion of our population with specially devised programs for people living in a world of science and technology so we'll be closer to the frontier of what is happening and be aware of its future potentialities, as well as enjoy it as a game.

The primary educational goal of planetariums has a significant role to play in teaching future teachers about the universe. Vanek (1970) wrote that the subject matter areas in which teachers are most knowledgeable (and, therefore, confident) are quite influential in the material which is really taught in the classroom. "Our teachers are faced with a whole new generation of children, all of them believing in life beyond the Earth and believing in the imminence of space travel. Elementary teachers are not all equipped to handle this."

Another recent development concerns a recent upturn of psuedoscience books about visitors from outer space, extraterrestrial unidentified flying objects, and others. Jack Dunn (1977) points out that these contemporary best-selling books to the public are filled with pseudoscience and half-truths about the universe but go unchallenged by rational arguments. These millions of books and nonobjective discussions in the media about such subjects must be countered by planetarium education. "Ignoring a subject is not going to make it go away--it only opens the public mind to the unprincipled hucksters who peddle pseudoscience with an eye to the fast buck. We (planetarians) are the voice of astronomy--and in some ways the most visible spokespersons for science" (Dunn, 1977).

Finally, in conclusion of this introduction, a final justification of the planetarium can be provided by identifying the prominent bases for space exploration and astronomical research. Carl Sagan (1973) justifies this activity from a human, historical, and scientific basis. He argues the scientific basis is that knowledge about physical and biological processes outside of our own terrestrial laboratories is excellent for providing insights into our understanding of nature. Beyond the comparative studies of extraterrestrial processes with our planet is the direct value of observing our planet with satellites and utilizing the advantage of low gravity and vacuum space stations for research and development. Technological advances made for the space program development have produced significant advances in every industrial nation. The human search for order and place in the universe is perhaps one of the largest yet subtle forces behind the exploration of our universe. Space exploration is merely an extention of previous generations of terrestrial explorers. Sagan noted that prosperous civilizations in the past were ones which encouraged and supported explorations and basic research generously. Space research is definitely altering the course of the history of the human race. Planetariums have a definite role to play in the communication of information of this exciting adventure.

Need for Research

The basic nature of this dissertation is concerned with fundamental research in a relatively young profession, but the general guidelines of competent and rational evaluation must prevail. The evaluation of a planetarium function such as public programing is a very difficult and challenging task. This is caused by several reasons. Time, cost, reliability, usefulness, and other factors may be some reasons, but a major underlying basis is that a planetarium does not produce explicitly tangible commodities such as automobiles or baseballs. Instead, it deals with education which is difficult to rationally evaluate from within or outside the specific system. However, evaluation through research is really inevitable because of the demands of the general public and educational administrators concerned with fiscal and accountability considerations. People who are directly involved in this young profession have strongly suggested internal research and evaluation, as will be noted in the following sections of this chapter and in Chapter II.

Dressel (1976) spoke to this point when discussing his convictions regarding evaluation in the Handbook of Academic Evaluation. "My first conviction is that evaluation is inevitable and ever present.

Every educational or social problem initiated and continues or is discarded because of some form of evaluation by some individuals or groups." The evaluation of public programing can give planetarium personnel a better perspective of their clientele, their own programing techniques and content, and furthermore, evaluation can provide a basis for change or evolution of a planetarium's operation to its administrative levels.

However, the evaluation must (in addition to being systematic, objective, and rational) be based upon the values and goals of the planetarium to be useful in effective decision making. On this basis, Dressel strongly suggested that the evaluation process and the administration or leadership which does the final decision making follow a new model of evaluation based upon the "identification and evaluation of values and thereby to foster a rational approach to decision making in full realization of the values involved." To the planetarium which is evaluating its public programing, this means not only considering the program's objectives but also the goals or values of the planetarium itself.

As will be substantiated by direct statements and inferences from the literature in this chapter and Chapter II, planetariums have a wide range of operating conditions including school, university, city, and museum establishments, but in each category there exists a definite lack of a written goals statement. In an unpublished survey of an example from each of these planetarium types in Michigan, Bisard (1975) found that each had some useful aspect of planning, but few had uniform planning strategies based upon written goals. He found:

> There are no uniform planning parameters or strategies in any type of planetaria. No current set of operating philosophies exist and thus no goal-setting takes place in the planetaria. The goals and philosophies found are those of the person being interviewed or surveyed. The entire field of planetarium education seems to possess that operational trait: no serious planning.

Consequently, evaluation is further stifled in many cases from a lack of written reference goals of that particular planetarium. Internal research or evaluation can be very healthy, as it can provide a self-analysis of efforts and possible new directions for the energies of the planetarium staff.

The amount of published research with regard to systematic evaluation of public programing is miniscule. Von Del Chamberlain (1972b) noted this is an important aspect of public programing but offered few suggestions on the exact techniques. It seems few planetariums do take surveys of their audiences but they usually just denote audience traits and subjective opinions of a usually nonrandom sample and do not in any manner evaluate the program's educational merits.

Other planetarians have written of the lack of research and the need to seriously evaluate programing techniques. The contemporary evaluation and research literature dealing with school programing is sparse (Muhl, 1975). However, the literature of evaluation and research pertaining directly to public programing is even more sparse (Schafer, 1975). Because of the significance of providing high-quality astronomical and science education to the general public and the challenge of conducting meaningful educational research in public programing, this project was conceived and developed.

Purpose of the Dissertation

The two previous sections of this chapter explained the brief history of the planetarium and the need for research in the profession. This need is not just based on the young age of the planetarium profession but it is founded on the firm belief that conscious evaluation by an organization is vital to its survival and evolution. On the practical side, the need for research is also based on finding the most optimum manner of utilizing a planetarium's vast audio-visual resources to provide effective and efficient education.

The purpose of this research was to conduct an experimental study in the public domain of planetarium programing. A moderately large planetarium (Abrams Planetarium in East Lansing, Michigan) was utilized because it had sufficiently large public attendance to obtain statistically significant results. To control for the effects of the program itself on the educational learning of the patrons, the experiment was carried out during one season of a single program, The Last Question, written by Isaac Asimov.

As public audience patrons experience a modern planetarium program, they may be exposed to hundreds of various individual audio-visual techniques or variables which may inspire, entertain, and, hopefully, educate them. The purpose of this experiment was to demonstrate that a well-designed and executed research plan could be conceived to yield sound and useful information with documentation about the educational effects of a single variable. The variable utilized in this study was the type of introduction employed just before the program commenced to explain to the audience patrons the subject matter of the presentation. The four types of subject matter introductions which were selected to be compared were a written handout to be read by the patrons, a personal introduction, a slide introduction, and no introduction or a null introduction.

Most planetariums that offer public programs usually have a variety of times which attract different types of patrons. Other purposes of the study were to measure or estimate the relative learning of the audiences at different program times and also to estimate the interaction effects of the factors of introductory treatment and program time.

Hypotheses of the Dissertation

The purposes for this research as introduced in the previous paragraphs can be restated in broad statements or hypotheses. These are rephrased into specific testable research hypotheses in Chapter III and their results are described in Chapter IV, while their conclusions and implications are explained in Chapter V. The following three general hypotheses formed the foundation for the direction of this study utilizing a single public planetarium program and a written post-test to measure relative learning due to different introductory treatments and/or program times:

> Interaction Hypothesis: There is no interaction between the factors of introductory treatment and program time on the relative learning of public planetarium audiences.
>
> Program Time Hypothesis: There is no difference in the learning by audiences at varying program times.
>
> Introductory Treatment Hypothesis: There is no difference in the learning by audiences who experience subject matter introductions presented with a written handout, by a person speaking, by projected slides, or with no introduction.

Overview

The overall purpose of a planetarium is to utilize its capabilities to educate the public about astronomy and space, and, in general, science. Thousands of planetariums exist in the world and the majority of these are actively striving to meet this educational goal. To provide an example of an experimental study in public programing which most of the planetariums could utilize, this study was undertaken. The second chapter of this work contains a summary of the research in the planetarium profession in addition to the literature cited in Chapter I. A description of the research design of the entire experiment is provided in Chapter III. The statistical results of the analysis of the data from that experiment are examined and summarized in Chapter IV, while the conclusions and implications for planetariums and other educational facilities are explained in Chapter V.

CHAPTER II

REVIEW OF THE LITERATURE RELATED TO PLANETARIUM EDUCATION

Literature Review

This chapter is devoted to a survey of the literature related to planetarium education. Some of the reports and articles which were consulted described surveys while others described actual experiments. A few of the sources were devoted to the encouragement of research and study of the best methods of utilizing the planetarium as an educational facility. Because this dissertation dealt primarily with public programing by planetariums, special emphasis was given to similar types of literature, even though the majority of the literature was not directly concerned with public programing.

As was noted in Chapter I, the amount of published research with regard to systematic evaluation of public programing is miniscule. Von Del Chamberlain (1972b) noted that evaluation of public programing is a vital aspect of writing a complete public planetarium program, but he offered few suggestions or representative methods. A few of the planetariums have taken surveys of their audiences but, as noted in the previous chapter, these merely denote audience traits and their subjective opinions while the sample is usually drawn in a nonrandom fashion. However, Wieser (1976) conducted a useful survey in three phases at a major Canadian planetarium in Calgory. The survey's purpose was to evaluate services, images, and programs in three phases: random telephone calls were made throughout the area; a questionnaire was mailed to known patrons; and personal audience interviews were conducted at the planetarium. One of the most dramatic results of this survey was the initiation of a change in the public program scheduling to allow differing public programs at different times of the day and week. This is a drastic step away from the usual practice of showing one public program for an extended period of time. This change of program time, content, and type was precipitated by analysis of the survey data which included the visitor's frequency of attendance, age, residency, sex, program topic popularity, patron occupation, advertising effectiveness, and patron motivation for attendance. He found that more flexibility in the public programing schedule would allow for better matching of program topics and audience interests. Wieser believed the survey contributed to providing better programing for the public, although he did not attempt any measurement to justify this conviction.

Moore's (1965) survey on adult traits with regard to attendance traits stands as one of the earlier attempts to improve public programing. This thesis operated under the assumption that the planetarium is a popularizer of a specialized subject. He randomly selected from a list of adult education students and studied via a written questionnaire the differences of attending and nonattending adults with regard to media participation, attitudes, and vocabulary recognition. Moore found the nonattenders read more books and listened to more radio but read fewer newspapers. The attenders watched less television, attended more movies, and had a much larger space vocabulary than the nonattenders. The attitude toward space exploration was superior for the attenders but age was quite strongly linked to positive attitude in this situation. Furthermore, the space vocabulary of the attenders was positively correlated with the number of planetarium visits. Moore regarded his efforts as a pioneering effort in trying to identify the basic characteristics of the planetarium attender so as to improve public programing.

Two more general surveys done to provide insight into the functioning of major planetariums are those of Brannley (1970) and Schafer (1975). Brannley surveyed only 12 major planetariums in the United States which together served over three million people annually. It was his opinion (not really a conclusion of the research) that the sky show was their most important function.

Schafer's survey stands alone as the most comprehensive and accurate survey of major planetariums in North America. He completed a thesis entitled "A Study of the Current Practices in the Operations of Major American and Canadian Planetaria as Educational Institutions," which was based on a survey of planetariums with dome diameters of 50 feet or larger and museum-related planetariums of 40 feet or more. The return response was 28 out of 47 or 60 percent of the entire population, and his sample was found to be very representative of the total population. This survey provides many insights into school and public programing practices and philosophies of the major planetariums. As with any comprehensive study, it raised many questions and areas for further research. A chi-square approach in testing relations between pairs of variables was used to find 600 significant pairs at the .05 level of significance among the 139 variables (pp. 32-33).

Schafer found that planetariums do very little with regard to evaluation of public programing. He strongly advocated planetarium evaluation and suggested why evaluation is usually not well done. "In the planetarium this is difficult for there are no firmly established criteria for what the outcome of a planetarium presentation should be" (p. 67). His survey indicated the means and relative ranking which was most frequently used to evaluate shows as attendance figures (.90), comments by audience patrons when leaving the show (.88), critical self-appraisal (.70), formal survey of audience (.20), letters of reaction (.19), media reviews (.13), and professional evaluation by outside specialists (.01) (p. 89).

The only serious attempt by members of the professional planetarium community to write down detailed general guidelines suitable for a textbook for constructing public planetariums was a series of articles in the <u>ISPE Planetarian</u> edited by Von Del Chamberlain. Writing in the initial installment, Chamberlain (1972a) presented his suggestions as how to best conduct public programing. He suggested that, after a topic has been selected according to the goals of the institution, the interests of the writer, the nature of the community, and the relevancy of the subject matter, the topic should be researched as to the subject matter and alternate methods of presentation, format, and sequencing. He also noted the importance of seating and prelude to the quality of the public program:

> Two types of presentation are desirable. Displays, music, and other artistic effects help set the mood, preparing people mentally for the program by causing them to think about related ideas. Perhaps even more important, people must be physically prepared; one must not forget the crucial importance of dark adaption. It is appropriate to plan programs with interesting stimuli in the theatre as the audience enters and is being seated. This is done by the use of suitable music and projection effects started when the doors are opened (p. 18).

Chamberlain also noted that learning may be supplemented by subject-matter-related seating slides. "Seating slides, often projected in multiples, are normally concerned in some way with the program topic" (p. 18). However, Schafer, Chamberlain, Moore, and all other writers and researchers in the profession have not provided information or conducted experiments on the effectiveness of the use of the prelude or preparatory atmosphere to the quality of the public program. The reason is few people evaluate their public programs in a rigorous experimental format directed toward evaluation of the educational impact of their efforts.

As noted above, Chamberlain (1972b) encouraged research in the profession when he wrote, "One should not consider the job of preparing a public program complete until he has evaluated its success" (p. 50). He further suggested or argued that attendance figures may not be the most reliable method due to the interaction of other variables such as advertising, weather conditions, or competing activities with attendance statistics. As a minimal attempt to evaluate a program, he described a relative method of comparing public programs by an audience survey. He suggested a form similar to one side of an index card in which the questions could be answered with a check mark by the patrons. Chamberlain did not provide examples of questions or reports of planetariums which had attempted this technique. This suggested survey technique would probably not evaluate learning due to the program directly, but only the audience's opinion of topic selection, effects, and similar traits which may or may not relate to the educational quality of the program. In addition to this reservation, when a questionnaire is merely handed out to volunteers at the exit door after a show, the statistical advantage of a random sample is probably lost and other confounding variables are encountered.

As might be expected with a new medium or technology of education, initial attempts to evaluate it compared planetarium education with the more standard classroom techniques. Since educational testing of school programs is much easier than with public programs, the school programing research is relatively more abundant. Rosemergy (1967) found nothing when looking for treatment effects between planetarium and classroom teaching of selected astronomy topics to sixth-grade students while blocking on intelligence, reading ability, initial understanding of astronomy, or sex. Wright (1968) contrasted planetarium attenders and nonattenders and discovered the latter were superior in learning at the .01 level but found no differences when the groups were not given preparation or follow-up activities. In addition, groups prepared by the teachers and by the planetarium lecturer showed no differences on the achievement post-tests. Tuttle (1966) found no differences in learning with 400 students in the spatial concepts of two- or three-dimensional reasoning at the sixth-grade level in contrasting the planetarium and classroom while matching by intelligence, age, and reading level.

However, other researchers have criticized these negative results on several grounds such as the testing devices used to evaluate learning observational astronomy. Dean and Lauck (1972) found the best test for the learning of observational astronomy was a personal interview under the real sky. When Dean and Lauck compared a classroom and planetarium for their relative effectiveness in teaching observational astronomy, they discovered the planetarium to be superior. Not only can the testing devices be questioned in the literature studies, but the treatment effect such as a bus ride to a planetarium and the novelty of the planetarium experience itself contains many confounding variables. For example, Smith (1966) found the planetarium superior to the classroom, but he tested in the location where the treatment took place. Several other positive results for planetarium utilization were obtained by Reed (1972), Soroka (1972), and Haywood (1975).

Much of the school programing research has value when applied to public programing research. For instance, Ortell (1977) described his research which compared community college students who had an entire astronomy class in the planetarium with another similar group in a classroom. Both groups had the same instructor and subject matter, while the results indicated that in all 50 tests (t-tests) the planetarium audience was superior with regard to astronomy learning, final grades, overall grade point average, intelligence, and many others. Ortell forgot one important aspect in his research design: the random assignment of treatments to subjects. He allowed the students to choose which treatment they desired and therefore allowed many confounding variables to enter the experiment.

There have been no active experiments with public programing described in the literature. Some surveys have been described, but these were descriptive and passive while several writers have called for more active research by planetariums of all sizes. The major planetariums (which also affect the most people) do have additional staff and could do more rigorous evaluation and research on public programing, while the smaller installations could perform limited evaluation projects. As noted earlier, Chamberlain's (1972b) simple index card technique would provide a baseline for research. "The only valid evaluation of the program is the reaction of those who witness it" (p. 50). Furthermore, he suggested, "One should not consider the job of preparing a public program complete until he has evaluated its success" (p. 50).

Bishop (1975) proposed research projects such as evaluating the effect of music on concept learning or studying the variables which affect interest or motivation in a school program. Yet, similar to others, she did not use randomization in assigning the groups to treatments. She has also proposed other topics and noted the implications of research on music or special effects for the ever-increasing budgets of planetariums with statements such as the following:

> As this [constructing or purchasing new special effects] usually involves money, time, and effort, it is obvious that we operate on the assumption that such auxiliary effects will improve the program. Is it possible that we are sometimes doing unnecessary work if the conceptual understanding is not improved? (p. 6).

Bishop further emphasized and encouraged more research in the planetarium in light of current educational psychology theories such as those of Piaget, and she reminded the planetarians that if students are on the verge of changing levels, planetariums can help the evolution of cognitive levels. "Planetarium research projects hopefully will help to establish evidence that particular activities promote transition between levels of thinking" (p. 6).

Other writers have recently directly or indirectly called for research to be conducted. Ary (1975) implied evaluation when he considered the consequences of the competition as planetariums blindly produce more spectacular lighting and sound effects for public audiences to compete with space-related movies costing millions of dollars to produce. Rodger (1976) countered Ary's concern over lack of emphasis on the educational component of public programs by encouraging the planetariums to experimentally find their appropriate location between a strictly "educational facility" and a "lighting effect" or "show business" operation. Nevelle (1975) stresses the importance of diversity in the skills necessary for the contemporary planetarium director to produce high-quality programs and still retain audience support with the following statement:

> Above all, a planetarium director must be a synthesizer, capable of drawing on all these fields in order to create, in its entirety, an hour of edifying entertainment, a program of such quality and breadth, that it not only draws the afficionado back, but draws with him a vastly enlarged audience, by appealing to an ever wider and more varied taste and to the heart as well as to the mind of man (p. 6).

Muhl (1975) supports Bishop's comments in calling for research to substantiate factors which work best in making a good program:

> The criteria of stable attendance can no longer be equated with success in the creation of a program. Programs should be judged within the framework of the findings of educational researchers and psychologists who deal directly with learning environments of the students (p. 7).

He goes so far as to suggest that it might be just possible in light of the diversity of research results that funds might be better spent for an astronomical and space science materials center rather than a planetarium. Muhl's main thrust was to have planetariums seek a unique role for themselves in each function. He described recent research in "peak experiences" in which "one hour of peak experience may have much more impact on the individual than many less powerful experiences" (p. 7). He suggested these experiences occur when the audience member has dropped fears, anxieties, defenses, and inhibitions and is free to learn. However, Muhl failed to describe a manner of doing this with a school or public program.

The awareness of the need for evaluation is increasing in the profession. Bisard (1978) wrote about this need and reported on a specific experiment to empirically evaluate the effectiveness of planetarium exhibits. The major journal of the planetarium profession, the IPS Planetarian, has recently added a new section called "Focus on Education." It is anticipated that this feature section will encourage and report research efforts of the membership to investigate effects of variables on learning in addition to other educational topics (Bishop, 1978). An electronic feedback system which is portable and capable of obtaining continuous audience response profiles during a program has been designed, assembled, and tested at Strasenburgh Planetarium (Gutsch, 1979). It has been utilized in the affective domain but not the cognitive domain of learning. Several smaller Spitz planetariums have electronic response systems, but they have not generated any published experimental results.

Summary

This chapter contained a synopsis of the literature pertaining to planetarium education. Few of these publications were directly related to public programing, while the majority were involved in school planetarium programing. There were several experimental school planetarium projects and no experimental public planetarium programing attempts reported in the literature. Several authors pointed out the need for more evaluation projects and activities in all aspects of the planetarium profession.

Several significant surveys have been conducted. Wieser's decision to use more flexible scheduling of public planetarium programs to fit the estimated audience traits based upon an extensive survey and interview project is one of the more recent significant activities. Moore's survey which attempted to discover the basic differences between public planetarium attenders and nonattenders was one of the pioneering efforts in improving public programing. Finally, Schafer's comprehensive survey about the actual activities of planetariums which pointed out the small amount of evaluation which is being done in the profession was a very informative source.

In a larger sense, very few books or written guidelines exist which describe how to produce public planetarium programs. The most noteworthy attempt was by Von Del Chamberlain, who described the salient features or techniques of writing and researching the script. He also noted that evaluation processes should be included in every program and also pointed out the importance of correct eye accommodation techniques, seating slides, and introductions to the public program.

The school planetarium programing research projects described in the literature were very ambiguous in their experimental results, especially the projects which attempted to compare classroom and planetarium learning. Very few of the school planetarium research projects dealt with evaluating the effects on learning of a particular variable of the program. Several authors pointed to the need for fundamental research in planetarium education to determine the techniques and devices which optimize the educational quality of the presentation.

CHAPTER III

DESIGN OF THE RESEARCH

Introduction

It is evident from the literature that public programing is a vital aspect in attempting to meet the communication goal of most planetariums. Little research has been conducted on the variables which affect learning in a public planetarium program. Several authors in the planetarium profession have written about the need and value of programing evaluation even though very little is actually done. The purpose of this dissertation was to conduct an experimental public planetarium program study to investigate a particular programing variable.

The research design which is described in this chapter allowed for the relative measurement of learning in public planetarium audiences who experienced subject matter introductions of four different formats. The four formats were a written handout, a personal presentation, a slide summary, and a null introduction. These four types of introductions were called "treatments" and were randomly assigned to all 60 program times. All the audiences viewed the same public presentation with one of the four treatments, so treatments was one of the factors of the design.

The 60 public presentations were to be offered on different days and times, which meant that "program time" was another factor of the design. It was anticipated that audiences which attend Sunday afternoon programs differ significantly from either the 8:00 P.M. or 10:00 P.M. audiences in ways that may affect learning. Thus, program time became a factor of the design.

A random sample of each audience was selected to complete a post-test which attempted to measure the relative learning of the audiences and also gathered demographic data. The statistical analysis using these data was a two-factor Analysis of Covariance or Ancova. The main effects of the two factors of introductory format and program time in addition to their interactions were studied as well as comparisons of the different types of audiences from the demographic data.

Description of Samples and Populations

The sample for this research consisted of 1,511 subjects who were randomly selected from 8,158 patrons of the audiences utilized in the study. The method of random selection consisted of identifying seats prior to each presentation in a random fashion. These seats were marked on their right arm with a small gummed dot. In the original seat designation, a table of random numbers was used in conjunction with the seat numbers for the selection process. Abrams Planetarium contained 254 permanent seats in a unidirectional arrangement. As the audience entered the chamber, they usually filled the back of the chamber before the front of the chamber. Because of the wide range of attendance totals, the actual number and general location of the selected seats had to be modified for each presentation to insure an adequate sample size. The time to distribute and recollect the post-tests in the intermission period of the public programs necessitated approximately 30 subjects per program. The average number of subjects which were selected and tested per presentation was 28, which accounted for 18.5 percent of the total experimental population. Another method which might have been satisfactory would have been random selection of the rows of seats of patrons to be tested. Other satisfactory schemes can be imagined which are based on random selection and provide conditions conducive to adequate testing of the patrons.

The sample consisted of 18.5 percent of the total attendance for the 1978 season of The Last Question at Abrams Planetarium. The season was originally scheduled for 60 programs over 10 weekends but a severe winter storm reduced the season to 9 weekends and 54 programs. These 54 programs were equally divided among the 8:00 P.M., 10:00 P.M., and Sunday afternoon presentation times. As summarized in Tables 19, 20, and 21 of Chapter IV, the audiences of the three program times were most different in age and highest educational level. The Sunday audiences had a much higher proportion of children and much lower proportion of MSU students than the 10:00 P.M. audiences. The 8:00 P.M. audiences were intermediate in their composition traits to the Sunday and 10:00 P.M. audiences. The composition categories of adults, MSU students, and children were specified by the planetarium's ticket sales practices. Children were defined as people from 5 to 12 years of age, while persons who were older than 12 years of age and not MSU students were admitted as adults. MSU students were admitted at a reduced rate if they presented a valid identification card. Of the total sample, 12 percent were in elementary school, 23 percent were enrolled in a high school or their highest academic level was high school, and 65 percent were enrolled in or attended a post-secondary institution. Similar attendance trends and compositions are evident from comparisons with previous presentations of the same public program, The Last Question.

To facilitate comparisons with other situations, the sample populations were described in the preceding paragraphs. The following description of the public program and the planetarium facilities used in the study should also assist future studies. The Last Question is a popular planetarium production of a science fiction story about the future of the universe, and this edition was narrated by Leonard Nimoy. The original story was written by Isaac Asimov, while the planetarium edition used in this research project was produced by the Gates Planetarium in Denver, Colorado, with additional audiovisual effects provided by Abrams Planetarium. The program was entirely taped and thus all of the public presentations for this study were essentially identical.

Abrams Planetarium is located at Michigan State University in East Lansing, Michigan. Its projector is a Spitz STP and the dome diameter is 15.2 meters with a unidirectional seating capacity of 254 patrons. The total annual budget in 1977-78 was approximately $200,000 with about one-third of that support being provided by various program admissions and the remaining amount coming from state and local sources. The staff consisted of a director, two staff astronomers, two production technicians, one display technician, one planetarium specialist, and a secretary. In addition to the regular staff, two graduate students, two student technicians, one student artist, three student lecturers, and three student cashiers-bookkeepers usually constitute the temporary staff.

Abrams Planetarium usually offers eight different public programs during a year. These public programs are presented six times per weekend, while hundreds of school programs and special group lectures are given annually. The planetarium's staff teaches several introductory astronomy classes during the academic year and also publishes sky bulletins and regular astronomical news items in science magazines. The total attendance in 1977-78 included 33,000 for its public programs, 24,000 for the school programs, 8,200 for sky lectures, 11,000 for music album concerts, and 4,200 for general science university classes. The population of the metropolitan area is about 300,000 people and the school service area is approximately 50 miles in radius.

Although this research was conducted in one planetarium for a particular science fiction program during one of its seasons, the experimental results and generalizations can be applied to other situations. The results and conclusions can be extended to other types of planetarium programs since the factors which were tested in the study are common to all planetarium programs. The extension to other types of planetarium programing such as for school groups is based on the fact that introductions are also an important part of school planetarium programing. This experiment was conducted in a moderately large planetarium because it had sufficient attendance to make such an experiment valid. Abrams Planetarium is located on a large university campus (Michigan State University) and has a higher than average student attendance. However, the range in characteristics among all planetariums is very large and they share a common educational goal. All planetariums can benefit by acknowledging the results of this experiment in their basic programing techniques.

Measures

Four introductory treatments were randomly assigned to the public presentations and after each presentation, a random sample of the audience members completed a post-test. The unit of analysis was the session or the individual program presentation which received the specific treatment. The basic datum for the analysis was the average of these post-test achievement scores for each presentation. This datum or average score was the dependent variable or the measure used to estimate the relative learning from the four different introductory treatments. The purpose of this section is to describe the procedures and instruments used for measuring that relative learning. This will include descriptions of the assignment procedure for the introductory treatments, the selection of the subjects, the post-test introduction, the introductory treatments, and the post-test instrument.

Assignment of Introductory Treatments

The experimental theme of this research centered around an estimation of the relative learning which took place with different introductory techniques at all the program times for an entire season of one public planetarium program. The public programs given by Abrams Planetarium are usually scheduled at 8:00 P.M. and 10:00 P.M. on Friday and Saturday evenings with 2:00 P.M. and 4:00 P.M. presentations on Sundays for a total of six programs per weekend. The initial schedule of programing called for a 10-week season of 60 presentations of the science fiction program of The Last Question by Isaac Asimov. Because of the attendance patterns and records with public programs at Abrams Planetarium, the 8:00 P.M. audiences were considered as one group, the 10:00 P.M. audiences were considered as a second group, and the Sunday afternoon audiences were combined as the third group for the study. The four introductory treatments were randomly assigned to a listing of the 60 programs with the stipulation of producing a 4 (treatments) by 3 (program times) factorial design with five programs in each of the 12 cells of the design. A major snowstorm caused the university and the planetarium to essentially close for one weekend and this created uneven cell sizes, as displayed in Table 1 of Chapter IV.

Selection of Subjects

The selection of the subjects to take the post-test at the conclusion of each public program was also a randomized process. The initial plans called for randomly selecting 30 seats from all 254 seats in the chamber. This number of subjects was selected on the basis of being a large enough statistical sample and as a reasonable number of post-tests to be distributed and then collected from the subjects in various parts of the chamber. The total time which was allocated for the post-test was restricted to the normal 10-minute intermission between the main public program and the secondary program, which consisted of either a "sky lecture" or a "light show." A "sky lecture" is a live description of the celestial objects to be found in the skies and is usually presented after the 8:00 P.M. and Sunday afternoon programs. The "light show" is a combination of visual effects with popular music, which is usually presented after the 10:00 P.M. programs. Thus, the post-test was explained and administered during the intermission period.

The above initial plan was modified because all the seat locations of a planetarium chamber are not of equal educational value and few of the programs had full attendance. The possibility of having a patron sit in each of the selected 30 seats at every presentation was very low. Therefore, the rows and their seats of the chamber which offered approximately the same quality of view were selected. Of these seats, 35 were randomly identified and marked with a small, inconspicuous, gummed dot on the right arm of the seat. This technique provided an average random sample size of 28 subjects per presentation with a standard deviation of 5.5 and a range of subjects from 13 to 35. Table 13 in Chapter IV includes these data for each program and indicates the total sample was 1,511 patrons or 18.5 percent of the total attendance.

Post-Test Introduction

The post-test was administered to the randomly selected patrons during the 10-minute intermission immediately following the public program. The Last Question ends with a very dramatic creation of the universe by the main character of the program, "The Universal AC." Immediately following the conclusion of every presentation, the audience members were thanked for attending the program and were asked to help in the improvement of public planetarium programing by participating in a post-test. The post-test was presented to the audience as an extension to the program material and as a way of obtaining feedback from the audience patrons. The introduction and administration of the post-test were standardized to alleviate any confounding variables related to administrator-subject interaction. The verbal summary of the post-test introduction which was always given by the same person is contained in Appendix A. The post-test, optical scan answer sheet, and pencil were all previously attached to a clipboard. At the end of the introduction, the clipboards were distributed to the selected subjects and after their completion, they were collected by the planetarium staff.

Introductory Treatments

The research design of the study provides a model for planetarium evaluation. It allows for measurement of the relative learning effects on the audience due to a specific variable. Many variables affect the amount of learning by public audiences from a planetarium experience. These have been noted by several people in the literature, but none of them have been experimentally tested. The introduction to a planetarium program was selected to be that specific variable to be tested in this study because it is a common part of most programing techniques. There exists no written consensus of the best introductory technique as evidenced by the wide range of introductory styles. Four typical introductory formats were selected and written to explain the subject matter of The Last Question. This subject matter dealt with energy, entropy, and the evolution of the entire universe on a very large time scale and its theme was therefore quite abstract. The selected formats were a written program or handout, a personal introduction, a slide introduction, and no introduction or a null introduction.

The written handout was a one-page description of the public program which was distributed as the audience entered the planetarium chamber. The patrons were asked to read the handout and it was collected by the staff just as the planetarium lights were dimmed. Its text is contained in Appendix B.

The personal introductory format consisted of a short speech by a person in the front of the chamber in the sight of all audience members. The person welcomed the audience to the planetarium and stated that he would like to explain the theme of the planetarium program. The introducer then proceeded to explain the subject matter of the program with the same description as the written handout introduction which is contained in Appendix B. The same person did all the personal introductions in the study to reduce the possibility of additional variables in the design.

The slide introduction was done with two carousel projectors on the planetarium's dome as the cove lights were being dimmed and after the audience had been seated. The written and visual material of the slides was altered between the two projectors and the sequence depicted essentially the same message as the written handout and the personal introduction. The script of the slide introduction is contained in Appendix C.

The written handout, personal introduction, and slide introductions are all examples of active introductions that are used in some form or combination by many planetariums. Many public programs do not use an active introductory format of any substance and thus one treatment in this study consisted of no introductory technique and was a control treatment in this experiment. This was called the null introductory treatment.

All the presentations of The Last Question did have some common introductory features such as the regular advertising in the local newspapers and on radio stations by the planetarium. In addition, the entrance to the planetarium chamber had a large painting of Isaac Asimov and the taped planetarium program included a few preliminary remarks by Asimov. His remarks told of how The Last Question was the first planetarium production of a popular science fiction story. Asimov briefly described, defined, and defended the literature of science fiction. None of these preliminaries discussed the subject matter of the planetarium program.

The Instrument

The design of the research had one dependent variable to estimate the relative learning of audiences who experienced different introductory treatments to the same public planetarium presentation.

A random sample of patrons from each audience took a post-test immediately after the presentation. The average score of these individual subjects on the post-test constituted an achievement score for that audience and this score was the dependent variable of the research or the datum for the analysis. The unit of analysis was the individual session or audience that received the specific treatment. The post-test instrument is contained in Appendix D.

The post-test contained 9 multiple-choice demographic questions and 10 true or false subject matter questions. An optical scan answer sheet for computer scoring and a scoring pencil were also distributed to each selected patron. The length of the post-test was constrained to approximately 10 minutes because it took place during the intermission between the main public program and the secondary sky or light show as explained previously.

The demographic questions were placed first on the post-test to possibly reduce any testing anxiety by the subjects. The purpose of collecting the demographic data was to provide covariates for the statistical analysis of the design and a way of comparing audiences at different program times. These demographic variables were selected on the basis of other surveys in the literature and their potential relevance in contrasting groups of people who attend public planetarium programs. Most of these were objective questions except for the self-analysis of the patron's mathematics and science aptitude. These data will also provide a baseline for future research and comparisons at the planetarium. The selected demographic data to be surveyed were:

1. Age
2. Highest level of formal education
3. Sex
4. Self-analysis of mathematics and science aptitude
5. Number of planetarium programs attended in the last year
6. Number of times person has been to this program this season
7. Type of public program preferred
8. Source of information about this program
9. Number of science fiction books read in the last year

As noted in the previous two chapters of this research, public planetarium programs have some mixture of inspirational, educational, and entertaining themes which are woven together by the writer and producer. The first step in estimating the learning from a public program is to consult its educational goals and objectives. The goals and objectives of The Last Question dealt mainly with knowledge of entropy, energy, stellar evolution, the universe, and science fiction. The subject matter questions were constructed after the analysis of the program's educational goals and objectives. The questions pertained to specific objectives of the program and were formulated in a concise true or false format for the ease of the patron in completing the post-test in the allotted time. The questions tested the patron's knowledge of the basic definitions and measures of entropy, the law of entropy, energy, stellar evolution, and the literature of science fiction. The instrument was not pilot-tested in the traditional manner because the main thrust of the study was the relative impacts of certain intact treatments and these could not effectively be applied. Test statistics such as percentage correct, discrimination, and level of difficulty for each question are contained in Appendix E. The average index of discrimination was .56

and the mean level of difficulty was .66. The reliability coefficient of the entire test was .4. The post-test actually estimated the level of knowledge of a particular audience about the subject matter of the program. However, the instrument measured the relative amount of learning of different groups of people in the design because of the random assignment of treatments to the groups and the random selection of subjects within each group. The true-false subject matter questions used were the following:

1. The ENTROPY of the air in a balloon measures its randomness.
2. The ENTROPY of the air in a balloon measures its mass.
3. During the combustion of a fuel in an engine the AVAILABLE ENERGY decreases and the ENTROPY usually decreases.
4. If a system has a certain amount of ENTROPY in 1978, it will probably have more in 2078.
5. A law of nature about ENTROPY is: "Over a period of time, the ENTROPY of a system will increase."
6. Our Sun is a star which will never run out of AVAILABLE ENERGY.
7. Stars which are more massive than our Sun will have longer life-spans.
8. Although stars do die, new stars will always replace them.
9. Science fiction considers the potential effects of science and technology of human beings.
10. The Last Question refers to the possibility of increasing ENTROPY on a large scale.

Research Design

The primary purpose of this research was to compare the relative amount of learning between audiences who experienced different subject matter introductions to the same public planetarium program. No similar experimental studies of this nature have been reported in the planetarium literature pertaining to public programing. The sample was drawn from public planetarium audiences and the instrument used to measure or estimate the relative learning was a post-test given to randomly selected subjects immediately after the planetarium presentation.

The principal factor of this design was the introductory treatment to a public planetarium program. As described earlier in this chapter, four different introductory formats were chosen and thus the treatment factor had four levels and was a fixed independent variable rather than a random independent variable. An introductory treatment was randomly assigned to each of the presentations of the planetarium program, The Last Question, to test for the relative learning of different introductory formats. The analysis units were chosen to be the 54 individual presentations rather than the 1,511 individuals who actually took the post-test because the 54 individual presentations were independent and the criterion of independence is basic to analysis of variance. The only negative aspect of this is that the reliability of each datum is smaller but this is a relatively minor point compared to the value of having independent groups.

As previously noted, the public programs at Abrams Planetarium were presented at 8:00 P.M. and 10:00 P.M. on Friday and Saturday evenings with 2:00 P.M. and 4:00 P.M. programs on Sundays. On the basis of past experience and ticket sales, it was realized that the composition of the audiences at these various times were quite different. These demographic differences could conceal any comparative learning effects of the four different introductions. Therefore, another factor had to be taken into account for the variation of audiences at different program times. This factor was called the "program times" and was a fixed independent variable composed of three distinct levels. The three levels of the program time were 8:00 P.M., 10:00 P.M., and Sunday program times.

The research design needed two factors to estimate the learning effects or educational impacts of different introductory treatments on public planetarium audiences at various times. A factorial design such as this study allows research into the effects of two variables on the dependent variable as individual and joint variables (or their interactive effects). These two factors in the study were the introductory treatment with four levels and the program times with three levels. The season for the public presentation of The Last Question was to last for 10 weeks or 60 programs. The introductory treatment was randomly assigned to these 60 programs with the restraint that they be equally divided among the levels of the time factor. This resulted in a balanced design with 12 cells each containing 5 programs. There were 20 presentations scheduled at each of the 3 program times and 15 presentations were planned for each of the 4 introductory treatments. However, as previously noted, a major snowstorm caused the university and the planetarium to essentially close for one weekend and this created uneven cell sizes, as displayed in Table 1 of Chapter IV.

The statistical analysis utilized in this research design was an Analysis of Covariance or Ancova with two factors. Both of the two factors or variables of classification were fixed independent variables. The basic principle of an Ancova is that other measures, which are called the covariates, are sampled with the hope that the regression of the dependent variable on these covariates will be considerable. A regression was performed on the covariates of the demographic data to predict the achievement scores and then an Analysis of Variance or Anova was performed on the difference of the actual achievement and predicted achievement scores. Hence, Ancova essentially consists of measuring specific covariates which may yield more predictive power for the dependent variable or achievement score in this design by using regression techniques. When two or more covariates are utilized as in this research, multiple-regression techniques must be employed. If the regression techniques with the covariates on the achievement scores is significant, a more powerful significance test will be obtained or more precision will have been gained in the analysis.

Research Hypotheses

As noted above, a factorial design allows the study of both the separate and joint effects of two variables or factors on the dependent variable. The separate effect is called the main effect and refers in this experiment to the impacts of introductory treatments or program times on the achievement score or audience learning. The joint effect was the interaction effect of both factors on the learning by the audience. Its research hypothesis was:

> Interaction Hypothesis: There is no significant interaction of introductory treatment and program time for learning by the audience as measured by a post-test during a public planetarium program.

The research hypotheses of the main effects of both factors were:

> Program Time Hypothesis: There is no significant difference in learning as measured by a post-test between the 8:00 P.M., 10:00 P.M., or Sunday afternoon audiences for a public planetarium program.
>
> Introductory Treatment Hypothesis: There is no significant difference in learning as measured by a post-test of a written program introduction, personal introduction, slide introduction, or null introduction in a public planetarium program.

In addition to the research hypotheses of the interaction and main effects in this experimental design, two orthogonal contrasts for the program time factor and three orthogonal contrasts for the introductory treatment factor were allowed in the analysis. Orthogonal contrasts are a restricted set of hypotheses formulated as contrasts which will give nonredundant information and have sums of squares that will total to the sums of squares between the groups. The sum of the products of the coefficients of the orthogonal contrasts will equal zero. These contrasts are needed because rejection of the above main hypothesis of either factor implies that at least two of the three or four means of the levels of the program time or treatment factors may be significantly different. Mere rejection of these hypotheses would not tell which means differed significantly, while the multiple-comparisons procedures are required to determine which of the sample means show large enough differences to permit the conclusion that the underlying populations are significantly different. With regard to the program time factor, the mean achievement scores of the Sunday audiences were contrasted with those of the 8:00 P.M. and 10:00 P.M. audiences, while the mean achievement scores of the 8:00 P.M. and 10:00 P.M. audiences were contrasted against each other. For the treatment factor, the mean achievement scores of the audiences who experienced the null introduction were contrasted against those of the audiences who experienced the three active introductory treatments. In addition, the mean achievement scores of the audiences with the personal introductions were contrasted with those of the audiences who underwent the written and slide introductory treatments, while the mean achievement scores of the audiences who had the written introduction were contrasted with those of the audiences who had the slide introductory treatment.

Research Analysis

The model used to test the above research hypotheses and upon which the analysis of this study was based assumes that each mean achievement score of a sample from each audience was made up of five parts. These parts or effects are the grand mean of all the mean achievement scores, an effect due to the introductory treatment, an effect due to the program time, an effect due to the interaction of the program time with the introductory treatment, and an error term which would be the difference of the actual mean achievement score and the sum of the four other parts or effects. If the above null hypotheses were true, then the sums of the two main effects and the interaction effects would each vanish. This model assumes that the mean achievement scores were randomly drawn from normal populations with equal variances and the different samples are independent. These criteria have been satisfied as much as possible by the random assignment of introductory treatments to the sessions and by the random selection of the subjects from the audience of each session.

The research design used in this study is a highly recommended and acceptable style or a "true experimental design" (Campbell & Stanley, 1966). Campbell and Stanley would have described this design as one without a pre-test and with a control group which would have been the null introductory treatment. Campbell and Stanley defended this type of design as one of the best experimental designs in that it controls for the majority of the sources of internal and external invalidity because of the use of randomization:

> While the pretest is a concept deeply embedded in the thinking of research workers in education and psychology, it is not actually essential to true experimental designs. For psychological reasons it is difficult to give up "knowing for sure" that the experimental and control groups were "equal" before the differential experimental treatment. Nonetheless, the most adequate all-purpose assurance of lack of initial biases between groups is randomization. Within the limits of confidence stated by the tests of significance, randomization can suffice without the pretest (p. 25).

The design utilized a single written post-test to provide a measure of relative audience learning for several reasons. If a more absolute measure of learning were desired, it could be argued that the post-test scores should have been compared with appropriate pre-test results, but the resulting sensitization of the audience would have almost certainly had some effect on the learning by the patrons. Pre-tests could have been given to some audiences within each of the cells of the design and a post-test administered to different audiences of the same cell. However, this design would have demanded a significantly larger sample size than 60 planned presentations. With regard to the treatment factor, a relative rather than an absolute measure of its educational effectiveness would be more useful to planetarium educators. Caution should be displayed when utilizing the results of this design with the second factor of program times. The instrument may have measured the audience's relative knowledge level rather than the relative amount of learning from the experience. Certainly, the ideal design would pre-test and post-test with appropriate written or nonwritten instruments for each subject's reading level and/or comprehension ability without sensitization effects. The specific design of this research permitted the main purpose of the study to be achieved, which was to efficiently and effectively conduct an experimental study within one season of a public planetarium program.

Summary

The design of this experimental study allowed for the investigation of the relative educational impacts of a particular variable on the audience of a public planetarium program. That variable was the introductory treatment factor and it was composed of four levels of which one level was no introduction or a null treatment. The other three active introductions were a written handout, a personal introduction, and a slide introduction, all of which contained essentially the same information with regard to the subject matter of the public program.

Another factor that had to be experimentally controlled was the type of audience viewing the presentation, which was governed by the time of the public presentation. This factor had three levels, which were the 8:00 P.M., 10:00 P.M., and Sunday afternoon program times.

An introductory treatment was randomly assigned to each of the presentations of a single public planetarium program. After each presentation, a random sample of each audience was selected for a post-test examination to provide a measure of relative learning and gather demographic data. An Analysis of Covariance was performed on the mean achievement score and demographic data for each presentation. The results of this statistical analysis are described in Chapter IV, while the conclusions and implications for planetariums and other educational facilities are described in Chapter V.

CHAPTER IV

RESULTS OF THE STUDY

The experimental design of the dissertation was described in Chapter III. The specific results of the experimental study will constitute this chapter. After a brief restatement of the problem and the research design, a preliminary examination of the data will be presented. This preliminary analysis will examine the experimental data to provide an overall view of the design and the implied results. The principal statistical results will then be presented and include discussion of the techniques, variables, and estimated effects of the factors. Furthermore, demographic results will be tabulated and summarized. The general conclusions and implications of the experiment for planetariums and other educational facilities will be presented in Chapter V.

Restatement of the Problem and Research Design

It was evident from the literature that public programing is a vital part of the communication goal of planetariums and in addition, little research has been done in this field other than subjective surveys of audience traits at a particular time. The purpose of this study was to conduct an experimental research project in public planetarium programing. The principal factor to be tested was the effects of four introductory treatments on the learning of the audiences during a season of one public planetarium program. Public planetarium programs are usually offered at a variety of times during the week and so the type of audience at one program time may be significantly different than at another program time. Because this will affect the audiences' relative performances on an achievement test, the program time factor was added to the study. This second factor of program time had three levels which were 8:00 P.M., 10:00 P.M., and Sunday afternoon program times. The four introductory treatments were randomly assigned to all the public programs during one season at three program times. Demographic data were also collected on selected covariates and an Analysis of Covariance was used as the main statistical technique to test the hypotheses explained below.

One goal of this research was to investigate if there was any evidence to suggest that certain types of audiences learned statistically different amounts as measured by a post-test depending upon the type of introductory format. This was the "interaction" of introductory treatment with program time and its research hypothesis was:

> Interaction Hypothesis: There is no significant interaction of introductory treatment and program time for learning by the audience as measured by a post-test during a public planetarium program.

Another goal of this research was to investigate the learning effects of offering the same program to different types of public audiences or different program times. The three program times or audience groups were 8:00 P.M., 10:00 P.M., and Sunday afternoon programs. The 8:00 P.M. and 10:00 P.M. programs were on Friday and Saturday evenings, while the Sunday afternoon programs were at

2:00 P.M. and 4:00 P.M. Thus, there were six public presentations per weekend during the 10-week season for this particular planetarium presentation. This overall research hypothesis was stated as:

> Program Time Hypothesis: There is no significant difference in learning as measured by a post-test between the 8:00 P.M., 10:00 P.M., or Sunday afternoon audiences for a public planetarium program.

Two statistical contrasts were allowed by the statistical technique for the three program times. These compared the Sunday audiences with the 8:00 P.M. and 10:00 P.M. audiences and the 8:00 P.M. with the 10:00 P.M. audiences relative to the learning based upon their achievement scores on a post-test. The two contrasts were also formulated as research hypotheses and were stated as follows:

> Time Contrast Hypothesis 1: There is no significant difference in learning as measured by a post-test between 8:00 P.M. and 10:00 P.M. audiences as compared with the Sunday afternoon audiences in a public planetarium program.

> Time Contrast Hypothesis 2: There is no significant difference in learning as measured by a post-test between the 8:00 P.M. audiences and the 10:00 P.M. audiences in a public planetarium program.

The primary purpose of this research was to investigate the effects of four introductions to a public planetarium program on the relative educational learning of the audiences. The overall research hypothesis was:

> Introductory Treatment Hypothesis: There is no significant difference in learning as measured by a post-test of a written program introduction, personal introduction, slide introduction, or null introduction in a public planetarium program.

Three statistical contrasts were allowed by the design technique among the four introductory treatments. These three orthogonal contrasts were formulated as research hypotheses and were stated as follows:

> Treatment Contrast Hypothesis 1: There is no significant difference in learning as measured by a post-test between a written program introduction, a personal introduction, a slide introduction as compared to a null introduction in a public planetarium program.

> Treatment Contrast Hypothesis 2: There is no significant difference in learning as measured by a post-test between a written program introduction and a slide introduction as compared to a personal introduction in a public planetarium program.

> Treatment Contrast Hypothesis 3: There is no significant difference in learning as measured by a post-test between a written program introduction and a slide introduction in a public planetarium program.

A two-factor study consisting of four introductory levels and three program time levels was designed to investigate these hypotheses. Originally, 60 programs were planned which provided for 5 programs per cell, but severe weather conditions cancelled one complete weekend of the season or 6 programs. Thus the design was unbalanced, which necessitated certain precautions to be taken in the statistical analysis techniques. The number of measures per cell is shown in Table 1. The unit of analysis was the average achievement score on a post-test given to selected people in the audience for each program utilizing a specific introduction at a particular program time. The same taped public planetarium program was utilized in all 54 programs. The public program was the most recent planetarium edition of <u>The Last Question</u>, which was originally a science fiction short story by Isaac Asimov. The methods of the experimental design are found in Chapter III.

Table 1.--Number of programs per cell of the two-factor design.

Program Time	Introductory Treatments				Totals
	Written Program	Personal	Slide	Null	
8:00 P.M.	4	5	4	5	18
10:00 P.M.	4	5	5	4	18
Sunday	4	4	5	5	18
Totals	12	14	14	14	54

Preliminary Statistical Analysis

An overview of the implied results was obtained by consideration of some preliminary statistical data. The individual post-test scores of the random sample of audience members as described in Chapter III were tabulated and averaged for each audience. This average achievement score of a single program which used a particular introduction constituted one achievement score and was the dependent variable utilized to measure relative audience learning. The achievement scores in each cell, the cell mean, and the cell standard deviation are displayed in Table 2. When these data were plotted in graphs of achievement score versus program time and introductory treatment, several generalizations were suggested. (See Figures 1 and 2.)

Figure 1 is a graph which implies that the type of introduction to a public planetarium program does affect the educational outcome of the program. Specifically, the post-test achievement scores with the null introduction (T_4) turned out to be consistently

Table 2.--Resultant program scores of the two-factor design and their cell means and standard deviations.

Program Time	Introductory Treatments: Written Program T_1	Personal T_2	Slide T_3	Null T_4	Mean Time Score
	6.86	7.32	7.93	5.84	
	7.12	7.63	7.71	6.37	
8:00 P.M.	7.42	7.48	8.03	6.42	
	7.12	7.43	7.00	6.73	
		8.65		6.12	
Mean	7.13	7.70	7.67	6.30	7.18
s	.23	.54	.46	.34	
	7.50	7.23	7.52	6.21	
	7.29	7.53	8.04	6.94	
10:00 P.M.	7.21	7.52	7.15	7.03	
	6.81	8.04	7.96	6.91	
		6.62	8.00		
Mean	7.20	7.39	7.73	6.77	7.31
s	.29	.52	.39	.38	
	6.50	7.38	7.61	4.89	
	6.56	6.27	6.85	5.83	
Sunday	6.59	7.86	7.26	6.29	
	6.22	7.60	6.16	4.76	
			7.44	5.09	
Mean	6.47	7.28	7.06	5.37	6.51
s	.17	.70	.58	.66	
Mean Treatment Score	6.93	7.46	7.48	6.10	Grand Mean 7.00

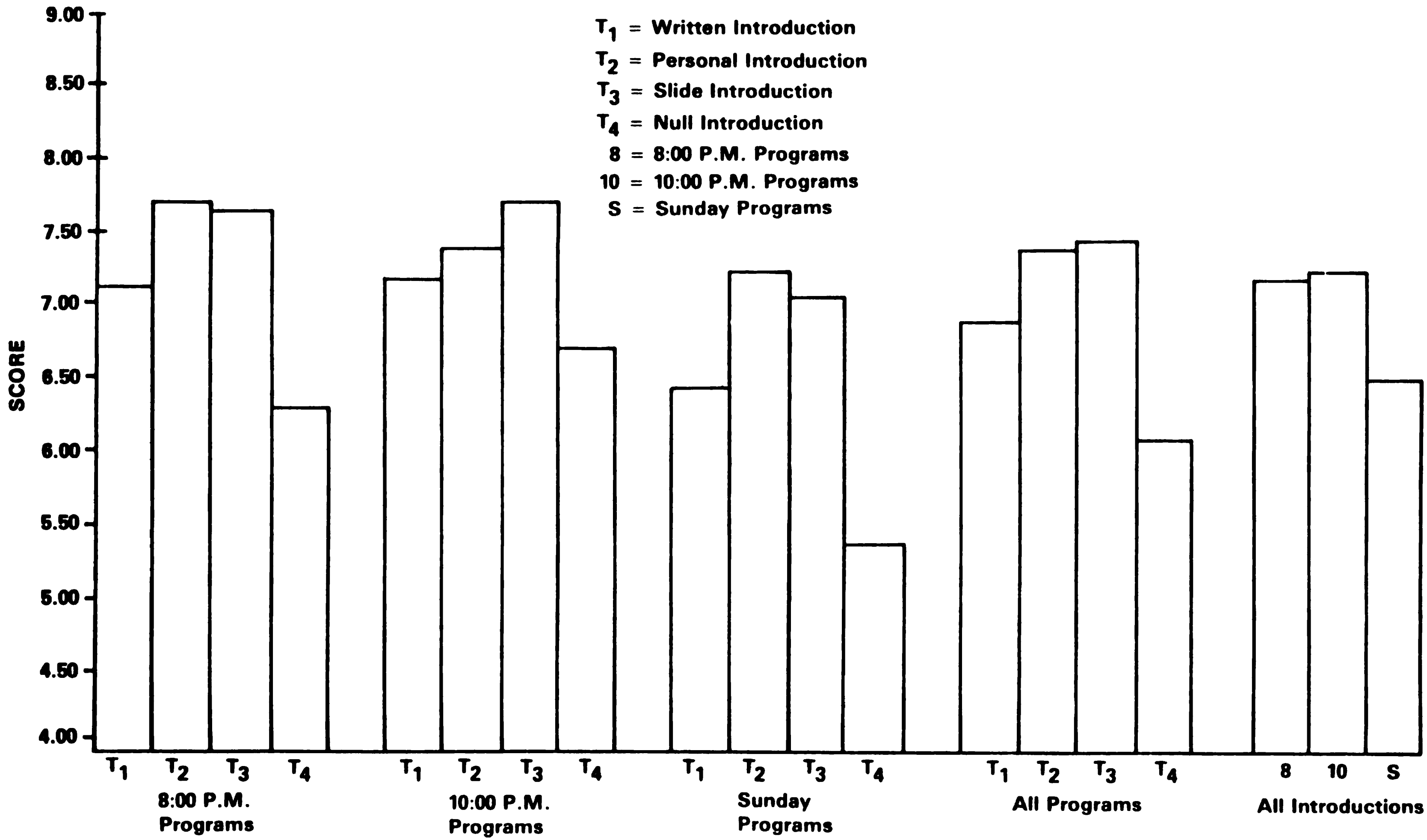


Figure 1.--Program score versus introductory treatment and program time.

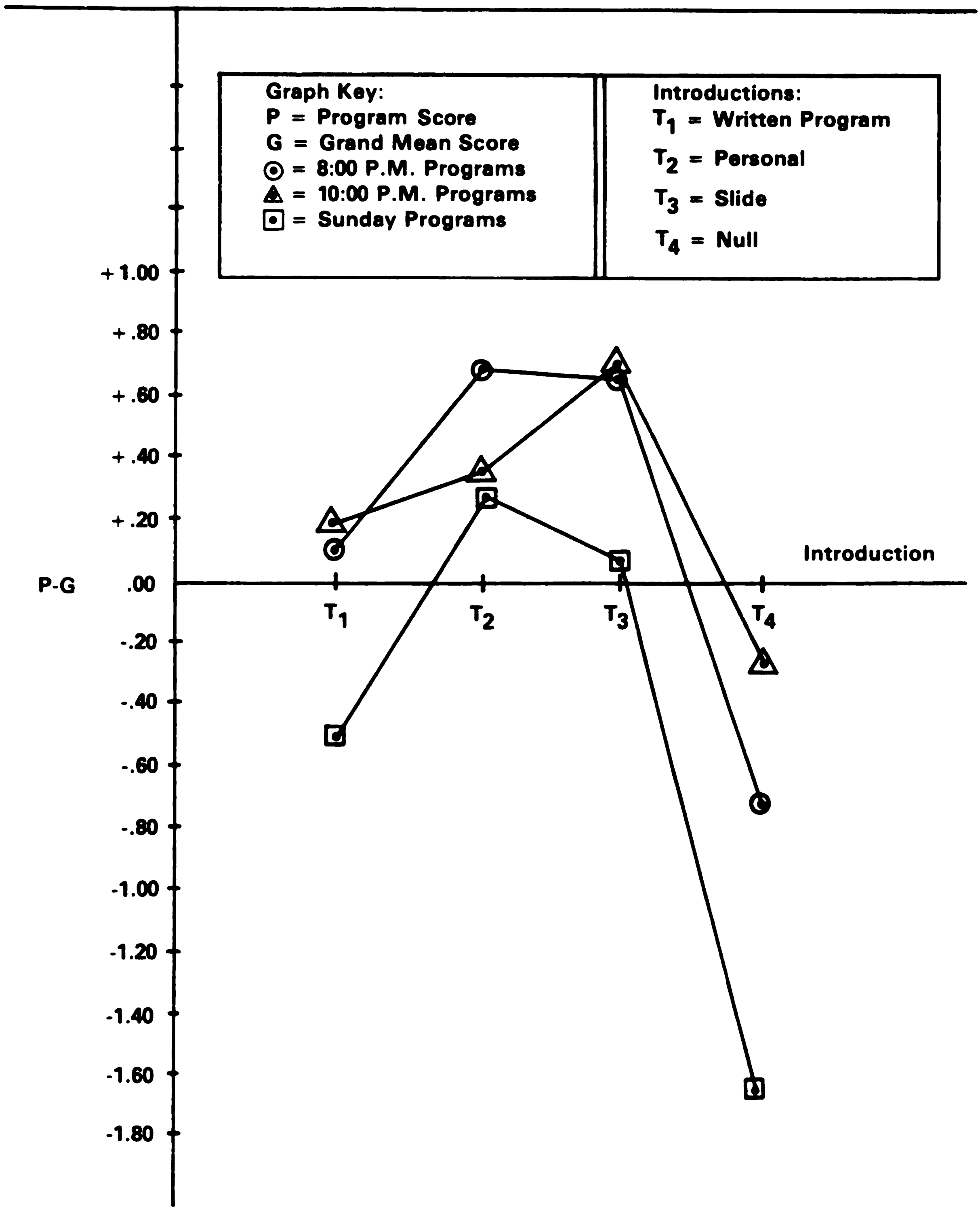


Figure 2.--Differences of program score and grand mean score for different introductory treatments and program times.

less than the other introductions tested at all program times. The scores obtained with the written program introduction (T_1) ranked third after the personal or slide introductions (T_2, T_3) at all program times. Furthermore, there was very little difference between the achievement scores of those programs with the personal and slide introductions.

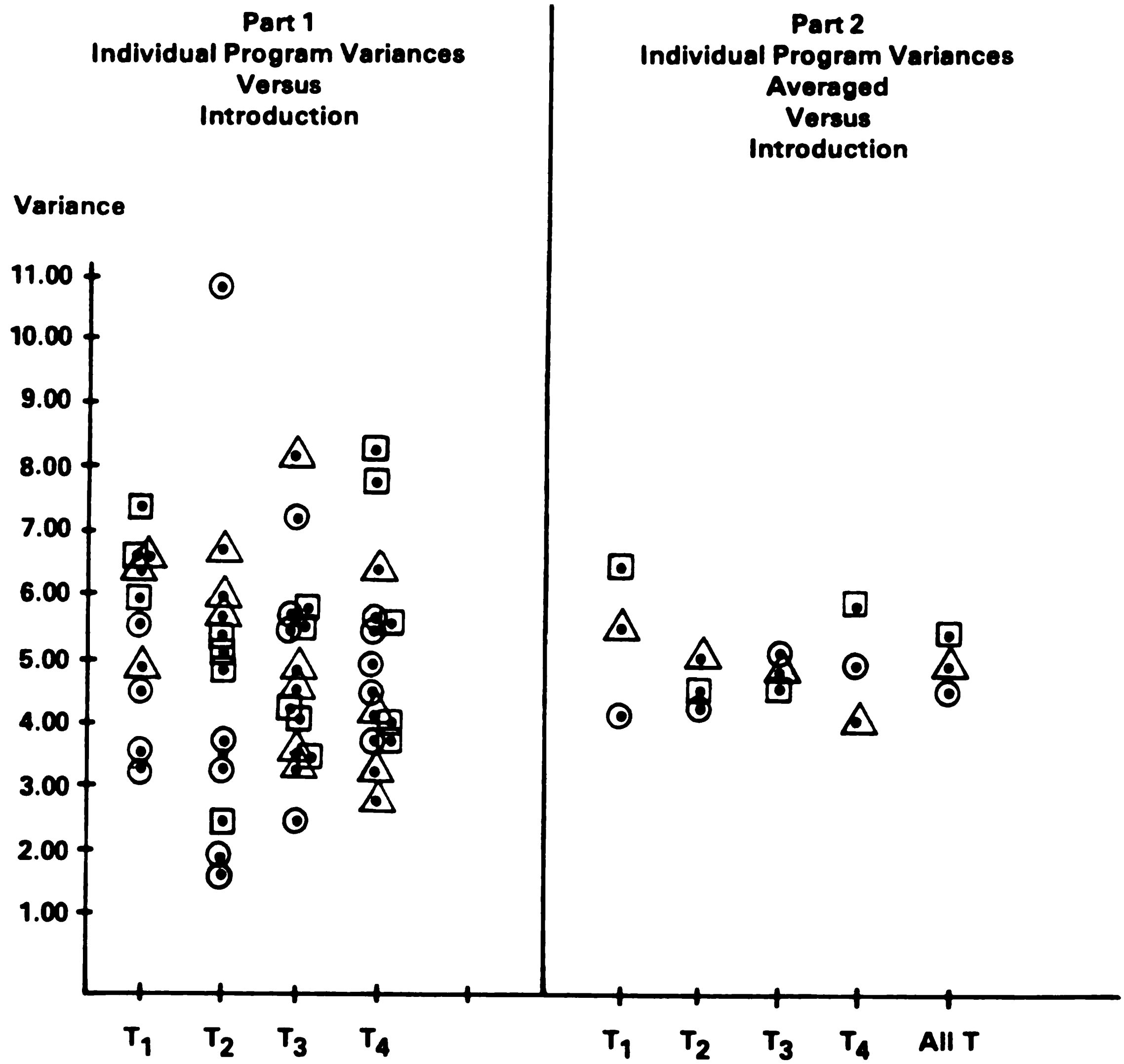
The achievement scores for Sunday programs in Figure 1 indicate that a personal introduction was far superior to no introduction. The 8:00 P.M. scores showed a similar relative ranking of the four introductions as the Sunday audiences (in the order of personal, slide, written, and null) but was higher in score for every introductory type. There was also evidence from the standard deviations and ranges of the scores in Table 1 for less variability and spread among the subjects from the 10:00 P.M. audiences for all introductory types than with the Sunday patrons. Thus, it seemed that Sunday audiences learned less well with each introductory type and exhibited higher variability and more spread in learning than other audiences. It was implied that the time of the public planetarium program affected the educational impact of the program, but more accurately, the type of audience which attended the program at a particular time probably influenced the relative learning effects.

The above achievement score contrasts and variations for different program times with each of the four introductions are further supported by Figure 2. This graph plots the difference of the average achievement score of a cell and the grand mean versus the type of introduction for each of the three program times. It is quite obvious that the null introductions produced relatively lower scores in all three groups, especially in the Sunday audiences.

The effect of introductory practices on the variability of the post-test achievement scores and hence learning is implied by Figures 1 and 2 with the null treatment and Sunday audiences showing the greatest spread. Analysis of the range of achievement scores in the 12 cells further supports this observation. Sunday audiences exhibited the largest range of scores, which was 2.97. More information on the score variability may be obtained by studying the variance of each of the 54 programs as done in Figure 3. This graph consists of two similar segments: The first part is a graph of the variance of each program score plotted against treatment; the second part is the data of the first part averaged over time and is the averaged variance of the program score of each of the cells of the design. This graph further supports the higher variability of learning for Sunday audiences and for all audiences experiencing the null introductory treatment.

Principal Statistical Analysis

When statistical inference was applied to these data, many of the above subjective assessments which were largely based on the graphical results of program achievement score averages were demonstrated to be statistically significant. Statistical inference was possible to use because the research design called for randomization of treatments to programs and random selection of subjects to be surveyed within the audiences. Without these randomizations, the basic



Graph 3 Key

Program Times:

⊙ = 8:00 P.M.
△ = 10:00 P.M.
⊡ = Sunday

Introductions:

T_1 = Written Program
T_2 = Personal
T_3 = Slide
T_4 = Null

Figure 3.--Score variance versus introductory format.

assumptions of the inferential statistical techniques would not necessarily be true and any inferences drawn might be invalid. The basis for utilizing an Analysis of Variance technique with two fixed independent variables and with a single measurement is that each value of the dependent variable (program achievement score) can be perceived as consisting of four additive parts. These are the column effects (introduction), row effects (time), their interaction effects, and a residual in addition to a common value for all 12 cells of the design. It is also assumed that the variance of each cell population is the same and the sample populations have normal distributions and equal variances. The best method of achieving these assumptions is random assignment of treatments and selection of subjects as described in Chapter III.

The preliminary statistical analysis was not sufficient since it did not specify which treatment(s) and time(s) were significantly superior with regard to the learning by the general public during a planetarium program. Therefore, the following statistical contrasts of specific treatments and program times were used to investigate the data. By collecting demographic data about the patrons completing the post-test, an Analysis of Covariance (Ancova) and a multivariate analysis could be utilized with the basic data in Table 2 to yield more informative and powerful results.

Ancova consists of measuring specific antecedent variables or covariates which may yield more predictive power of the dependent variable of achievement score through regression techniques. A regression is performed between the covariates and the dependent variable so that new or adjusted values of the dependent variable are obtained. An Analysis of Variance (Anova) is then performed on the adjusted means and variances. When two or more covariates are utilized, multiple-regression techniques must be employed. In addition, it is assumed that within each population the covariates and the dependent variable are approximately normally distributed. Ancova is an extension of Anova, which utilizes regression techniques to give more precision in the analysis.

The dependent variable in the study was the mean of the achievement scores of randomly selected audience members in a particular program. This dependent variable was a measure of the relative learning of the audiences. Two variables of the nine demographic variables collected during the post-test were not used as covariates because their numerical values were not appropriate to the regression techniques. These variables were the manner in which the patron found out about the public program and the patrons' preferred type of public program. The seven covariates utilized in the study are listed in Table 3 and described in Chapter III. To simplify the data presentation, the 12 cells of the research design were coded or assigned labels, as summarized in Table 4.

The mean covariate values and their standard deviations for each of the 12 cells of the research design are listed in Tables 5 and 6. The covariate means of the cells with respect to the three program times are summarized in Table 7 to give a comparative perspective of the audience traits.

Table 3.--Covariate descriptions, names, levels, and numerical values.

Covariate Description	Name	Levels	Values
1. Age Range	Age	1. 12 or less	1.00
		2. 13-17	2.00
		3. 18-25	3.00
		4. 26-40	4.00
		5. >40	5.00
2. Highest Level of Formal Education	Education	1. University or college level	1.00
		2. Attending university or college	2.00
		3. High school	3.00
		4. Attending high school	4.00
		5. Elementary or middle school	5.00
3. Sex	Sex	1. Female	0.00
		2. Male	1.00
4. Math and Science Aptitude	MS Level	1. High math and science	1.00
		2. High math and low science	2.00
		3. Low math and high science	3.00
		4. Low math and science	4.00
5. Number of Previous Visits to a Public Planetarium Program in the Last 12 Months	Visits	1. 0	1.00
		2. 1	2.00
		3. 2	3.00
		4. 3	4.00
		5. ≥4	5.00
6. Number of Previous Visits to This Public Planetarium Program in the Last 12 Months	Program	1. 0	1.00
		2. 1	2.00
		3. 2	3.00
		4. 3	4.00
		5. ≥4	5.00
7. The Number of Science Fiction Books Read During the Last 12 Months	Books	1. 0	1.00
		2. 1	2.00
		3. 2	3.00
		4. 3	4.00
		5. ≥4	5.00

Table 4.--The identification code of the twelve cells of this design.

Program Time	Introductory Treatment			
	Written Program	Personal	Slide	Null
8:00 P.M.	1	4	7	10
10:00 P.M.	2	5	8	11
Sunday	3	6	9	12

Table 5.--Means of the covariates and program scores within each cell.

Score	Cell	Age	Education	Sex	MS Level	Visits	Program	Books
7.13	1	3.11	2.15	.61	2.19	1.82	1.09	2.35
7.20	2	3.09	2.20	.51	2.21	2.24	1.22	2.34
6.47	3	2.96	2.92	.63	2.18	1.92	1.20	2.07
7.70	4	3.09	2.26	.54	2.15	2.03	1.21	2.39
7.39	5	3.05	2.03	.65	2.16	2.30	1.30	2.43
7.28	6	2.79	2.58	.51	1.98	1.82	1.07	2.09
7.67	7	3.15	2.16	.57	2.14	1.70	1.16	2.16
7.73	8	3.04	1.96	.63	1.82	2.20	1.15	2.43
7.06	9	2.84	2.90	.59	1.89	1.94	1.16	2.44
6.30	10	3.00	2.53	.51	1.98	1.92	1.16	2.27
6.77	11	3.03	2.07	.58	2.14	2.16	1.18	2.50
5.37	12	3.12	2.55	.57	1.80	1.94	1.08	1.67

Table 6.--Standard deviations of the covariates within each cell.

Cell	Age	Education	Sex	MS Level	Visits	Program	Books
1	.20	.31	.11	.11	.12	.06	.15
2	.10	.14	.11	.13	.15	.16	.24
3	.21	.48	.07	.09	.19	.11	.38
4	.34	.48	.15	.27	.16	.06	.50
5	.12	.11	.07	.17	.34	.16	.20
6	.12	.57	.10	.12	.74	.28	.30
7	.08	.23	.05	.05	.20	.11	.73
8	.09	.21	.10	.31	.22	.19	.37
9	.32	.62	.09	.17	.21	.09	.34
10	.11	.20	.06	.32	.15	.11	.20
11	.14	.16	.08	.16	.29	.23	.14
12	.30	.46	.06	.74	.15	.19	.60

Table 7.--Average values of the covariate means with respect to the three program times.

Times	Score	Cells	Age	Education	Sex	MS Level	Visits	Program	Books
8:00 P.M.	7.20	1,4, 7,10	3.09	2.28	.56	2.12	1.87	1.16	2.29
10:00 P.M.	7.27	2,5, 8,11	3.05	2.06	.59	2.08	2.22	1.21	2.42
Sunday	6.55	3,6, 9,12	2.93	2.74	.58	1.96	1.90	1.13	2.07

An Ancova was performed on the achievement scores and the covariates of all 54 public planetarium programs in a two-factor design. The correlations between each covariate and the dependent variable of score were quite weak and are listed in Table 8. The statistical effect of including the covariates in the analysis is summarized in Table 9. These weak correlations indicate it was not necessary to include the covariates in the analysis since their inclusion resulted in only a mere 5.6 percent more knowledge of the variance of the scores.

Since the final design did not have the same number of programs in each cell as noted in Table 1 and explained earlier in this chapter, the factors of program time and introductory treatment were confounded. This means the two factors may not have been independent of each other. The factor of prime importance in this research was the comparison of four introductory techniques. However, most public planetarium programs are offered at different times and thus have different types of audiences. To control for this practical matter, the audiences were grouped or described as either 8:00 P.M., 10:00 P.M., or Sunday afternoon audiences. Because of the relative importance of treatments over times and the final unbalanced design as noted above, the treatment factor was analyzed last in the statistical procedure. Another separate analysis was also completed with the time factor analyzed last and similar statistical results were obtained.

The technique of multivariate analysis with particular orthogonal contrasts was utilized and the results are displayed in Table 10. Orthogonal contrasts are a restricted set of hypotheses formulated as

Table 8.--The correlation matrix of the covariates and the dependent variable.

	Score	Age	Education	Sex	MS Level	Visits	Programs	Books
Score	1.00							
Age	.06	1.00						
Education	-.01	-.79	1.00					
Sex	.05	-.02	.05	1.00				
MS Level	.06	.30	-.30	-.01	1.00			
Visits	-.05	.06	.16	.26	.22	1.00		
Programs	-.13	-.02	.11	.19	-.01	.53	1.00	
Books	.11	.21	-.22	-.07	.39	.19	.10	1.00

Table 9.--Summary statistics for regression analysis with seven covariates.

Variable	Square of Multiple Regression	F Statistic	Probability Less Than	Step Down F	Probability Less Than
Score	.0558	.2957	.9511	.2957	.9511

Table 10.--Statistical results of the Ancova and multivariate analyses.

Source	SS	df	MS	F	p
Main Effects:	23.4217	5	4.6843	20.9121	.001
Time Factor:	6.5895	2	3.2948	14.7089	.001
1,2 Versus 3	6.4387	1	6.4387	28.7063	.0001
1 Versus 2	.1508	1	.1508	.6723	.4169
Treatment Factor:	16.8322	3	5.6107	25.0478	.001
1,2,3 Versus 4	14.4564	1	14.4564	64.4527	.0001
1,3 Versus 2	.3730	1	.3730	1.6628	.2043
1 Versus 3	2.0028	1	2.0028	8.9295	.0047
Interaction	1.9020	6	.3170	1.4134	.2323
Explained	25.3237	11	2.3022	10.2777	.001
Residual	9.4080	42	.224		
Total	34.7317	53	.655		

Key for Table 10:

Definitions

Source = Source of variation
SS = Sum of squares
df = Degrees of freedom
MS = Mean square
F = Observed statistic
p = Probability

Time Factor

1 = 8:00 P.M. programs
2 = 10:00 P.M. programs
3 = Sunday programs

Treatment Factor

1 = Written program introduction
2 = Personal introduction
3 = Slide introduction
4 = Null introduction

contrasts which will give nonredundant information and have sums of squares that will total to the sums of squares between the groups. The sum of the products of the coefficients of the orthogonal contrasts will equal zero. The number of contrasts allowed was one less than the number of levels in the factor. Thus there were two time contrasts and three treatment contrasts using this technique. One of the two time contrasts examined the difference between Sunday scores and all others or the combined 8:00 P.M. and 10:00 P.M. scores. A second contrast was devised to see if there was significance in the difference of the scores of the 8:00 P.M. and 10:00 P.M. audiences. The first treatment contrast as listed in Table 10 compared all three types of introductions to the null introduction. The second contrast examined the statistical difference between the personal introduction and the other two active introductions which utilized a written program or handout and a slide presentation. The last treatment contrast in Table 10 examined the statistical significance of the difference in the achievement scores of the written versus the slide introductory treatments.

Interaction of Introductory Treatment and Program Time

No statistically significant interaction of the introductory treatment and program time was found because the F statistic for interaction was 1.41 ($p < .2323$) as noted in Table 10. This result verifies the same type of conclusion of noninteraction that was suggested by Figure 2 in the preliminary statistical analysis. Thus all audiences scored lower and hence learned less with no introductions.

The Sunday audiences always learned less than the 8:00 P.M. and 10:00 P.M. audiences with all treatments and appeared to learn the most when a personal introduction was utilized. All audiences scored lowest with the written program compared to the personal and the slide introductions. The statistics reveal that, according to the average scores obtained with the post-test, 8:00 P.M. and 10:00 P.M. audiences scored relatively the same, especially on the personal and slide treatments.

Program Times

Once again, a qualification of these statistical results should be noted with regard to the nonorthogonality of the design. If the same number of programs were obtained in each of the 12 cells of the research design, then the results of the two-factor analysis would have been independent. However, because of the unequal cell size, the factors of program time and treatment cannot be considered independently and are confounded. In the present statistical analysis, the treatment variable was investigated last because it was considered to be of more importance in the study. Another separate analysis was also completed with the time factor analyzed last and similar statistical results were obtained. Because of this additional supporting analysis and the strength of the following statistical results, the negating effect of this confounding qualification can be considered minimal.

The interpretation of the results with respect to the program times must certainly consider that the audiences are quite different, as indicated by a F statistic of 14.71 ($p < .001$). According to the analysis of the achievement scores with the statistical contrasts, Sunday audiences definitely learned less than the 8:00 P.M. and 10:00 P.M. audiences because the difference is statistically significant with a F statistic of 28.71 ($p < .0001$). It was also well established by the data that the 8:00 P.M. and 10:00 P.M. audiences achieved very similar scores on the post-test and thus there was no significant difference in the educational learning between these two program time groups with all the treatments, as indicated by a F statistic of .67 ($p < .417$).

Introductory Treatments

As previously stated, three orthogonal contrasts were allowed with the introductory treatment variable since it had four levels. Since the contrasts are orthogonal, they are strictly independent or there are no correlations between them. There was a significant main effects result for introductory treatments, as indicated by a F statistic of 25.05 ($p < .001$) as noted in Table 10. The major statistical contrast of the written program, personal, and slide introductions with the null introduction yielded a significant difference with a F statistic of 64.45 ($p < .0001$). This indicated that all active treatments proved better than the null introduction. The statistical contrast of the personal introductory treatment with the written program and slide introductory treatment revealed the difference not to be significant with a F statistic of 1.66 ($p < .2043$). By examining Figure 1, this result may be expected because this contrast combined a higher average score (the slide introduction) with a lower average score (the written program introduction) to compare with an intermediate average score (the personal introduction). However, the simple contrast of a written program introduction with a slide introduction revealed the introduction with slides to be significantly superior with a F statistic of 8.93 ($p < .0047$). Once again, reference to Figure 1 may illuminate this simple contrast in light of the previous result. This contrast compared the highest average program score (the slide introduction) with the lowest average program score (the written program introduction).

A similar result to this last simple contrast would have probably occurred if the personal and written program introductions were contrasted because the average program scores of the audiences with the personal and slide introductions were nearly identical (7.46 and 7.49, respectively). A simple t-test comparison of the significance of the difference of the scores of the audiences with the personal and written program introductions revealed a test statistic of 2.69 and the critical two-tailed value is 2.07. Thus the difference of the written program and personal introductory treatments was significant at the .05 level.

Estimation of Effects

These statistical results can be elucidated by consideration of the relative impact of a particular treatment or program time upon a planetarium patron's achievement score or learning. This study attempted to provide for estimates of the effects of such factors and contrasts among the factors. The frequency distribution of the scores of all individuals who took the post-test during the study is contained in Table 11. The first column of Table 11 shows the possible scores, while the second and third columns denote the absolute frequency and relative frequency of that particular score. The final column of Table 11 is the cumulative frequency or the percentiles of the score distribution. For instance, if a particular patron had received an introductory treatment which would have resulted in more learning and hence a higher achievement score, the percentile change would have been the difference in percentiles for the score change. Figure 4 is a representation of the data in Table 11. Note that a change of unity in the achievement score could have resulted in different percentile jumps dependent upon the score. A change from a score of 8 to 9 represented a percentile change of approximately 22 percentiles, while a score change of 4 to 5 represented a percentile change of approximately 8 percentiles. The average percentile change per score unit greater than an achievement score of 3 is about 17 percentiles.

The confidence intervals of the contrast effects on the achievement score and learning which was obtained from the statistical analysis of the data are summarized in Table 12. The five allowed contrasts are listed in the left column and their corresponding 95 percent confidence interval effects are listed in the right column. The first, third, and fifth contrasts were statistically significant, as described previously in this chapter. These three contrasts have their uncertainties less than their effects. For example, the third

Table 11.--Frequencies of individual scores.

Score	Absolute Frequency	Relative Frequency (%)	Cumulative Frequency (%)
0	39	2.6	2.6
1	11	.7	3.3
2	14	.9	4.2
3	58	3.8	8.1
4	98	6.5	14.6
5	123	8.1	22.7
6	182	12.0	34.7
7	230	15.2	50.0
8	271	17.9	67.9
9	339	22.4	90.3
10	146	9.7	100.0
	1511	100.0	

Mean = 7.016	Standard deviation = 2.313
Mode = 9.000	Skewness = -.989
Median = 7.502	Range = 0-10
Kurtosis = .705	Variance = 5.352
Standard error = .060	N = 1,511 individuals

contrast of Table 12 states that the average effect (95 percent confidence level) on the patron's achievement score is 1.166 ± .295 if the patron experiences any of the active introductions (treatments 1, 2, or 3) as opposed to the null introduction (treatment 4). The fifth contrast effect in Table 12 is a negative effect (-.557 ± .373) since treatment 3 (the slide introduction) produced higher achievement scores than treatment 1 (the written program introduction) and this contrast is phrased as treatment 1 minus or versus treatment 3 in Table 12.

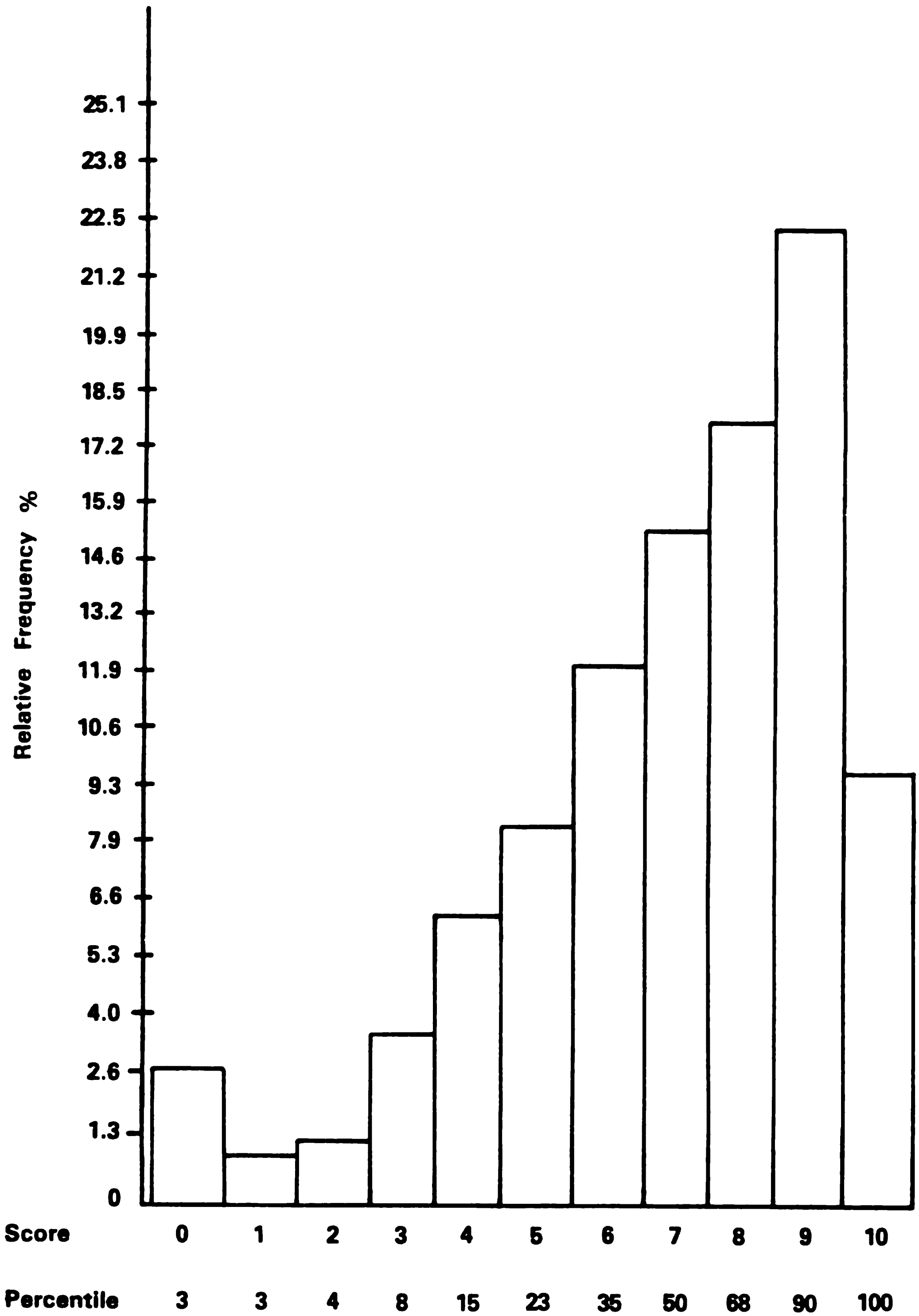


Figure 4.--Individual score histogram.

Table 12.--Confidence intervals of the contrast effects on score.

Contrasts	Confidence Interval
Times 1,2 Versus 3	.698 ± .274
Time 1 Versus 2	-.053 ± .316
Treatments 1,2,3 Versus 4	1.166 ± .295
Treatments 1,3 Versus 2	-.223 ± .315
Treatment 1 Versus 3	-.557 ± .373

Key for Table 12:

Time Factor:

1 = 8:00 P.M. programs
2 = 10:00 P.M. programs
3 = Sunday programs

Treatment Factor:

1 = Written program introduction
2 = Personal introduction
3 = Slide introduction
4 = Null introduction

To estimate the effect or potential percentile change of a treatment(s) or program time(s) on a particular patron's score and hence their relative learning, the statistical effect of the contrasts of Table 12 must be combined with the patron's achievement score as in Table 11. For example, a patron who attended a planetarium program which used the null introduction may have achieved a post-test score of 7, which would have placed that patron near the 50th percentile according to the frequency distribution of Table 11. However, if the patron had attended a program with any of the active introductions, the patron would probably have scored one point higher on the post-test according to the estimated effect from Table 12, which was 1.166 ± .295. This would have been a change of 18 percentiles as noted in Table 11. Overall, the strength of this contrast is the greatest and, as will be pointed out in Chapter V, it says that an active introduction is much better than none at all.

Demographic Data Analysis

The attendance figures for the 54 planetarium programs are summarized in Table 13. For each of the programs listed in the first column, the type of program introduction and the time of the program are identified in the second column by the same code as used in Table 12. For instance, the eighth program has a code of "12" in the second column indicating a written program introductory treatment (1) and this occurred at 10:00 P.M. (2). The third column of Table 13 is the total attendance for each program, and these numbers are further analyzed into the total number of adults, MSU students (with a valid student identification card), children (less than 12 years of age), and complimentary tickets in columns 6, 7, 8, and 9, respectively. These data are the results of ticket analysis and records of Abrams Planetarium. The definition of the adult ticket is based upon the ticket sales standard and is defined as all people older than 13 years of age and not an MSU student. Thus, a large number of high school students would be in the "adult" category. The total of the post-tests which were completed and their percentage of the total population are summarized in columns 4 and 5, respectively.

The direct results of Table 13 reveal that, of the 8,158 patrons, 1,511 patrons or 18.5 percent of the total population completed the post-test. The majority of the public planetarium patrons for this program were adults, as they accounted for 3,960 out of the

Table 13.--Population statistics for the planetarium programs of this study in the 1978 season.

Program Number	Program Treatment and Time*	Total Program Attendance	Total Completed Post-Tests	Sample Percentage (%)	Adults	MSU Students	Children	Compli-mentary
1	21	177	22	12.4	67	90	16	4
2	32	257	29	11.3	67	184	0	6
3	31	249	29	11.6	144	78	25	2
4	32	264	26	9.8	113	146	5	0
5	43	146	19	13.0	75	18	40	13
6	43	183	23	12.6	108	38	35	2
7	21	129	30	23.2	60	68	0	1
8	12	254	28	11.0	90	163	0	1
9	11	195	28	14.4	123	53	14	5
10	32	255	27	10.6	107	138	1	9
11	13	74	20	27.0	43	15	11	5
12	23	92	13	14.1	49	27	16	0
13	31	64	14	21.9	28	25	9	4
14	22	238	35	14.7	31	202	1	4
15	11	200	33	16.5	127	59	14	0
16	42	254	29	11.4	137	111	4	2
17	13	80	23	28.8	38	25	13	4
18	43	110	34	30.9	55	26	29	0
19	41	49	25	51.0	15	26	4	4
20	22	164	30	18.3	53	109	2	0
21	11	99	33	33.3	71	14	10	4
22	12	251	34	13.5	124	122	5	0
23	23	70	26	37.1	46	11	13	0
24	33	62	26	41.9	42	12	6	2
25	21	101	29	26.6	55	33	13	0
26	32	177	27	15.3	64	110	3	0
27	31	173	32	18.5	96	58	13	0
28	22	235	31	13.2	100	118	5	12
29	13	86	27	31.4	46	5	26	9
30	23	124	35	28.2	76	10	31	7

Table 13.--Continued.

Program Number	Program Treatment and Time*	Total Program Attendance	Total Completed Post-Tests	Sample Percentage (%)	Adults	MSU Students	Children	Compli-mentary
31	21	52	23	44.2	26	23	1	2
32	22	177	28	15.8	63	108	4	2
33	41	206	35	17.0	119	32	47	8
34	42	256	33	12.9	121	121	6	8
35	13	126	32	25.4	89	9	28	0
36	33	130	26	20.0	85	12	29	4
37	41	68	24	35.3	35	23	10	0
38	32	139	24	17.3	30	99	0	10
39	31	95	27	28.4	57	27	11	0
40	12	259	34	13.1	141	87	14	13
41	33	98	34	34.7	60	18	20	0
42	43	73	21	28.8	44	10	8	11
43	21	69	20	29.0	31	28	9	1
44	42	158	34	21.5	72	79	5	2
45	11	102	34	33.3	56	21	18	7
46	12	220	31	14.1	147	64	5	10
47	33	85	25	29.4	40	10	28	7
48	43	86	22	25.6	51	10	20	0
49	41	102	34	33.3	47	35	18	2
50	42	192	34	17.7	76	107	1	8
51	41	175	33	18.9	102	28	37	8
52	22	266	34	12.8	130	96	10	30
53	23	95	20	21.1	26	8	23	26
54	33	117	32	27.4	62	16	22	17
Totals		8158	1511	..	3960	3165	738	282
Averages		151	28	18.5	73	59	14	5

*Program Treatment = 1, 2, 3, or 4 and Time = 1, 2, or 3.

grand total of 8,158 or 48.5 percent. It should also be noted that if an MSU student did not have a valid identification card, the admission would occur under the higher-priced adult admission rate. This situation most likely tended to inflate the adult attendance figures at the expense of the MSU student attendance figures. The admissions to MSU students were the second largest group, with 3,165 out of the total or 38.8 percent. The admissions of children totaled 738 or 9 percent of the total attendance, while the complimentary admissions accounted for 282 patrons or 3.5 percent of the total attendance.

One of the two factors in the design was program time, which had three distinct levels. Table 14 summarizes the population data of adults, MSU students, and children for the three program times. The data of Table 14 do not include the complimentary admissions and thus the percentages of the total paid attendance (7,783) for the adults, MSU students, and children are 50 percent, 40 percent, and 9 percent, respectively. The Sunday audiences contained the largest percentage of children (23 percent) and the smallest percentage of MSU students (16 percent), while the 10:00 P.M. programs contained the smallest percentage of children (2 percent) and the largest percentage of MSU students (55 percent). An obvious result from the data of Table 14 is that the 8:00 P.M. program percentages for adults, MSU students, and children (56 percent, 32 percent, and 12 percent) are intermediate to the Sunday program percentages (61 percent, 16 percent, and 23 percent) and the 10:00 P.M. program percentages (43 percent, 55 percent, and 2 percent).

Table 14.--Summary of population data* for the three program times of the study.

Program	Adults		MSU Students		Children		Totals
8:00 P.M.	1259	56%	721	32%	269	12%	2249
	32%	16%	23%	9%	36%	3%	29%
10:00 P.M.	1666	43%	2164	55%	71	2%	3901
	42%	21%	68%	27%	10%	1%	50%
Sunday	1045	61%	280	16%	398	23%	1723
	26%	13%	9%	4%	54%	5%	22%
Totals	3970	50%	3165	40%	738	9%	7873

*These data do not include complimentary admissions.

Key for Table 14:

Total Patrons	% of Row
% of Column	% of 7873

The largest percentage of adults and MSU students (42 percent and 68 percent) attended the 10:00 P.M. program, while the smallest percentages for these two groups occurred during Sunday programs (26 percent and 9 percent). The reverse was found for children, in that their largest percentage (54 percent) was on Sunday and their smallest percentage (10 percent) was for the 10:00 P.M. programs. These percentage figures are supplemented by consideration of the relative sizes of the populations at the three program times. Nearly 50 percent of the patrons attended the 10:00 P.M. programs, with 29 percent at the 8:00 P.M. programs and about 22 percent at the Sunday afternoon presentations. Thus the three program times had distinct differences as to attendance patterns and demographic composition.

Comparisons With Previous Seasons

Similar attendance trends are evident from comparisons with previous presentations of the same public program, The Last Question, when the data of Table 13 are summarized into weekly totals by adult, student, child, and total admissions for the 8:00 P.M., 10:00 P.M., and Sunday programs. This is done for the 1972, 1975, and 1978 seasons for the same public program in Tables 15, 16, and 17, respectively. These tables do not tabulate the complimentary admissions, although the weekly totals contain them. This analysis was chosen because of the design's emphasis on program times at 8:00 P.M., 10:00 P.M., and Sunday afternoons as being distinct levels of the program time factor.

Trends are apparent in the data of these tables, especially when such data are plotted on a histogram format as in Figure 5 for the 1978 season. The number of MSU students dropped as the season proceeded, while the number of adults was nearly constant during the same period. This was especially evident in the 10:00 P.M. data of Figure 5. Furthermore, a "turnover" point was noted in the 1978 data of Figure 5 for the 10:00 P.M. programs, at which the adult sum became comparable and eventually surpassed the MSU student sum. These data are listed in Table 18 and plotted in Figure 6.

The seasons of 1975 and 1978 for the program, The Last Question, were very similar as to the calendar dates of the programs and, therefore, provide an opportunity to evaluate the generalizability of any

Table 15.--Population statistics for the planetarium programs by program time and by week for 1972.

Week	8:00 P.M. Programs				10:00 P.M. Programs				Sunday Programs				Weekly	
	Adult	Student	Child	Total*	Adult	Student	Child	Total*	Adult	Student	Child	Total*	Sum	Mean
1	146	280	25	463	120	289	0	418	112	55	55	244	1125	188
2	198	305	25	550	155	380	4	550	131	79	60	293	1393	232
3	177	330	37	548	157	403	11	572	138	77	79	299	1419	237
4	192	204	43	456	147	194	22	383	81	37	30	157	996	166
5	165	199	23	403	125	255	6	383	56	33	41	138	924	154
6	129	182	18	341	137	241	3	385	32	33	8	75	801	134
7	139	153	23	333	135	204	3	352	84	42	65	201	886	148
8	133	48	7	204	140	69	5	232	98	15	52	167	603	101
Totals	1279	1701	201	3298	1116	2035	54	3275	732	371	390	1574	8147	
Program Average	80	107	13	206	70	127	3	205	46	23	24	98	170	

*The complimentary admissions are not listed but they are included in the totals.

Table 16.--Population statistics for the planetarium programs by program time and by week for 1975.

Week	8:00 P.M. Programs				10:00 P.M. Programs				Afternoon Programs				Weekly	
	Adult	Student	Child	Total*	Adult	Student	Child	Total*	Adult	Student	Child	Total*	Sum	Mean
1	319	130	54	522	268	163	3	438	155	67	61	291	1251	209
2	232	299	22	564	244	318	6	575	180	193	14	389	1508	251
3	251	260	36	553	267	273	0	566	120	60	46	228	1347	225
4	252	189	44	499	232	305	0	545	259	81	52	396	1440	240
5	212	179	36	367	318	193	6	458	169	53	58	278	1103	184
6	175	120	27	340	202	272	4	483	136	55	60	252	1075	179
7	91	100	12	219	167	193	8	374	89	46	32	169	762	127
8	227	116	41	405	207	217	7	439	184	36	58	286	1130	188
9	204	124	42	417	187	206	10	417	154	33	65	262	1096	183
10	197	137	34	343	202	185	8	401	134	26	26	191	935	156
Totals	2160	1654	348	4429	2294	2325	52	4696	1580	650	472	2742	11647	
Program Average	108	83	17	211	115	116	3	235	79	33	24	137	194	

*The complimentary admissions are not listed but they are included in the totals.

Table 17.--Population statistics for the planetarium programs by program time and by week for 1978.

Week	8:00 P.M. Programs				10:00 P.M. Programs				Sunday Programs				Weekly	
	Adult	Student	Child	Total*	Adult	Student	Child	Total*	Adult	Student	Child	Total*	Sum	Mean
1	211	168	41	426	180	330	5	521	183	56	75	329	1276	213
2	183	121	14	324	197	301	1	509	92	42	27	166	999	167
3	155	84	23	264	168	313	5	492	93	51	42	190	946	158
4	86	40	14	148	177	231	7	415	88	23	19	132	695	116
5	151	91	26	274	164	228	8	412	122	15	57	210	896	149
6	145	55	48	258	184	229	10	433	174	21	57	256	947	158
7	92	50	21	163	171	186	14	398	114	28	28	171	732	122
8	87	49	27	171	219	143	10	378	91	20	48	171	720	120
9	149	63	55	277	206	203	11	458	88	24	45	212	947	158
Totals	1259	721	269	2305	1666	2164	71	4016	1045	280	398	1837	8158	
Program Average	70	40	15	129	93	120	4	223	58	16	22	102	151	

*The complimentary admissions are not listed but they are included in the totals.

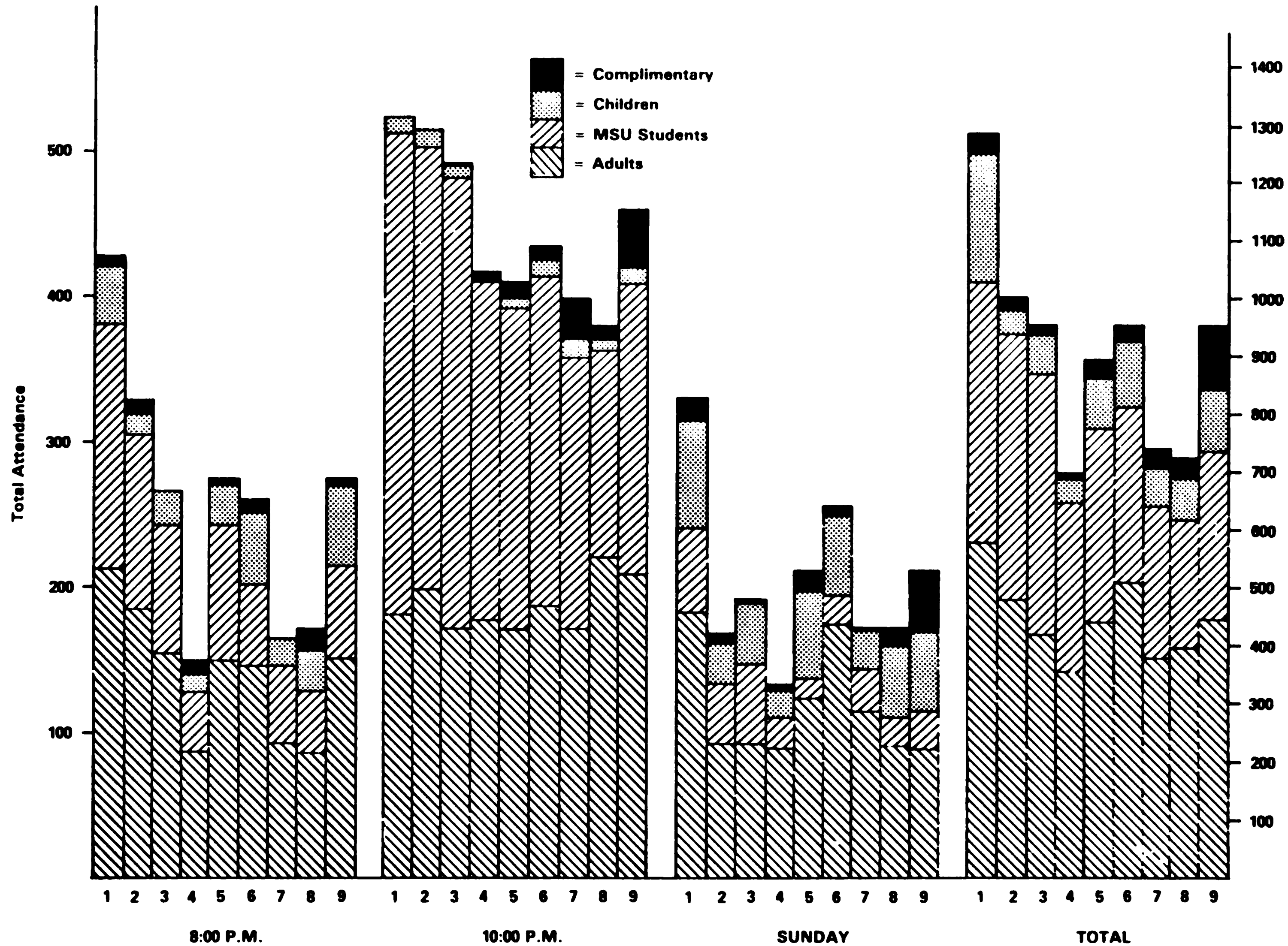


Figure 5.--Total weekly attendance by population and time.

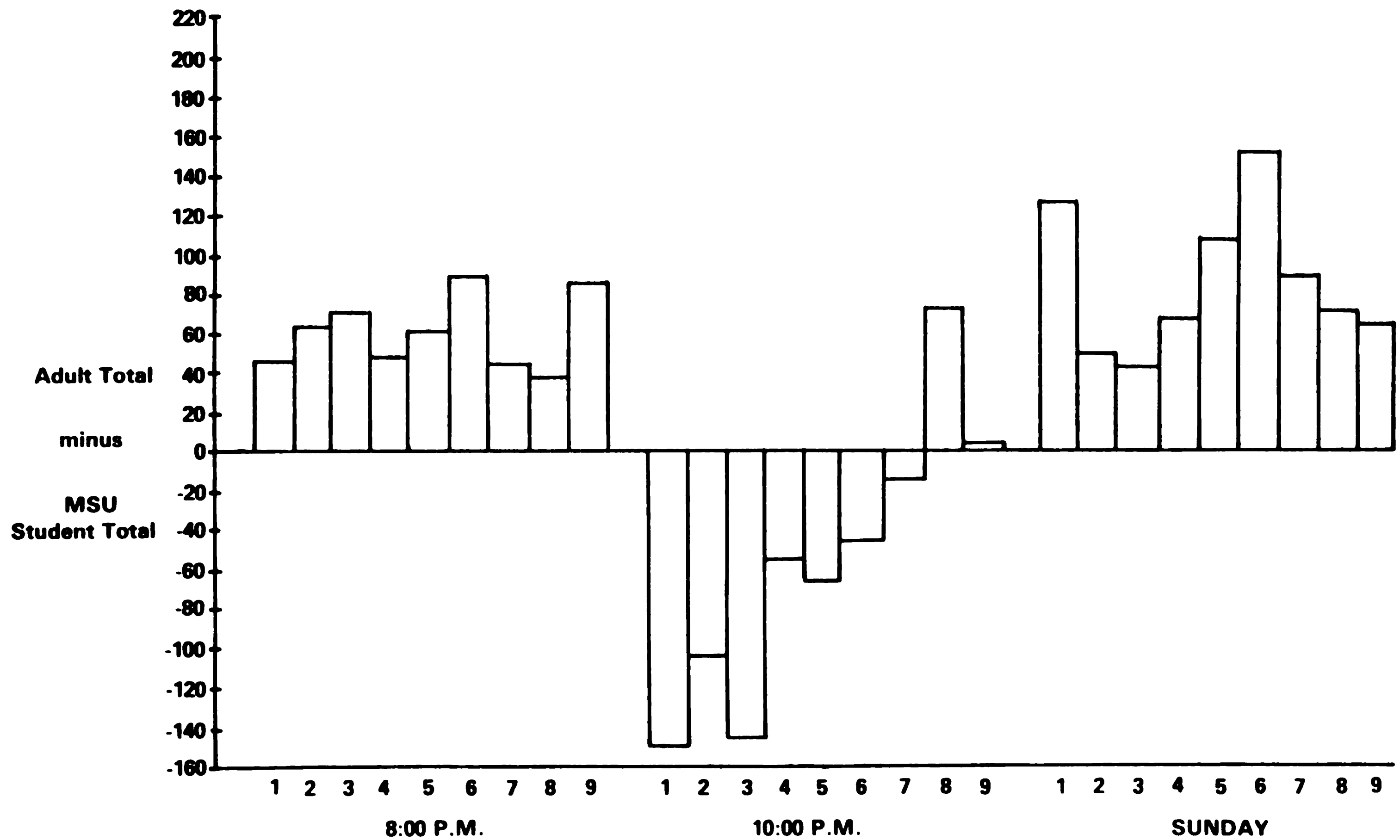


Figure 6.--Weekly numerical differences of adult and MSU student patrons versus the program time.

experiments and conclusions based on the 1978 samples to other seasons. Figure 7 is a comparison of the total 1972, 1975, and 1978 adult and MSU student patrons for each week by the program times and grand total. The first week of the 1975 data was unusual because it followed a very short week of the initial week of university classes for the winter term. The 1975 and 1978 trends are similar in many respects. For instance, the adult and MSU student totals of the 8:00 P.M. and Sunday programs correlate quite well in that the adults group was usually the higher of the two groups and their plots are fairly parallel in Figure 7. The 10:00 P.M. audiences had a majority of MSU students early in the season, but this was drastically reduced by the last weeks of the season. This latter observation also supports the conclusion of Table 18 and Figure 6 in that the 10:00 P.M. student population became smaller with respect to the adult population as the season progressed. Last, from Figure 7, it can be seen that the adult population dropped much slower than the MSU student population. This may have been due to the effect of advertising or relative sizes of the population pools from which the MSU student and adult patrons belong. More research is needed to clarify such trends with the same or different programs, as will be pointed out in the next chapter.

It can be said with some degree of confidence that, based upon the above evidence, the demographic data of the patrons for the 1978 programs used in this research do not appear to be atypical.

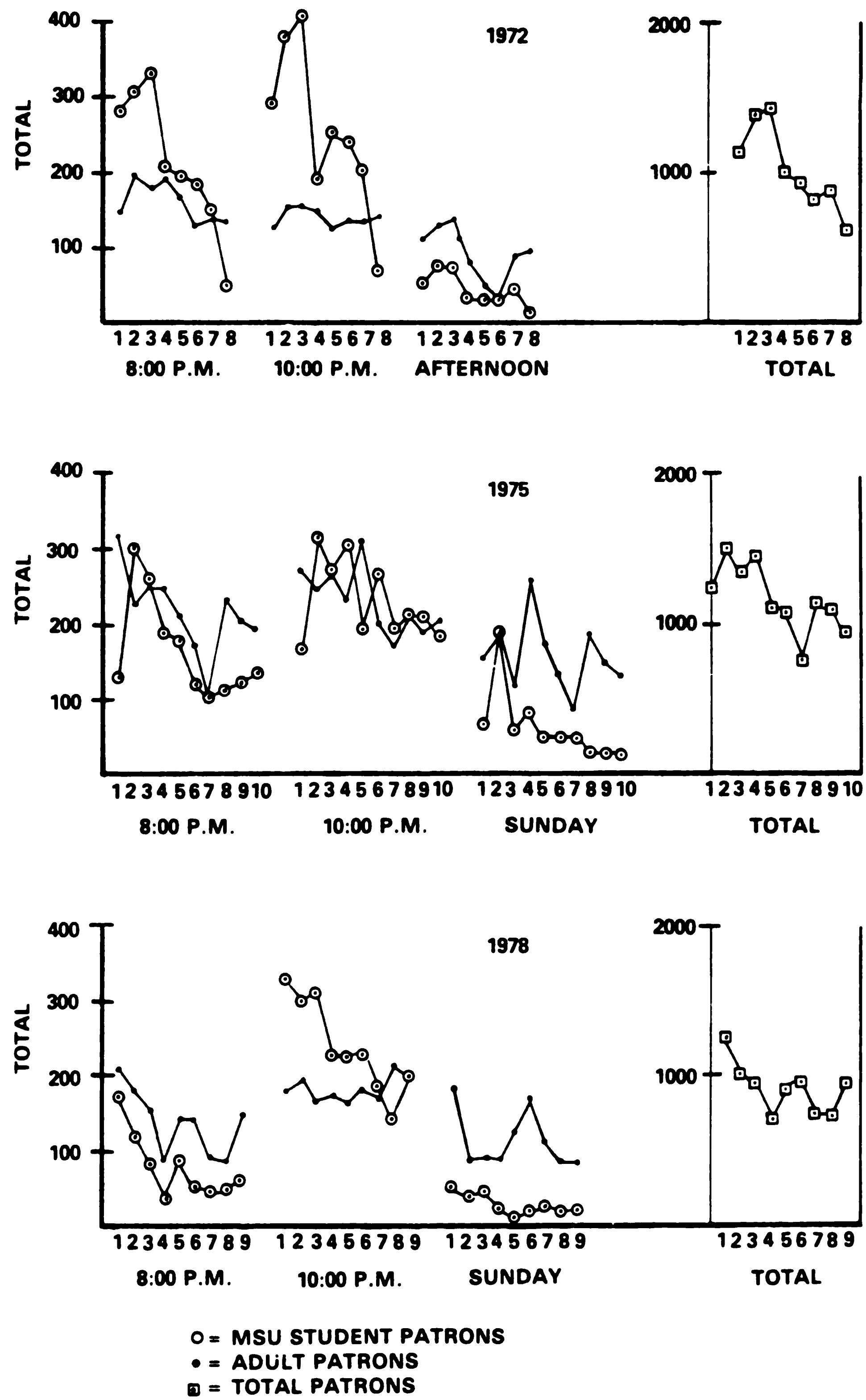


Figure 7.--Comparison of the 1972, 1975, and 1978 attendance trends by population groups and program times.

Table 18.--Numerical difference of the adult and MSU student patrons versus the program time and week.

Week	Adult Attendance Total - MSU Student Attendance Total		
	8:00 P.M. Programs	10:00 P.M. Programs	Sunday Programs
1	+43	-150	+127
2	+62	-104	+ 50
3	+71	-145	+ 42
4	+46	- 54	+ 65
5	+60	- 64	+107
6	+90	- 45	+153
7	+42	- 15	+ 86
8	+38	+ 75	+ 71
9	+86	+ 3	+ 64

Covariate Comparisons of the Three Program Times

The primary purpose of this study was to evaluate the effect of different introductory treatments to a public planetarium presentation on the learning of the audience members. Since the average nature of the public audience varies from one particular program time to another program time, the research design had to control for this effect by random assignment of treatments to programs over the entire season of one public planetarium program. The main results indicate that learning by the audience depends upon the type of introduction utilized and most strongly upon whether an introduction is used at all. Furthermore, there was some evidence that audiences who attended a particular program time such as 8:00 P.M., 10:00 P.M., or Sunday afternoon programs probably learned less than other audiences with the same introductory treatment. A logical implication was to investigate the demographic differences of these three groups. This was partially done within the discussion regarding the covariates utilized in the statistical analysis and summarized in Tables 3 through 9. The previous section utilized ticket records to clarify the distinctiveness of the three program times. The following tables and discussion recapitulate the covariate data and extend it to include other data collected in the post-test questions.

Table 19 is a listing of the codes, descriptions, names, levels, and their corresponding assigned numerical values of the demographic data collected in the post-test questions for the study. Table 20 is a summary over each of the 54 programs of the score and

Table 19.--Codes, descriptions, names, levels, and the assigned numerical values of the demographic data collected in the post-test questionnaire for the study.

Code	Description and Name	Level	Value
V1	Age Range	1. 12 years or less	1.0
		2. 13-17 years	2.0
		3. 18-25 years	3.0
		4. 26-40 years	4.0
		5. Over 40 years	5.0
V@	Highest Level of Formal Education	1. University/college level	1.0
		2. Attending university/college	2.0
		3. High school	3.0
		4. Attending high school	4.0
		5. Elementary/middle school	5.0
V3	Sex	1. Female	0.0
		2. Male	1.0
V4	Math and Science Aptitude (MS Level)	1. High math and science	1.0
		2. High math and low science	2.0
		3. Low math and high science	3.0
		4. Low math and science	4.0
V5	Number of Previous Visits to a Public Planetarium Program in the Last Year	1. 0	1.0
		2. 1	2.0
		3. 2	3.0
		4. 3	4.0
		5. 4 or greater	5.0
V6	Number of Previous Visits to This Public Planetarium Program in the Last Year	1. 0	1.0
		2. 1	2.0
		3. 2	3.0
		4. 3	4.0
		5. 4 or greater	5.0
V7	Type of Preferred Public Planetarium Program	1. Current astronomy topics	1.0
		2. Current space exploration	2.0
		3. Science fiction	3.0
		4. Historical astronomy	4.0
		5. Basic astronomy	5.0
V8	Source of Information About This Program	1. Radio	1.0
		2. TV	2.0
		3. Newspaper	3.0
		4. Planetarium poster	4.0
		5. Word of mouth	5.0
V9	The Number of Science Fiction Books Read This Year	1. 0	1.0
		2. 1	2.0
		3. 2	3.0
		4. 3	4.0
		5. 4 or greater	5.0

Table 20.--Data summary of score and demographic questions from the post-test questionnaire compiled for individual programs.

Program Number	Total Subjects	Mean Score	Standard Deviation	Program Treatment	Program Time	V1--Age	V2--Education	V3--Sex	V4--MS Level	V5--Visits	V6--Program	V7--Preferred	V8--Source	V9--Books
1	22	7.32	3.30	2	1	2.77	2.45	.73	2.14	2.18	1.18	2.27	3.41	2.50
2	29	7.52	2.85	3	2	3.10	1.69	.76	1.69	2.45	1.31	2.03	2.90	2.69
3	29	7.93	2.30	3	1	3.14	1.93	.55	2.14	1.72	1.10	2.72	3.21	3.03
4	26	8.04	1.89	3	2	3.08	1.92	.58	2.31	2.42	1.15	2.54	3.85	2.81
5	19	4.89	1.97	4	3	2.68	3.26	.58	.58	1.79	1.10	2.32	2.74	.68
6	23	5.83	2.99	4	3	3.17	2.26	.61	1.74	1.96	1.26	2.39	3.43	2.09
7	30	7.63	1.38	2	1	3.13	2.17	.47	1.87	1.97	1.23	2.83	3.83	2.97
8	28	7.50	2.20	1	2	2.96	2.04	.57	2.29	2.29	1.14	2.68	3.82	2.46
9	28	6.86	2.34	1	1	3.21	2.21	.71	2.07	1.86	1.00	2.57	3.93	2.29
10	27	7.15	1.88	3	2	2.93	2.04	.52	1.85	2.04	1.30	2.89	4.15	2.48
11	20	6.50	2.42	1	3	3.05	2.60	.55	2.10	2.05	1.10	2.30	2.85	1.60
12	13	7.38	2.26	2	3	2.61	3.23	.46	2.15	2.38	1.08	3.15	4.15	2.08
13	14	7.71	2.67	3	1	3.21	2.00	.64	2.07	1.57	1.29	1.79	1.71	1.29
14	35	7.23	1.85	2	2	3.03	1.89	.57	2.03	2.00	1.14	2.71	4.14	2.37
15	33	7.12	2.13	1	1	2.82	2.42	.64	2.33	1.97	1.12	2.03	3.79	2.39
16	29	6.21	2.50	4	2	3.07	2.00	.55	1.90	2.52	1.41	2.17	3.86	2.34
17	23	6.56	2.71	1	3	3.17	2.78	.70	2.26	2.09	1.30	2.35	4.26	2.52
18	34	6.29	2.78	4	3	3.26	2.50	.60	1.91	1.79	.76	2.15	3.71	1.97
19	25	5.84	2.23	4	1	3.00	2.40	.50	1.84	2.12	1.28	2.04	3.56	2.16
20	30	7.53	2.39	2	2	3.23	2.00	.73	1.97	2.27	1.37	2.70	3.57	2.13
21	33	7.42	1.79	1	1	3.27	1.70	.45	2.21	1.70	1.12	2.54	4.33	2.54
22	34	7.29	2.55	1	2	3.15	2.35	.56	2.03	2.03	1.15	2.50	4.21	2.62
23	26	6.27	2.34	2	3	2.85	1.85	.42	1.96	.88	.69	1.35	4.15	1.77
24	26	7.61	1.86	3	3	3.23	2.15	.65	2.15	2.15	1.11	2.35	3.35	2.35
25	29	7.48	1.92	2	1	3.24	2.10	.34	2.34	2.03	1.14	2.45	3.59	2.69
26	27	7.96	2.14	3	2	2.96	2.26	.59	1.48	2.11	1.15	2.48	3.63	2.30
27	32	8.03	1.55	3	1	3.19	2.31	.53	2.16	1.97	1.22	2.87	3.37	2.37
28	31	7.52	2.43	2	2	2.93	2.10	.64	2.26	2.23	1.10	2.48	3.52	2.52
29	27	6.59	2.56	1	3	2.67	3.63	.67	2.26	1.85	1.11	2.52	4.15	2.15
30	35	7.86	1.57	2	3	2.86	2.54	.49	1.86	1.57	1.17	2.54	3.80	2.49
31	23	7.43	1.85	2	1	3.56	1.65	.65	2.48	2.17	1.30	1.43	3.43	2.09
32	28	8.04	1.86	2	2	2.96	2.00	.71	2.39	2.11	1.43	2.25	4.04	2.46
33	35	6.37	2.14	4	1	2.83	2.77	.46	2.51	1.89	1.26	2.74	3.60	2.46
34	33	6.94	1.69	4	2	3.18	2.09	.58	2.18	2.15	.88	2.94	3.94	2.45
35	32	6.22	2.57	1	3	2.94	2.66	.59	2.12	1.69	1.28	2.87	2.84	2.03
36	26	6.85	2.34	3	3	2.35	3.54	.50	1.88	2.04	1.11	2.69	4.00	2.31
37	24	6.42	2.34	4	1	3.04	2.33	.46	2.04	2.00	1.04	2.71	3.58	2.00
38	24	8.00	2.21	3	2	3.13	1.88	.71	1.79	1.96	.83	2.54	3.17	1.88
39	27	7.00	2.39	3	1	3.04	2.41	.56	2.18	1.52	1.04	3.37	3.78	1.96
40	34	7.21	2.11	1	2	3.06	2.26	.56	2.32	2.26	1.12	2.35	3.79	2.18
41	34	7.26	2.36	3	3	2.88	3.06	.47	1.68	1.62	1.12	2.65	3.59	2.00
42	21	4.76	2.34	4	3	3.48	2.04	.52	2.48	2.09	1.09	2.05	3.62	2.09
43	20	8.65	1.35	2	1	2.75	2.95	.50	1.90	1.80	1.20	2.25	3.45	1.70
44	34	7.03	1.80	4	2	2.85	2.29	.68	2.26	2.15	1.29	2.23	3.76	2.53
45	34	7.12	1.82	1	1	3.15	2.26	.65	2.15	1.73	1.12	2.85	3.68	2.18
46	31	6.81	2.55	1	2	3.19	2.13	.35	2.19	2.39	1.45	2.71	3.93	2.10
47	25	6.16	2.01	3	3	2.76	3.40	.68	1.88	2.04	1.32	2.32	4.20	2.72
48	22	5.09	2.84	4	3	3.00	2.68	.64	2.27	2.09	1.18	2.68	3.36	1.50
49	34	6.73	2.33	4	1	3.12	2.44	.50	1.73	1.73	1.06	2.79	3.82	2.47
50	34	6.91	2.02	4	2	3.03	1.91	.50	2.23	1.82	1.15	1.91	3.94	2.68
51	33	6.12	1.95	4	1	3.00	2.73	.51	1.79	1.85	1.18	2.67	3.70	2.30
52	34	6.62	2.59	2	2	3.09	2.18	.59	2.15	2.88	1.44	2.26	3.50	2.68
53	20	7.60	2.23	2	3	2.85	2.70	.65	1.95	2.45	1.35	2.25	3.20	2.00
54	32	7.44	2.03	3	3	2.97	2.34	.63	1.88	1.84	1.16	2.59	3.22	2.84

demographic data utilizing the nomenclature of Table 19. To investigate the audience traits of the three program times, Table 21 was tabulated by treatment and program time. The averages contained in Table 21 were weighed according to the cell size and are therefore slightly different than the simple averages of the previously mentioned tables which discussed the covariates. It is evident from Table 21 and from the previous analysis of the covariate relations that there was no significant difference in the demographic data across the treatments during any one program time. This would be expected because of the randomized assignment of treatments to program.

When one compares the average values of the demographic variables between 8:00 P.M., 10:00 P.M., and Sunday programs, the patrons' age and their highest educational level were the most significant differences. The values of the average score and the demographic data were normalized and plotted in Graph 8 for the three program times. This observation supports the earlier evidence in this study that the Sunday audiences on the average have a lower age with lower educational levels and therefore learned less during the program compared to the other audiences. This is especially true when the Sunday audiences were compared to the 10:00 P.M. audiences. This also supports the ticket analysis, which implied that Sunday audiences are more family oriented or have a significantly higher number of children and almost no MSU students. As noted previously and summarized in Table 14, the 8:00 P.M. audiences were intermediate between the Sunday and 10:00 P.M. audiences in numbers of children, MSU students, and adults.

Table 21.--Data summary of scores and demographic information from the post-test questionnaire compiled by program treatment and time.

Program Time	Variable Name	Introductory Treatments: Written Program T_1	Personal T_2	Slide T_3	Null T_4	Averages
	Score	7.13	7.70	7.67	6.30	7.18
	V1--Age	3.11	3.09	3.15	3.00	3.08
	V2--Education	2.15	2.26	2.16	2.53	2.29
	V3--Sex	.61	.54	.57	.51	.55
8:00 P.M. Programs	V4--MS Level	2.19	2.15	2.14	1.98	2.11
	V5--Visits	1.82	2.03	1.70	1.92	1.88
	V6--Program	1.09	1.21	1.16	1.16	1.16
	V7--Preferred	2.07	2.25	2.69	2.59	2.40
	V8--Source	3.72	3.54	3.02	3.65	3.50
	V9--Books	2.35	2.39	2.16	2.28	2.30
	Score	7.20	7.39	7.73	6.77	7.30
	V1--Age	3.09	3.05	3.04	3.03	3.05
	V2--Education	2.20	2.03	1.96	2.07	2.06
	V3--Sex	.51	.65	.63	.58	.60
10:00 P.M. Programs	V4--MS Level	2.21	2.16	1.82	2.14	2.07
	V5--Visits	2.24	2.30	2.20	2.16	2.23
	V6--Program	1.22	1.35	1.15	1.18	1.23
	V7--Preferred	2.56	2.48	2.50	2.31	2.47
	V8--Source	3.94	3.75	3.54	3.88	3.76
	V9--Books	2.34	2.43	2.43	2.50	2.43
	Score	6.47	7.28	7.06	5.37	6.51
	V1--Age	2.96	2.79	2.84	3.12	2.93
	V2--Education	2.92	2.58	2.90	2.55	2.74
	V3--Sex	.63	.51	.59	.57	.58
Sunday Programs	V4--MS Level	2.18	1.98	1.89	1.80	1.95
	V5--Visits	1.92	1.82	1.94	1.94	1.91
	V6--Program	1.20	1.07	1.16	1.08	1.13
	V7--Preferred	2.51	2.32	2.52	2.32	2.42
	V8--Source	3.52	3.82	3.67	3.37	3.59
	V9--Books	2.08	2.08	2.44	1.67	2.07
Averages of Scores		6.93	7.47	7.47	6.10	7.00

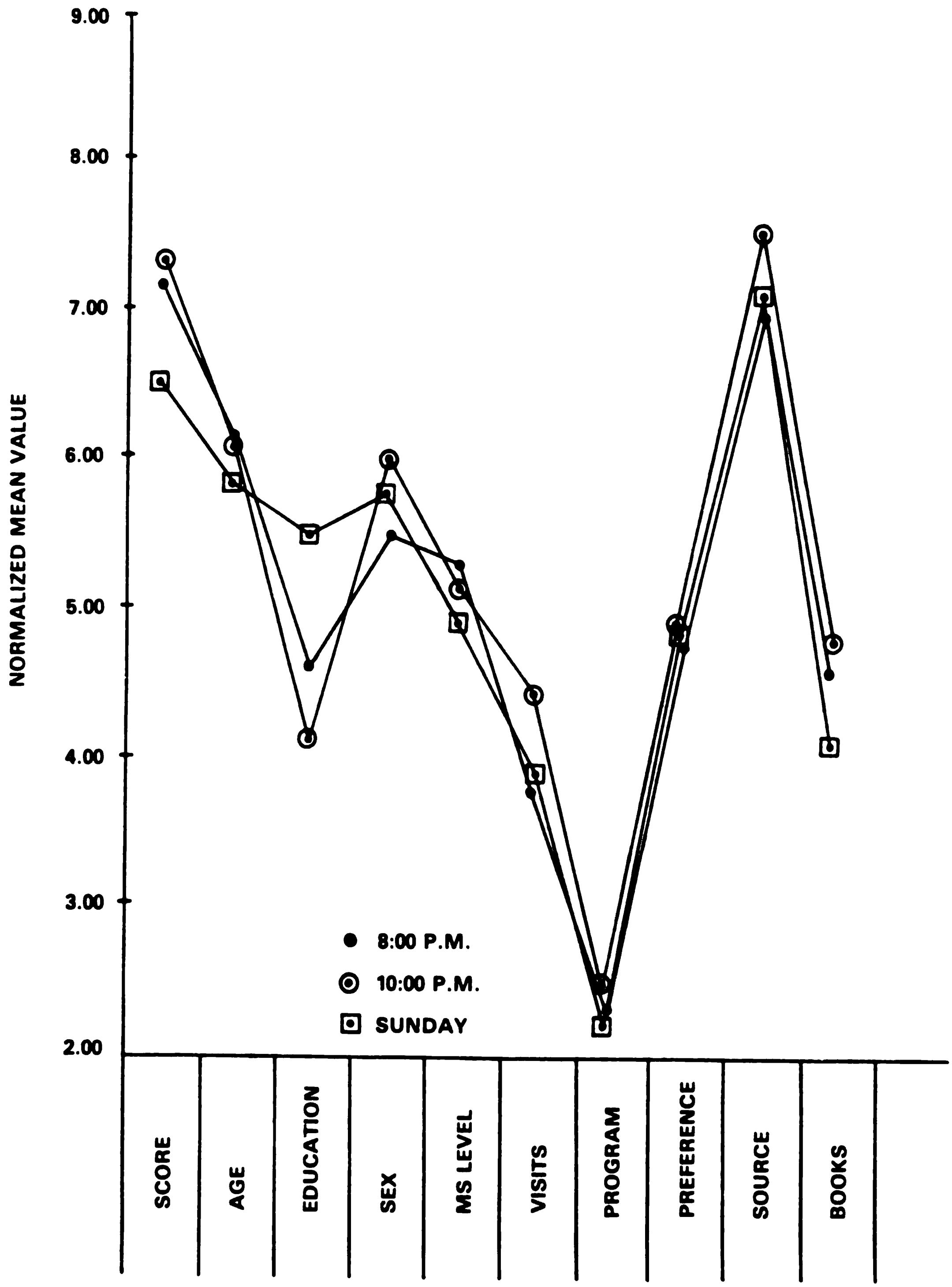


Figure 8.--Normalized mean values of the score and demographic data for each program time.

The real reasons for such score differences, and hence learning differences, probably involved the differences in the learning abilities of the patrons. This is an area which deserves more active experimental work. As will be described in the next chapter, the matching of program topics, associated vocabulary, and introductory styles with the reading level, cognitive level, and other audience learning traits needs more attention in the field of planetarium education and administration.

Summary and Restatement of Acceptable Hypotheses

The study was experimental in nature and the purpose of this chapter was to present the specific results of that experiment. The three main hypotheses and their five contrast hypotheses which were to be investigated are:

> Interaction Hypothesis: There is no significant interaction of introductory treatment and program time for learning by the audience as measured by a post-test during a public planetarium program.
>
> Program Time Hypothesis: There is no significant difference in learning as measured by a post-test between the 8:00 P.M., 10:00 P.M., or Sunday audiences for a public planetarium program.
>
> > Time Contrast Hypothesis 1: There is no significant difference in learning as measured by a post-test between 8:00 P.M. and 10:00 P.M. audiences as compared with the Sunday afternoon audiences in a public planetarium program.
> >
> > Time Contrast Hypothesis 2: There is no significant difference in learning as measured by a post-test between the 8:00 P.M. audiences and the 10:00 P.M. audiences in a public planetarium program.

Introductory Treatment Hypothesis: There is no significant difference in learning as measured by a post-test of a written program introduction, personal introduction, slide introduction, or null introduction in a public planetarium program.

> Treatment Contrast Hypothesis 1: There is no significant difference in learning as measured by a post-test between a written program introduction, a personal introduction, a slide introduction, as compared to a null introduction in a public planetarium program.
>
> Treatment Contrast Hypothesis 2: There is no significant difference in learning as measured by a post-test between a written program introduction and a slide introduction as compared to a personal introduction in a public planetarium program.
>
> Treatment Contrast Hypothesis 3: There is no significant difference in learning as measured by a post-test between a written program introduction and a slide introduction in a public planetarium program.

In the research, the four introductory treatments to be compared were randomly assigned to all the possible programs across the three program times during the season of one particular public planetarium program. The main statistical design consisted of an Analysis of Covariance (Ancova) of the two-factor study. The unit of analysis was the average of the post-test scores given to randomly selected audience members in each program. Additional demographic data gathered during the post-test allowed for comparisons of audiences.

The experimental results indicated that no interaction took place between the levels of the two factors of the design, and the Interaction Hypothesis was accepted as stated above. The audiences which attended the programs at 8:00 P.M., 10:00 P.M., or Sunday afternoons all learned much less with no introduction. With regard to the three active introductions, the audiences learned less with a written program distributed to them as they entered the planetarium chamber.

There was no significant statistical difference in the learning for those audiences experiencing the personal or slide introduction. The experimental results indicated that audiences of the three program times did not learn the same amount. Thus the above overall Program Time Hypothesis was rejected and the following alternative hypothesis was accepted:

> Alternative Program Time Hypothesis: There is a significant difference in learning as measured by a post-test between the 8:00 P.M., 10:00 P.M., or Sunday audiences for a public planetarium program.

Specifically, it was found that the Sunday audiences learned less than the other two time groups, and so the above Time Contrast Hypothesis 1 was rejected and the following alternative hypothesis was accepted:

> Alternative Time Contrast Hypothesis 1: There is a significant difference in learning as measured by a post-test between 8:00 P.M. and 10:00 P.M. audiences as compared with the Sunday afternoon audiences in a public planetarium program.

There was no significant difference in learning between the 8:00 P.M. and 10:00 P.M. audiences, and the above Time Contrast Hypothesis 2 was accepted. The analysis of demographic data revealed the most significant difference of the three audience groups to be age and the educational level which was supported by the ticket sales records. The Sunday audiences were found to be distinctly different than the other two program time groups in terms of composition of adults, MSU students, and children. The attendance pattern of the season (1978) was similar to previous seasons (1972, 1975) for the same public program. There was no measured learning difference linked to the sex of the patron, the frequency of planetarium attendance, or any of the other demographic data.

The experimental evidence indicated that all program introductions were not equally effective in promoting learning cognitive material in a public planetarium program. Thus the above overall Introductory Treatment Hypothesis was rejected and the following alternative hypothesis was accepted:

> Alternative Introductory Treatment Hypothesis: There is a significant difference in learning as measured by a post-test of a written program introduction, personal introduction, slide introduction, or null introduction in a public planetarium program.

The results indicated that a written program distributed as the audience entered the chamber or a personal or slide introduction presented when the audience was seated in the chamber were all superior to not having any introduction of the subject material with regard to the learning achieved by the audience. The above Treatment Contrast Hypothesis 1 was rejected and the following alternative hypothesis was accepted:

> Alternative Treatment Contrast Hypothesis 1: There is a significant difference in learning as measured by a post-test between a written program, personal, and a slide introduction as compared to a null introduction in a public planetarium program.

The results indicated that the combined written and slide introductory treatments were not superior in facilitating learning when contrasted with the personal introduction. The above Treatment Contrast Hypothesis 2 was therefore accepted as stated. However, the slide introductory treatment was found to be significantly superior to the written program introduction, and so the above Treatment Contrast Hypothesis 3 was rejected and replaced by the following alternative hypothesis.

> Alternative Treatment Contrast Hypothesis 3: There is a significant difference in learning as measured by a post-test between a written program introduction and a slide introduction in a public planetarium program.

The above statistical hypotheses which were tested formulate the main research interests of the study. Other results such as further treatment contrasts, program contrasts, estimated effects, and demographic contrasts were also found. The conclusions and implications of the results will constitute the next chapter.

CHAPTER V

CONCLUSIONS AND IMPLICATIONS OF THE RESULTS

Introduction

The experimental results presented in the previous chapter lead to certain conclusions and implications for implementation and research in the field of planetarium education and other similar organizations. The design of the study facilitated the extension of the results from an experimental population to a larger and more general population.

The experimental population consisted of 8,158 people who attended the 54 public planetarium programs during the 1978 season for the science fiction program, The Last Question. This program was written by Isaac Asimov and produced by the Gates Planetarium in Denver, Colorado, in cooperation with the Abrams Planetarium in East Lansing, Michigan. This popular science fiction program was narrated by Leonard Nimoy, and a brief introduction was provided by Isaac Asimov in the first two minutes of the presentation. The experimental population and the program are described with the research design in Chapter III. Four typical introductory techniques were randomly assigned to the programs, and 1,511 audience members were randomly selected for participation in a post-test questionnaire to measure relative learning and collect demographic data.

The general population to which the inferences can be extended includes all planetarium facilities. Some of the following conclusions and implications relate specifically to public planetarium programing but many of the conclusions can be extended to all educational functions of planetariums. In addition, some of the results can be extended or related to teaching situations in similar organizations such as museums of science centers.

Conclusions From the Results

As noted earlier in this research, planetariums vary in their locations, sizes, and audiences while they all have the same basic purpose of educating the general public about astronomy and the space sciences. The planetarium profession is very young and has not developed a common basis of operational techniques to maximize their educational goals as few well-designed experiments have been conducted to reveal the best techniques and procedures to utilize with specific audiences. The results of these comparisons between introductory treatments in the experiment merit analysis and discussion because most planetariums regularly use some of these formats or a combination of them.

Introductory Treatments

The overall accepted experimental hypothesis pertaining to the use of subject matter introductions to a public planetarium program was that there is a significant difference in learning as measured by a post-test between a written program introduction, a personal introduction, a slide introduction, and a null introduction in a public planetarium program. It can be concluded the type of introduction used by a planetarium for its public presentations is important in influencing the education of its patrons. This overall conclusion of the importance of the subject matter introduction can be easily extended to school programing by planetariums, museum educational presentations, science center programs, and even to general classroom teaching situations.

In conclusion, the experimental results substantiate that audience members learned significantly different amounts with different introductory formats as measured by a post-test. The written program introduction was handed out to each patron as they entered the planetarium chambers. The personal introduction consisted of a subject matter description of the program by the researcher, utilizing a microphone in front of the audience just before the program commenced. The third type or format of introduction was done by utilizing 35mm slides containing written and supporting visual effects which portrayed the same introductory message as the written program and the personal introduction. These slides were projected on the planetarium's dome using two carousels just before the program was to begin. Both the personal and slide presentations were started after all patrons had been seated. All three introductions contained the same factual information pertaining to the program. The complete description of the treatments and other design considerations are contained in Chapter III.

The above four introductions studied in this research are typically utilized in planetariums and there are several ways of contrasting them. They may be viewed as a progression in the amount of personal human involvement in their delivery in the order of personal introduction (the most), written introduction (partially), slide introduction (minimally), and null introduction (no personal involvement). Another way of contrasting the four treatments might be by the relative amounts of attentiveness demanded of the audience by the treatment. This might also be labeled as the techniques' basic "compulsiveness" or their relative ability to compel the audience members to interact intellectually with the substance of the introductory message. The null treatment would be viewed as the least compelling, with the written introduction as slightly more compelling. The personal and slide introductory formats demanded much more attention of the audience members. Another manner of viewing the four introductory treatments might be with regard to the amount of reading or listening that is involved on the part of the audience. The personal introduction requires the audience to listen, while the slide and written program introductions require reading to be performed. These techniques of analysis did not form a substantial basis for research in this study but do provide insight or a reference upon which to base conclusions and implications.

The most important conclusion of this research is that an active introduction is superior to no introduction in facilitating learning in a public planetarium program. In this work, there were three typical active treatments and one null treatment. It can be concluded that if one of the goals of a planetarium's programming efforts is to educate its patrons in some cognitive manner such as learning the physical traits of astronomical bodies, understanding an astronomical process, or other science education task, then some type of introduction should be planned and utilized. This introduction might take several forms or it may just be one style, but the introduction must prepare the patron for the subject matter of the program. This conclusion can be extended to all planetariums which provide educational programing to school groups as well as to public audiences. These introductions may be loosely referred to as "advance organizers" (Ausubel, 1968, p. 149) since they alert the minds of the patrons to upcoming information, and therefore the results may be interpreted to be supportive of the value of such pre-conditioners to learning in all educational situations. This general conclusion of the importance of an active introduction as opposed to a null introduction can be extended beyond the planetariums to museums, science centers, and even to the classroom.

When considered over all program times, the experimental results indicate the written program introduction was significantly less effective in promoting learning compared with a personal or slide introductory technique. The major difference of these two categories of treatments might be described as the amount of compulsiveness or encouragement given to the patron to pay attention to the introduction. The written program distributed as the people entered the chamber was much less compulsive than a person standing and speaking in their midst or a series of attractive slides being projected upon the planetarium dome as the room lights were being dimmed. Thus, it may be concluded that introductions which are more compulsive like the personal or slide introductions in this experiment are more effective in facilitating learning. When the written introduction was compared directly with the slide introduction, it proved to be less effective. The written and slide introductions were identically written messages but presented with different media at slightly different times. There was very little difference in the amount of personal involvement by the researcher in the two methods. Based upon these results, it may be concluded that the slide presentation of introductory material is superior to a written handout of the same introductory material.

The results indicate that there was no significant difference found when the personal introduction was statistically compared with the written and slide introductory techniques together over all programs. As explained in Chapter IV, this probably occurs because the slide and personal treatment results were nearly identical and the written and personal treatments were very different. The amount of personal involvement by the introducer was greatest in the personal introduction and yet this does not seem to be a significant factor in this experiment. The personal introduction involved all listening by the patrons rather than reading as in the written and slide introductions, and so listening did not seem to be a significant factor either. It cannot be concluded whether the personal or the slide introduction is superior over all program times on the basis of this experiment. Neither can it strictly be concluded that personal involvement or the amount of listening and reading were significant factors in the relative amount of learning since these factors were not part of the research design. These latter factors do provide some ideas for further research as pointed out in the implications section of this chapter.

The effect of introductions on the variability of the post-test scores and learning also was investigated. This research noted that with no introductions, the scores were not only lower but were also more variable and had a larger range than the scores of audiences with other introductory treatments. The written program introductions seemed to have the smallest range and variance of program scores and hence, learning. The personal and slide introductions had similar program scores and variances but the personal treatment exhibited the widest range of all four types of introductions. It is difficult to determine whether such score differences are significant but the general ramifications indicate that any type of planetarium introduction will tend to make audience learning increase and to become more homogeneous as measured by a post-test instrument. For this to occur, the introductions probably raised some learning levels of certain patrons more than others. These patrons would have scored relatively lower without such a treatment, and thus the effect of such treatment would be to produce more homogeneous learning in addition to raising the relative level of information transfer.

In summary, the conclusions with regard to the relative effect or impact of specific introductory formats on learning in a public planetarium program at all program times based upon this research are the following:

1. All introductory techniques are not equal in the ability to facilitate learning.

2. The three active techniques of a written program, personal, and slide introductions are all superior to the null introduction.

3. The slide introduction is superior to the written program introduction.

4. The personal introduction is superior to the written program introduction.

5. The personal and slide introductions are approximately equal.

6. The null introduction will result in not only lower learning but more variable and a wider range of learning.

Program Times

The overall accepted experimental hypothesis with regard to program times was that there is a significant difference in learning as measured by a post-test between the 8:00 P.M., 10:00 P.M., and Sunday audiences for a public planetarium program. It can be concluded that audiences of different program times learn significantly varying amounts of subject matter. The identical program was presented at all three program times, while the four introductory treatments were randomly assigned to all the presentations. A post-test given to randomly selected patrons of each audience allowed for an independent measure of the dependent variable called the achievement score. In addition, demographic data collected from each patron provided for comparisons between the audiences in regard to specific covariates. These demographic data provided the basis for the conclusion that the three types of audiences are significantly different in composition, which may lead to their different achievement scores or learning from the public program.

A significant result of the research was that patrons who attended the programs on Sunday afternoons learned significantly less than the 8:00 P.M. or 10:00 P.M. audiences. The accepted alternative hypothesis with respect to program times was there is a significant statistical difference in learning as measured by a post-test between the audiences at 8:00 P.M. and 10:00 P.M. as compared with Sunday afternoon programs for a public planetarium presentation. The Sunday programs were usually lower in attendance and consisted of a very different audience composition than the other program times. In fact, the three program times can be viewed as a continuum in audience traits ranging from the 10:00 P.M. audiences to the 8:00 P.M. audiences and finally to the Sunday afternoon audiences. In this progression, the percentage of MSU students decreased from a high percentage to a very low percentage, while the children and adult population proportions increased from low to high values. The Sunday audiences were on the average much younger and thus had lower educational levels or knowledge levels. It is possible to conclude that this is the underlying reason for statistically lower achievement scores for Sunday audiences. The audience scores also indicated that the above progression also holds for score variability and hence learning variability. Thus it can be concluded that Sunday audiences not only scored the lowest and hence learned the least amount for all introductory treatments, but their learning varied the most and had the largest range.

The actual values of the achievement scores were highest for the 10:00 P.M. audiences and these were followed closely by the scores of the 8:00 P.M. audiences, while the lowest scores were achieved by the Sunday audiences. However, the difference between the 10:00 P.M. and 8:00 P.M. achievement scores was proven not to be statistically significant. The test instrument and design were not powerful enough to detect any significant learning differences between the 10:00 P.M. and the 8:00 P.M. audiences if such learning differences really existed, as implied by the above discussion of the attendance patterns. It can be concluded on the basis of these results that there were no learning differences between the 8:00 P.M. and the 10:00 P.M. audiences.

In summary, the conclusions with regard to the three different types of audiences and their relative learning in a public planetarium program as measured by a post-test in this research are the following:

1. The audiences of different program times learn significantly different amounts.

2. The Sunday afternoon audiences learn significantly less than the 8:00 P.M. or 10:00 P.M. audiences.

3. The three types of audiences which attend the Sunday afternoon, 8:00 P.M., and 10:00 P.M. programs have populations that range from lower to higher age and educational levels. This population composition difference manifests itself in a wide difference of learning for audiences of these program times.

4. The 8:00 P.M. and 10:00 P.M. audiences did not statistically differ in their relative amount of learning from the planetarium presentation.

Interaction of Introductory Treatment and Program Time

The experimental results indicate that there was no significant interaction of the introductory treatment factor with four levels and the program time factor with three levels. It can be concluded that there is no significant interaction of introductory treatment and program time for learning by the audiences as measured by a post-test during a public planetarium program.

It can be concluded from the above result that all audiences learned less with no subject matter introduction and, in general, the Sunday audiences always did less well than the 8:00 P.M. and 10:00 P.M. audiences with all treatments. The 8:00 P.M. and 10:00 P.M. audiences learned equally well with the written and slide introductions and they learned significantly more than Sunday audiences. However, the slide introduction achievement scores for all three program times were also significantly higher than the written program scores. As was stated in the previous sections of this chapter, an important conclusion is that learning was more facilitated by the slide introductory format than with the written handout format. This is an interesting result, since both types of introductions utilized the same written words, sentences, and overall message, but their delivery vehicles were different. The message on the written handouts was done in formal paragraph style and was freely given to each patron before the program. The slide presentation was done with two slide projectors utilizing some graphics and the identical written message but in sentence style. The slides were projected using the usual dramatic feature of a planetarium theater of cross-fading on the hemispherical dome as the room lights were dimmed.

The relative rankings from the highest to the lowest achievement scores in three out of four introductory treatments were the 10:00 P.M., 8:00 P.M., and Sunday afternoon audiences. The exception was with the audiences experiencing the personal introduction, in which the 8:00 P.M. audiences scored higher than the 10:00 P.M. audiences and Sunday audiences. This presents an enigma since the real underlying reason(s) is (are) not evident. However, when the original data were examined it was found that one 10:00 P.M. program was unusually low in its average achievement score and that one 8:00 P.M. program was unusually high in its score. These two achievement scores caused the large range of the scores in the personal introductory technique. Consideration of the 95 percent confidence intervals of the achievement score values in the 12 cells of the study alleviates much of the above uncertainty about relative rank since most of these comparisons were not significant. This means the only confident statement or conclusion that can be made is there is no interaction or that Sunday audiences learned significantly less than the other audiences with all four techniques and there was no significant difference in learning between the 8:00 P.M. and 10:00 P.M. audiences.

However, a legitimate type of question might examine which active introductory technique works best with a particular audience. The most confident answer based upon this experiment is that with the Sunday afternoon audiences, the personal introduction and slide introduction are superior to the written introduction in facilitating the learning process. The written program introduction as used in this work is not the best type of introduction to be utilized with Sunday audiences or audiences with a large fraction of families or children. The reasons for this are not clear, but the reading and listening levels of the audience and the introduction are most certainly involved. This supports the other data of this study, which suggest the 8:00 P.M. and Sunday audiences are more similar than the 10:00 P.M. and Sunday audiences. It is a less confident observation about the best introductory technique for the 10:00 P.M. audiences when one considers the experimental confidence levels. The 10:00 P.M. audience patrons seem to learn equally well with any active introductory technique, although the evidence favors slightly more learning with the slide introductory format.

Experimental Technique

The process of evaluating learning with these experimental techniques in a public planetarium program received no negative reactions by the audience members, as monitored by the researcher during and after the post-test for each program. The researcher presented the post-test to the audience in a manner which made it seem like a part of the public program and not a separate or isolated survey. This "blending" of program and post-test may have assisted in reducing or eliminating negative reactions of the public patrons. In addition, the attendance pattern for the season was not adversely affected by this evaluation study as measured by ticket analysis of similar seasons for the identical public program.

The above subjective result is one of the most important results for planetariums and other similar professions such as museums and science centers. It is concluded that useful research can be conducted with public presentations if the research design is well planned and presented in a constructive manner in which the patrons are made to feel useful or helpful without feeling threatened. In general, the study proved that experimental research and supportive demographic material can be conducted and obtained in a public planetarium setting without affecting the patrons' attitudes and attendance patterns. As was noted above, this result was not a rigorous finding in that attitude instruments were not utilized and longitudinal studies were not conducted to solidify the conclusions and implications. However, the assumption was made that if no animosity or negative reactions were noted on the part of the patrons during and after the post-test, then there was probably very little negative effect of testing the public audiences. This is probably the main reason why most planetarium staff are reluctant to evaluate their programing. This study concludes that this reluctance is not always valid.

Implications of the Results

The implications for educational organizations are based upon the conclusions of the results of this research as expressed in the previous section of this chapter. These will consist of suggestions for implementation and for more research of certain aspects. The more specific implementations will pertain only to planetariums, while some of the general implications will be extended to other educational organizations such as museums, science centers, and school classrooms.

Introductory Treatments

The overall conclusion about the introductory treatments is that they are important in influencing the education of the patrons. The implication for planetariums is that the introduction before the main program is an important part of the total presentation, and therefore some kind of active introduction should be planned and presented for each public program. In this research it was concluded that the written program, personal, and slide introductions were all superior to the null introduction. The introductory format should include a subject matter summary to the planetarium presentation so as to prepare the audience for the salient features of the cognitive material. This implication can also be extended to school programing by the planetarium. Ideally, in school programing, the teacher has already prepared the students for learning in the planetarium, but some type of introduction within the planetarium is still necessary before the formal planetarium experience commences. On a more general level, educational organizations such as museums, science centers, and school classrooms should heed this main implication that active or open attempts to introduce upcoming subject matter instruction will usually result in more learning by the audience.

The written program or handout introduction was concluded to be the least effective of the active introductions in facilitating learning of the subject matter. This introduction was also the least compulsive of the active introductions in requiring the attention of the audience. This implies that if planetarium programers desire to utilize various types of introductory formats, they should use the introductions which require more attention by the audience patron to maximize cognitive educational learning. In the case of a written program introduction to be read before the presentation by the patrons, this result suggests a set of posters in the foyer which would give information and gain the patron's attention. These additional aids to the written handout may help the audience members learn more from the public planetarium program. The text of the written program handout may be changed to a more attractive format with diagrams, questions and answers for the patron about the subject matter, or cartoon figures to illustrate the message of the introduction.

In the case of a personal introduction, a more interactive type of introduction may be obtained by asking questions of the patrons and being less formal in the presentation of the introduction. This would be possible to arrange and still maintain the integrity of the introductory message.

When utilizing a slide introduction such as seating slides and/or dark light eye adjustment slides, the learning process might be enhanced by portraying the essence of the program with well-labeled slides and supporting music to obtain the attention of the audience and maximize learning. The essence of this implication is that introductory techniques must obtain and hold the attention of the audience. It is obvious this implication can be extended to all educational situations.

Another implication arising out of the results of the research pertaining to the comparison of the written and slide introductory techniques is that more research is needed to clarify the results. This additional research should try to decide if the slide introduction works better because of its medium or its more compulsive nature or both. Such research, if conducted in a research design to control the confounding variables, would be very beneficial to planetariums.

A similar implication for further research concerns the learning impact of the amount of personal involvement and media techniques in subject matter introductions. The audiences experiencing the personal or slide introductory techniques in this study scored equally well. More experimentation is needed to clarify the relation between learning and the amount of special audio-visual effects and techniques. In addition, careful research could be conducted to estimate the differences of the educational impacts of taped and live planetarium presentations.

These implications for further research are part of a general need for clarification in the planetarium profession. That need is for the verification of the most significant aspects or techniques of the planetarium experience in promoting learning.

In summary, the implications arising out of the research pertaining to subject matter introductions are:

1. Planetariums should utilize subject matter introductions in their public programs to maximize learning.
2. Planetariums should carefully consider and select appropriate subject matter introductions which will acquire and hold the patron's attention to facilitate learning from

the public planetarium program. This calls for more compulsive or compelling preparatory techniques as opposed to those introductions which are relatively voluntary such as reading written handouts.

3. Planetariums need to foster more research to verify the best techniques for facilitating learning that are available in the planetarium.

As stated before, the implications can be easily extended to school programing by planetariums, museums, science centers, and the general classroom because the primary goal of these educational organizations is to provide excellent science education.

Program Times

There was conclusive evidence that audiences who attend different program times may learn significantly different amounts. Such learning differences were probably generated in this research by the differences of the demographic composition of the audiences. A major implication arising from these conclusions is that educational facilities such as planetariums should consider the demographic traits of their audiences before planning the program. To do this accurately, the facility should measure the typical demographic traits of its audiences annually. Measuring the planetarium patrons by such things as their reading level, cognitive style, or intelligence level in addition to the usual demographic data as done in this research would be useful in school and public planetarium programing. Such results would be quite important in selecting fundamental program parameters such as goals, introduction techniques, vocabulary, number and type of visual effects, and other factors to be utilized for a particular program time or group with a school or public presentation. This area of study in planetarium education needs well-designed and carefully executed research to develop a solid experimental foundation upon which to build more effective and efficient programs.

A conclusive finding of this experiment was that the 8:00 P.M. and 10:00 P.M. audiences learned significantly more than the Sunday afternoon audiences. This implies that Sunday audiences and, to a certain extent, some members of the other program times, were at a disadvantage in that they learned less in the program because they probably had too low an educational level relative to the presentation. This is an unfortunate situation in that the educational goals of the planetarium are usually not met effectively while the people are short-changed in not being provided with the subject matter material at the right cognitive level. A similar situation occurs in museums in which large heterogeneous groups of people view exhibits which are usually aimed at one level or subpopulation of the total audience. The solution implied by these results is to modify the program to fit the traits of the audience. For planetariums which have vastly different patron populations at different program times, programing should be altered according to the estimated traits of the audience. This implies more flexible public programing within a typical program season so that modification or substitution of the principal planetarium program can be easily accomplished to accommodate different audiences. This modification might include introductory changes, visual and audio effect changes, vocabulary changes, or post-program changes. Substitution might include utilizing another complete program. For example, a sky show aimed more at the family population for Sunday audiences might have been more appropriate at Abrams Planetarium.

A finding of this research was that Sunday afternoon audiences learned less than the audiences at 8:00 P.M. or 10:00 P.M., as measured by an immediate post-test. As previously explained in Chapter III, the post-test was a written instrument which asked various subject matter related questions and was not directed toward any particular audience type. Thus, it might be hypothesized that the achievement scores of different audience groups measured their relative levels of knowledge and not the relative amounts of learning. This is the advantage of a design which incorporates pretesting of the subjects in that it would give indices of relative learning amounts. Various testing instruments might have been utilized to match each patron with an appropriate instrument but, as explained in Chapter III, this adds an additional factor or variable to the study.

For museums and science centers, various levels of exhibit information could be utilized which would depend upon the patron's educational level. For example, a display pertaining to the generation of electricity might include three levels of explanation. One explanation might be geared toward the nonreader or early elementary child, with a lot of graphics. On the intermediate level, the explanation might involve more technical graphics and interactive systems. The more advanced level would involve technical graphics and quantitative information in addition to the interactive system. The patron then could select one or more levels of explanation and interaction.

Another conclusion reached by this research was that the 8:00 P.M. and 10:00 P.M. audiences learned equally well despite their apparent demographic differences. This implies that the post-test did not discriminate enough or that the demographic differences were not significant and could not produce differences in the relative learning. As indicated earlier in this chapter, more research is needed to clarify this point.

In summary, the implications arising out of the research pertaining to program times are:

1. Planetariums should measure and consider the demographic traits of their audiences at different program times in planning the public program. Planetariums should not assume that all their audiences will learn equally from the same presentation. Thus, more emphasis should be placed on matching the program with the estimated audience.

2. Modification or even substitution of a public program may be necessary to maximize learning by the audience of a particular program time. This suggests more flexible programing for planetariums.

3. When planetariums test or survey their audiences an attempt should be made to match their instrument to their audience traits. If an absolute rather than a relative measure of learning as a function of a particular variable is desired, a design with pre-testing should be considered.

4. More research is needed on the impacts of variables which cause learning differences from planetarium presentations.

These implications may be extended to other educational organizations such as museums, science centers, and general classrooms. It is important for each of these facilities to be familiar with their patrons' traits to maximize their learning.

Interaction of Introductory Treatment and Program Time

The implications arising out of the results of this research indicate that different audiences learn different amounts of subject matter from identical presentations. Although no significant interaction was found, it was implied by this research that the type of introduction must be carefully selected for the particular type of audience as well as the correct modification or substitution of the main planetarium presentation. A major problem of instructing and evaluating the learning of heterogeneous audiences such as found in planetariums, museums, or science centers is this variability of audience traits. Active experiments with the variables which affect learning is one way of obtaining some concrete solutions.

Future Experimental Investigations

As noted in the previous sections of this chapter, future experimental work with public planetarium audiences should investigate other common planetarium procedures and techniques as to their measurable effects on the educational objectives with audiences of different types. These might include the effects of the number and type of certain visual and audio effects on the cognitive and affective domains of learning. Another interesting study could research the effect of interactive devices within a planetarium program which are now much easier with the recent increase in the technology of solid state electronics and mini-computers. Direct feedback by the audience as to their views or reactions to certain planetarium effects could be instructive (Gutsch, 1979). This information would be of great interest to the planetarium profession. Planetariums usually have a more homogeneous audience when dealing with a school group than with a general public audience, and so school experiments are easier.

A very important aspect of evaluation is the selection of the best instrument, especially when dealing with such heterogeneous groups as in public planetarium audiences. A written instrument may be too abstract for some patrons, while a personal interview may allow other confounding variables into the study. If the instrument is written, care should be taken as to its complexity, reading level, and length to accommodate the majority of the patrons.

The successful planetarium administrator must mix the correct amounts of entertainment, inspiration, and education in the public program to satisfy the patrons and if successful in this, they will return for future programs. Since attendance figures are vital to the funding of most planetariums, such an attempt to improve the planetarium's programing practices can prove beneficial to increased attendance and support. This particular study has implied that by slightly modifying a common technique, a patron can learn more. However, the precise connection between learning, entertainment, inspiration, and planetarium attendance patterns involves complex relationships which have not been resolved by the planetarium profession.

Summary and Evaluation in the Planetarium

This chapter has reported the conclusions and implications based on the experimental results of the research. The experiment was in the public programing domain of planetarium education, and so the majority of the conclusions and their implications can be directly applied to this population. Since school planetarium programing, museums, science centers, and school classrooms share many of the educational goals as public planetarium programing, some of the experimental conclusions and their implications also apply to these facilities. The conclusions and implications found in the study which relate to the relative learning from a planetarium program were the following:

1. All introductory techniques are not equal in their ability to facilitate learning.

2. The three active techniques of a written program, personal, and slide introductions are all superior to the null introduction.

3. The slide introduction is superior to the written program introduction.

4. The personal introduction is superior to the written program introduction.

5. The personal and slide introductions are approximately equal.

6. The null introduction will result in not only lower learning of subject matter but more variable and a wider range of learning will result.

7. The audiences of different program times may learn significantly different amounts.

8. The Sunday afternoon audiences learn significantly less than the 8:00 P.M. or 10:00 P.M. audiences.

9. The three types of audiences who attend the Sunday afternoon, 8:00 P.M., and 10:00 P.M. programs have population compositions which range from lower to higher age and educational level. This population difference may manifest itself in a wide range of learning for these program times.

10. The 8:00 P.M. and 10:00 P.M. audiences do not statistically differ in their relative amount of learning from the planetarium presentation.

11. There is no significant interaction of introductory treatment and program time.

12. Audiences at all program times learn less with no subject matter introduction.

13. Useful research can be conducted with public presentations if the research design is well planned and presented in a constructive manner in which the patrons are made to feel useful or helpful without being threatened. Blending the research techniques with the main program may assist in this regard.

14. Experimental research and supportive demographic material can be conducted and obtained in a public planetarium setting without adversely affecting the patrons' attitudes and attendance.

15. Planetariums should utilize subject matter introductions in their public presentations to maximize learning.

16. Planetariums should carefully consider and select appropriate subject matter introductions which will acquire and hold the patron's attention to facilitate learning from the public presentation. This calls for more compulsive or compelling introductory techniques as opposed to those introductions which are relatively more voluntary.

17. Planetariums should measure and consider the demographic traits of their audiences at different program times in planning the public program. Planetariums should not assume that all their public audiences will learn equally from the same presentation. More emphasis should be placed on matching the program with the estimated audience.

18. Modification or even substitution of a public program may be necessary to maximize learning by the audience of a particular program time. This suggests more flexible programing for planetariums.

19. Planetariums need to foster more evaluation with research which is well designed to verify the best techniques for facilitating learning that are available in the planetarium.

Our society is commencing to actively explore and colonize space. This activity may be perceived as a natural extension of the human curiosity and it forces people to become aware of their relation to the cosmos. The overall goal of planetariums is to provide high-quality science education about this exciting step for the human race. Knowledge of the methods and means of science is necessary for understanding astronomy and the space sciences. The quality of the planetarium experience should be commensurate with their high capital cost of construction. To insure that the education provided by planetariums is of the highest caliber, the planetarium profession must foster a basic awareness of the value of evaluation. Evaluation and its research process should be a continuous process, and any programing should not be complete without some formal manner of evaluation.

Evaluation within the planetarium profession has been miniscule, especially in public programing. School programing evaluation and testing is comparatively easy because of the direct connection with education and the homogeneity of the groups. The teachers who bring their classes to the planetariums desire their pupils to learn specific testable facts or concepts, while school administrators who fund such trips want substantiation of their educational value. However, a very small fraction of the total planetarium school programing effort is formally evaluated and its value is usually only verbally substantiated. This lack of solid verification in school programing becomes very apparent during stringent financial times, when difficult budget decisions have to be made by schools. More reliable support could be found if planetariums possessed a set of written common goals backed by well-designed experiments as to the unique educational capabilities of planetarium experiences.

Public planetarium programing presently faces a different and more direct dilemma. As noted in Chapter I, there are some people who believe that it is possible to strictly divide public programing into its entertainment, inspirational, or educational aspects. This type of analysis will be fatal for the majority of the planetarium profession because it detracts or modifies the initial and basic goal of the planetarium, which is educational in nature. Planetariums should not compete with the recent spectacular science fiction movies and their dramatic and expensive audio-visual effects. They should adapt those techniques which foster educational goals based upon thorough research within the planetarium profession as to the relationship between techniques and learning. Thus a science fiction theme for a planetarium program is adequate if the educational goals are well defined and the planetarium techniques foster their achievement. Planetarium administrators must realize that if the patron feels enjoyment by learning something from the program, then the patron has been both entertained and inspired. The direct dilemma faced by public programing is that if the patrons don't return to another program, then the planetarium's attendance quickly drops, as does its financial support. The positive attitude of evaluation aimed toward improvement of the programing effort must prevail.

This experimental research was conducted within the public planetarium programing domain because this aspect of planetarium research has received very little attention relative to its importance.

The scope of the experimental design was kept as small as possible while maintaining research integrity. This was done by randomly assigning treatments to programs and randomly selecting the subjects from each audience. The research demonstrates that useful information can be obtained by experimenting and testing the patrons of public programs without any negative effects.

The random selection of audience patrons and the actual overall administration of the post-test are techniques which could be improved by having the patrons go to a separate room for the post-test. Since most people attend the public programs in groups of two or more, the persons who were randomly selected from the audience were also the only ones in their social group participating in the post-test. This led to unnecessary interaction of the patron with other people. Another method might assume that people will sit randomly in a given area of the chamber and so the post-test may be given to that entire section of the chamber. As mentioned earlier, the selection of an appropriate measurement instrument is important, especially with the heterogeneous public planetarium audiences. Both selection techniques and instruments need more research in this field. A more ideal technique would be an electronic response and mini-computer combination to measure learning in a direct feedback mode. The evaluation technique used should not affect the test score results and must be within the financial bounds and staff assistance capability level of the planetarium.

This research has met its original goal of conducting research on the comparative educational impacts of introductory techniques on public audiences during a common planetarium production. It has also pointed out other areas in planetarium research which need attention and, hopefully, this type of design will serve as a model for other studies to utilize.

APPENDICES

APPENDIX A

POST-TEST INTRODUCTORY STATEMENT

APPENDIX A

POST-TEST INTRODUCTORY STATEMENT

The Planetarium AC would like to thank you for attending Abrams Planetarium. During this program we are conducting a survey to improve our public programing. The Planetarium AC would like to know:

Who are the audiences?
What kinds of programs do they desire?
What factors affect audience learning?

The AC has already randomly selected 30 of you to sample--he has placed a small dot on the right arm of the seats of those people to be surveyed! If you are sitting in a marked seat, please help us by raising your hand for the clipboard which has attached to it the questionnaire, answer sheet, and pencil to be distributed to you. Please answer alone! We will now have a brief intermission before the next program. Thank you for helping us bring you better public programing!

APPENDIX B

WRITTEN HANDOUT INTRODUCTION

APPENDIX B

WRITTEN HANDOUT INTRODUCTION

This is a science fiction story about energy, ENTROPY, and the future of our universe. Our universe contains billions of stars which are gathered into groups called galaxies. Humans are interested in how the universe changes and how this may affect the future. While studying the universe, we as humans have discovered some basic laws and many of them deal directly with the production of energy.

When scientists examine any self-contained system of the universe, there are certain laws which can be formulated. One of them deals with the randomness or lack of order of the parts of the system and is called the Law of ENTROPY.

ENTROPY is a measurement of the randomness of the energy in a system. The more the randomness of the parts of a system, the more the ENTROPY of the system. Furthermore, as the system uses or transforms energy, some of the energy gets changed into a type which cannot be completely recovered. Thus, some of the available energy gets lost.

For example, consider the automobile with its internal combustion engine. As the engine burns the fuel, only a small percentage of its available energy (less than 25 percent) goes into moving the car, while a large percentage (over 75 percent) is wasted and lost due to friction and incomplete combustion. The useless products of this energy process are frictional heat and exhaust gases which have more randomness than the original fuel. Furthermore, a lot of energy is lost for future recovery. Thus, ENTROPY has increased and available energy has decreased in this example.

Extending this to all sources of energy and even to the stars has made us aware that the universe is gradually running out of energy and the ENTROPY of the universe is increasing to a maximum. Stars will not be replaced by new stars at a rate sufficient to overcome this seemingly inevitable flow of ENTROPY.

Can ENTROPY ever be decreased to a large extent or will the universe just keep running out of energy? <u>The Last Question</u> ponders this possibility.

APPENDIX C

SLIDE INTRODUCTION SCRIPT

APPENDIX C

SLIDE INTRODUCTION SCRIPT

Slides With Graphics	Slides With Words
1. Spiral Galaxy	1. May the FORCE be with you.
	2. This program deals with ENTROPY and our UNIVERSE...
2. Cartoon figure with pointed ears and puzzled expression.	3. What is ENTROPY?
	4. ENTROPY has two aspects: ORDER AVAILABLE ENERGY
	5. ORDER: ENTROPY is a measurement of the amount of randomness of the parts of a system.
	6. AVAILABLE ENERGY: Any energy source produces some energy which cannot be recovered.
3. Unlabeled Car	7. Consider the AUTOMOBILE.
4. Car with parts labeled.	8. The automobile uses 25% of the fuel's energy to produce motion, while...
5. Car with % labeled.	9. 75% is lost in making the heated combustion products.
6. "Available Energy" 7. "ENTROPY"	10. Hence, ENTROPY has increased since some energy has been converted to a more random form.
	11. Extending this to all of Nature, we find a general law...
	12. "Over a long period of time the ENTROPY of a system will increase."
8. Galaxy 9. Pleiades	13. When astronomers apply this to the ultimate source of our energy-stars, we find...
10. Sun 11. Sunrise	14. ...stars must also die. Individual stars have different life spans dependent on their masses.
12. Planetary nebula	15. So ultimately, stars run out of energy and the ENTROPY of the Universe increases.
13. Crab Nebula	
14. Black Hole	
15. Cluster of Galaxies	16. Our primitive investigations infer this may be the ULTIMATE DEATH of the Universe...

16. ?????????????

17. ENTROPY??
18. Randomness??
19. Available Energy?
20. The Future??

17. ... but one always wonders if the flow of ENTROPY can ever be reversed.
18. This is THE LAST QUESTION.

APPENDIX D

ABRAMS PLANETARIUM AUDIENCE SURVEY

APPENDIX D

ABRAMS PLANETARIUM AUDIENCE SURVEY

Would you please help us to improve our public programs by answering the following questions on the attached answer sheet? Please do not mark on this page. Thank you.

1. What is your age?
    1) 12 or less
    2) 13-17
    3) 18-25
    4) 26-40
    5) over 40

2. What is your highest level of formal education?
    1) University or college level
    2) Presently attending a university or college
    3) High school
    4) Presently attending high school
    5) Elementary or middle school

3. What is your sex?
    1) Female
    2) Male

4. Which statement best describes your ability in math and science?
    1) High in math, high in science
    2) High in math, low in science
    3) Low in math, high in science
    4) Low in math, low in science

5. Before today, how many times have you been to public planetarium shows in the last 12 months?
    1) This is the first one.
    2) Once before.
    3) Twice before.
    4) Three times.
    5) Four times or more.

6. Before today, how many times have you seen the present public program?
    1) Today is the first time I have seen this program.
    2) Once before.
    3) Twice before.
    4) Three times.
    5) Four times or more.

7. What type of public planetarium show do you prefer the most?
   1) Current astronomy topics such as pulsars, quasars, and black holes.
   2) Current space exploration in our solar system.
   3) Science fiction.
   4) Historical astronomy showing ancient civilizations and their cosmic views.
   5) Basic astronomy such as the seasons, nighttime skies, and time.

8. Where did you find out about this program?
   1) Radio
   2) TV
   3) Newspaper
   4) Planetarium poster
   5) Word of mouth

9. How many science fiction books have you read in the past 12 months?
   1) None
   2) One
   3) Two
   4) Three
   5) Four or more

PLEASE MARK THE FOLLOWING STATEMENTS AS EITHER:
1) Generally true or 2) Generally false

10. The ENTROPY of the air in a balloon measures its randomness.
11. The ENTROPY of the air in a balloon measures its mass.
12. During the combustion of a fuel in an engine, the AVAILABLE ENERGY decreases and the ENTROPY usually decreases.
13. If a system has a certain amount of ENTROPY in 1978, it will probably have more in 2078.
14. A law of nature about ENTROPY is: "Over a period of time, the ENTROPY of a system will increase."
15. Our Sun is a star which will never run out of AVAILABLE ENERGY.
16. Stars which are more massive than our Sun will have longer lifespans.
17. Although stars do die, new stars will always replace them.
18. Science fiction considers the potential effects of science and technology on human beings.
19. THE LAST QUESTION refers to the possibility of increasing ENTROPY on a large scale.

THANK YOU VERY MUCH FOR YOUR COOPERATION. PLEASE RETURN THE QUESTIONNAIRE, ANSWER SHEET, AND PENCIL TO THE USHER.

APPENDIX E

STATISTICAL SUMMARY OF THE RESPONSES TO QUESTIONS ON THE ABRAMS PLANETARIUM AUDIENCE SURVEY

APPENDIX E

STATISTICAL SUMMARY OF THE RESPONSES TO QUESTIONS ON THE ABRAMS PLANETARIUM AUDIENCE SURVEY

Question	True	False	No Answers	Percentage Correct	Discrimination	Difficulty
1	978*	459	73	64.8	.653	.615
2	441	987*	82	65.4	.724	.616
3	398	1053*	59	69.7	.708	.629
4	1068*	383	59	70.7	.735	.611
5	1186*	266	58	78.5	.661	.669
6	80	1380*	50	91.4	.264	.862
7	844	609*	57	40.3	.428	.447
8	198	1254*	58	83.0	.420	.779
9	1345*	104	61	89.1	.312	.838
10	697	741*	72	49.1	.677	.523

* = correct answer.

BIBLIOGRAPHY

BIBLIOGRAPHY

Articles in Periodicals

Ary, Max. "The Third Stage of Planetarium Evolution." ISPE Planetarian 3 (Spring/Summer 1974): 11-13.

Bishop, Jeanne. "Format for a Mini-Research Investigation." ISPE Planetarian 4 (Spring/Summer 1975): 37-40.

________. "Planetarium Methods Based on the Research of Jean Piaget." ISPE Planetarian 5 (Fall 1976): 3-8.

Bondurant, Lynn R. "The Graded School Program, Part I." ISPE Planetarian 4 (Spring/Summer 1975).

Branley, Franklin. "Education in Major Planetariums." Bulletin of the American Astronomical Society 2 (1970): 192.

________. "Planetarium Education Programs in the United States." Projector 3 (April 1970): 24-26.

________. "Planetariums--An Evaluation." Science Teacher 31 (October 1964): 18-19.

Chamberlain, Joseph M. "The Sky in Replica." Natural History 69 (February 1969): 9-15.

Chamberlain, Von Del. "Planetarium Programing for the General Public." ISPE Planetarian 1 (June 1972a): 15-18.

________. "Planetarium Programming for the General Public." ISPE Planetarian 1 (September 1972b): 47-51.

________. "Planetarium Programming for the General Public." ISPE Planetarian 1 (December 1972c): 79-82.

Dean, N., and Lauck, G. M. "Planetarium Instruction--Using an Open-Sky Test." Science Teacher 39 (1972): 54-55.

Dunn, Jack. "UFO's: A Problem for Science--and the Planetarium." ISPE Planetarian 6 (Autumn 1977): 20-25.

Dwyer, F. M. "Adapting Visual Illustrations for Effective Learning." Harvard Educational Review 37 (1967): 350-416.

Franklin, Kenneth. "Careers in Astronomy." Sky and Telescope 24 (September 1962): 128.

Gallagher, Dennis. "There's Just No Accounting for Taste, Is There?" PPA, The Pointer--PAC, Planetarium Journal (Joint Issue) 2 (Summer 1970): 17-18.

Geoghegan, Jane. "More on Understanding Science." ISPE Planetarian 2 (Fall 1973): 116.

Hamilton, T. W. "Reading Scores and Planetarium Visits: A Correlation." ISPE Planetarian 5 (Fall 1976): 16-17.

Hurd, Paul DeHart. "Science and Communication." ISPE Planetarian 3 (Fall/Winter 1974): 63-71.

King, H. C. "Presidential Address." The Journal of the British Astronomical Association 70 (January 1970): 1-20.

Knapp, R. "A Major Advance in Projectors." Museum News 48 (November 1969): 12-15.

Marshall, Roy K. "The Planetarium." Sky and Telescope (First of Three Parts) 25 (November 1943): 3-5, 19.

________. "The Planetarium, Part II." Sky and Telescope 26 (December 1943): 12-13.

________. "The Planetarium, Part III." Sky and Telescope 27 (January 1944): 8-10.

Muhl, Gerald. "Seeking a Unique Role for Planetarium Educational Programming." ISPE Planetarian 4 (Fall/Winter 1975): 7-12.

Neville, Robert D. "The Planetarium Director--The Individual and the Changing Art." ISPE Planetarian 4 (Fall/Winter 1975): 2-7.

Nichelson, Thomas D. "The Planetarium Lecture." Curator 2 (1959): 269.

Ortell, Edward D. "The Value of the Planetarium as an Instructional Device." ISPE Planetarian 6 (Autumn 1977): 17-20.

Pitluga, George. "Planetarium Visit: An Evaluation by Teachers." Science Activities, December 1972, p. 15.

Powers, Stanley. "The Planetarium in College and University Education." ISPE Planetarian 2 (June 1973): 46-53.

Reed, George, and Campbell, J. R. "A Comparison of the Effectiveness of the Planetarium and the Classroom Chaulkboard and Celestial Globe in the Teaching of Specific Astronomical Concepts." School Science and Mathematics 72 (May 1972): 368-74.

Rodger, David A. "To Any Critics Who Are Listening." ISPE Planetarian 5 (Summer 1976): 24-26.

Rush, William. "Tips for the New Planetarian." ISPE Planetarian 6 (Autumn 1977): 3-9.

Shaw, William R. "A Workshop in the Teaching of Astronomy." Sky and Telescope 15 (March 1956): 213.

Smith, Theodore. "Effectiveness of Constellation Figures." ISPE Planetarian 3 (Fall/Winter 1974): 74-83.

________. "Using a Paper and Pencil Instrument to Evaluate Elements of Observational Astronomy." ISPE Planetarian 5 (Fall 1976): 8-17.

Soroka, John. "Considerations for Planetarium Educators." ISPE Planetarian 3 (Fall/Winter 1974): 112-23.

Sternig, John. "Astronomy." Science Education 33 (October 1939): 277.

Vanek, Polly H. "The Role of Astronomers in Elementary and Secondary Education." Bulletin of the American Astronomical Society 2 (1970): 25-27.

Verschuur, Gerrit L. "The Role of the Planetarium in Astronomy Education or Should We Do Shows on UFO's?" ISPE Planetarian 4 (Fall/Winter 1975): 13-17.

Warneking, Glenn. "Planetarium Education in the 1970's, A Time for Assessment." Science Teacher 37 (October 1970): 14-15.

Wiesner, S. "Prisoners of the Sun." PPA, The Pointer--PAC, Planetarium Journal (Joint Issue) 2 (Summer 1970): 19-20.

________. "Survey to Evaluate the Calgary Centennial Planetarium." ISPE Planetarian 5 (Summer 1976): 19-21.

Books and Special Reports

Ausubel, David P. Educational Psychology: A Cognitive View. New York: Holt, Rinehart, and Winston, Inc., 1968.

________. The Psychology of Meaningful Verbal Learning: An Introduction to School Learning. New York: Grune and Stratton, Inc., 1963.

Campbell, Donald T., and Stanley, Julian C. Experimental and Quasi-Experimental Designs for Research. Chicago: Rand McNally, 1966.

DeCecco, John P. The Psychology of Learning and Instruction: Educational Psychology. Englewood Cliffs, N.J.: Prentice-Hall, Inc., 1968.

Dressel, Paul L. Handbook of Academic Evaluation. San Francisco: Jossey-Bass, 1976.

Gallagher, D. Planetariums of the World. Winnipeg, Manitoba, Canada: Manitoba Museum, 1970.

Glass, Gene V., and Stanley, Julian C. Statistical Methods in Education and Psychology. Englewood Cliffs, N.J.: Prentice-Hall, Inc., 1970.

Hays, William L. Statistics for Psychologists. New York: Holt, Rinehart, and Winston, Inc., 1963.

Hill, Joseph E., and Kerber, August. Models, Methods and Analytical Procedures in Educational Research. Detroit: Wayne State University Press, 1967.

Korey, Ruth. Contributions of Planetariums to Elementary Education. Ann Arbor, Mich.: University Microfilms, 1963.

Moore, Maurice Gene. An Analysis of Planetarium Programming as It Relates to the Science Education of Adults in the Community. Ann Arbor, Mich.: University Microfilms, 1965.

Reed, George. A Bibliography for Planetarium Education: 1960-May, 1972. ISPE Special Report No. 2. Albany New York: ISPE (International Society of Planetarium Educators), 1972.

Rosemergy, J. An Experimental Study of Effectiveness of a Planetarium in Teaching Selected Astronomical Topics. Ann Arbor, Mich.: University Microfilms, 1967.

Sagan, Carl. Cosmic Connection: An Extraterrestrial Perspective. New York: Dell Publishing Co., Inc., 1975.

Sperling, Norman. A Catalog of North American Planetaria. ISPE Special Report No. 3. Albany, N.Y.: ISPE, 1973.

Conference Presentations

Bisard, Walter J. "Evaluation: Where Does It Fit Into Your Planetarium?" Paper presented at the fourth biennial conference of the International Planetarium Society, Inc., Washington, D.C., 1978.

Gutsch, Bill. "An Effective Domain Feedback System for the Planetarium." Paper presented at the fourth biennial conference of the International Planetarium Society, Inc., Washington, D.C., 1978.

Hall, Donald S. "Who Comes to the Strassenburg Planetarium?" In Proceedings of the 1974 Conference of ISPE. Edited by Robert Tate. Atlanta: ISPE, 1975.

Shapiro, Lee. "The Growth of Planetariums in the United States and the World." Paper presented at the fifth conference of the International Planetarium Directors Conference, Boulder, Colorado, 1975.

Unpublished Materials

Battaglini, Dennis. "An Experimental Study of the SCIS Involving 4th Graders' Ability to Understand Concepts of the Relative Position and Motion Using the Planetarium as a Testing Device." Ph.D. dissertation, Michigan State University, 1971.

Bisard, Walter J. "Planetarium Planning Procedures." East Lansing, Mich.: Abrams Planetarium, 1975. (Typewritten.)

Bondurant, Lynn. "Sky Identification: An Evaluation of Student Success." East Lansing, Mich.: Abrams Planetarium, 1970. (Typewritten.)

Curtin, Thomas. "An Analysis of Planetarium Program Content and the Classification of Demonstrators' Questions." Ph.D. dissertation, Georgia State University, 1975.

Haywood, Robert Ross. "The Developing and Field Testing of an Instrument Using the Planetarium to Evaluate the Attainment of the Concept of Annual Motion." Ph.D. dissertation, Georgia State University, 1975.

Oines, Ronald. "Comparative Effectiveness of Individually Prescribed Instruction and the Lecture Demonstration Method to Achieve Behavior Objectives for a Descriptive Astronomy Course." Ph.D. dissertation, Ohio State University, 1971.

Ridkey, Robert W. "A Study of Planetarium Effectiveness on Student Achievement, Perceptions, and Retentions." Ph.D. dissertation, Syracuse University, 1973.

Schafer, Sheldon. "A Study of Current Practices in Major American and Canadian Public Planetarium Operations." Master's thesis, Wagner College, Staten Island, New York, 1975.

Smith, Billy. "An Experimental Comparison of Two Techniques of Teaching Selected Astronomy Concepts to Sixth Grade Students." Ph.D. dissertation, Arizona State University, 1966.

Sunal, Dennis. "The Planetarium in Education: An Experimental Study of the Attainment of Perceived Goals." Ph.D. dissertation, University of Michigan, 1973.

Tuttle, Donald E. "Effects of the Use of the Planetarium Upon the Spatial Concepts Among Selected Sixth Grade Students in Elgin." Master's thesis, Northern Illinois University, 1966.

Wright, D. L. "Effectiveness of the Planetarium and Different Methods of Its Utilizations in Teaching Astronomy." Ph.D. dissertation, University of Nebraska, 1968.