THE PLANETARIAN is published each March, June, September, and December by the International Society of Planetarium Educators, Inc., under the auspices of the Publications Committee.

To make a change of address, please send an old mailing label, along with the new address, to Ronald N. Hartman, Mt. San Antonio College Planetarium, Walnut, CA 91789. Allow 30 days for an address change to take effect.

EDITOR: D. David Batch
Circulation Director: Ron Hartman
ISPE Publications Chairman: John Cotton
Editorial Assistance: Frank Jettner, George Lovi

Any project the size of a PLANETARIAN double issue cannot be the effort of a single person. The Editor wishes to acknowledge the most valuable assistance of Lee Shapiro and Betsey Taack, both of Abrams Planetarium.

COVER:
A modern Hopi silver "sky symbol" jewelry piece. Note the sunburst, cloud and rain motif, moon (astronomically inaccurate) and stars. From Von Del Chamberlain's article, beginning on page 89. Photo courtesy of author.

CONTENTS

Science and Communication
Paul DeHart Hurd ............... 63
The Spacearium
Charles G. Barbely ............... 72
The Effectiveness of Constellation Figures
Theodore V. Smith ............... 74
The Exobiologist
Jeanne Bishop ............... 83

Mirror Movers for a Trip to the Planets
Everett Q. Carr ............... 84
The Campfire Analogy for Annual Motion
Robert C. Tate ............... 86

American Indian Astronomy Program ........... 88
American Indian Interest in the Sky as Indicated in Legend, Rock Art, Ceremonial and Modern Art
Von Del Chamberlain ............... 89

A Report on IAU Commission 46
Dorothea E. Beetle ............... 107
Times Are Tough ............... 109

Jane's Corner
Jane P. Geoghegan ............... 110

Considerations for Planetarium Educators
John J. Soroka ............... 112

Dome Geometry
O. Richard Norton ............... 124

Planetarium Literature Review
George Reed ............... 129

THE PLANETARIAN, Vol. 3, Nos. 3 and 4 copyright 1974, International Society of Planetarium Educators. All rights reserved.

Inquiries regarding MEMBERSHIP in the International Society of Planetarium Educators should be directed to:
Walter Tenschert
Thomas Jefferson High School
6560 Braddock Road
Alexandria, VA 22312
I always find it somewhat disturbing to talk to a group of professionals in a field other than my own, even though we may have a common interest. However, Tom Gates had asked that I say something about science, science education, some of the changing directions that are taking place, and how these might be related to planetarium programs. I decided to accept this invitation because I realize how terribly important it is for all educational agencies to cooperate, especially those that have an interest in the fields of science. For the next few minutes I plan to scan the scene in science, society, and education. I'll be trying to indicate briefly what the future might hold for programs that you are mostly concerned with.

I think we can say without question that this is a time in history when there is a great complexity of problems. Unfortunately, science and technology are being blamed for most of these problems. In less than a decade we see that science has moved from a role of priest to that of servant. Caught in the middle of this switch from science as the dominant influence and "idol" held up to every youngster going through school, we find the whole field of education. As you know, the attitude of the general public towards education today is a somewhat dubious one. We have hundreds of books being published criticizing education and what schools are about, and at least two books solving all the problems of education--"Just teach school, America, and you won't have any more problems."

Let's take a look at science courses in the schools today. Be-
tween 1957 and 1970 the National Science Foundation spent an even one billion dollars to develop new curricula and to train people to handle them. These new curricula, developed during the 1960's, were structured and organized to reflect the discipline. Many of you will remember what Zacharius said way back in 1956 in the development of PSSE Physics. "If physics was taught the way that physicists understand it, it would be inherently interesting to children." Now, it's just about to disappear from the curriculum. We have the lowest enrollment we've ever had in physics this past year. Laboratory experiments of all kinds were devised to display the investigative aspects of science and show how scientific research takes place. The goals of science were to try to get young people to think like scientists or to know science as it is "known by scientists".

The rationale for teaching science during the 1960's was what my friends in Great Britain call enlistment science. We wanted to capture the interest of young people and enlist them into the field to help alleviate the technical manpower shortage. We certainly no longer have this condition—not with 3,000 unemployed Ph.D.'s in science alone. We either were very successful or we failed, for I'm not sure how you interpret these results.

Now the educational problems and the crisis we have in the 1970's are certainly entirely different from those in the 1960's. First, we are in a period of great social tension and great cultural turbulence. Recently we have seen the emergence of a counter-culture in which young people reject the traditional life values and express a loss of faith in existing social institutions. They are anti-establishment and they criticize schools for lacking relevance. The issue to them is not how much better life is now than it used to be, but how bad society is today compared to what it could be. They point out the seemingly endless piling of crisis upon crisis: economical, political, social, educational, environmental, technical and others. Don't forget the tension of everyday life, for example the insecurity of unemployment, loneliness, racism and violence. We can go on for quite some list. In the last few years we have watched this counter-culture move from what in 1968 was described as an acid culture to a drug culture and then to a disturbing quiescence. I suppose none of us are fooled into thinking that this youth revolution has failed. I suspect it has just gone into hiding to seek new direction. While there's no doubt the world of the 1970's is not the world of 10 years ago, it is also quite apparent that the emerging lifestyles of the 1970's are in contrast with those of the 1960's. This change has come about very suddenly, note the sociologists, political scientists, and others.

Where does science and technology fit into all of this? We find that both are on trial. Technology which has maintained the strength of our economy for decades is now regarded as an enemy of our natural environment and as a major force in the dehumanization of many. There exists a fear of technological development without some kind of prior assessment in terms of human values. There is a bill before Congress for the establishment of an office of technical assessment which will examine each invention, whether it will have any influence or not, and decide in advance if it should be censored. Scientists, who have enjoyed the isolation of the objective world for centuries, are now put upon by the general public to direct their research activities towards the common good and to add
a dimension of social responsibility to the scientific enterprise.
Science is thus on the defensive, characterized by an anti-science sentiment among the general public and students alike. I might say that Congress, after appropriating money for research for the National Science Foundation this year (1972), found that the Bureau of the Budget had cut the amount of money in half.

The more pessimistic writers do see an end to continued progress, a slowdown in human achievement. We are in the midst of a quite conservative movement. We find that there are commissions in Congress that want to set up a bureau of social responsibility. We find the general public saying, "Yes, we're willing to spend one billion dollars next year for research if you'll establish a Manhattan project to find a cure for cancer, but not one penny to find another particle in the atom". Notice that biologists are fighting it because we're not ready for a Manhattan project in biology. We don't have the amount of information that was held in 1943 on atomic fission. Nevertheless, the pressures are there. Science as an enterprise is not the same science we had 10 years ago.

One of the most important issues is how to bridge the various gaps between science, science and society, science and technology, and then proceed to the individual and what he is to be taught. We must do this at the very time that society is undergoing an extensive cultural transformation and much soul searching in an effort to find itself. We require a new kind of vision about the world it is possible to achieve and what this is going to mean for education.

Science, through its technological applications, forms a delicately balanced system that influences to a major degree both our society and political life, nationally and internationally. Conditions have advanced to the point where we can no longer consider it separate from the social forces which determine our course of human activities and our manner of living. The international environmental conference of last summer (1972) and other international conferences offer some encouragement. We're just beginning to look at science and technology in developed and undeveloped countries, seeing the impact upon different societies, viewing a global picture.

Given these new outlooks, new goals for science instruction ought to be developed. They must include science teaching for the general citizen. He must learn to place what he finds out about science in a social context with the focus upon the welfare of mankind. It seems quite certain that we are moving closer and closer to science that is more moral.

To achieve this broad purpose would require that science be presented with as much emphasis upon its application to human affairs as upon its theoretical structure and investigative processes, which is the way it has been presented in the last 10 to 15 years. It is evident that science and technology have become linked in various ways to all aspects of human existence. It may be a question as to whether science is a servant of society or society the handmaiden of science. There are no doubts that each depends upon the other for survival.

No longer, then should science be taught as an elitest subject, as it has been in most high schools. Science has been dedicated solely to its own advancement independent of the rest of society, governed by its own rules, and erected entirely by its own policies. This suggests, then, a need for a new synthesis of science and technology. We need an
approach to science education that is more comprehensive, goes beyond disciplines, and considers the whole of science in terms of its meaning for the individual.

During the past several years over 200 colleges and universities have established such programs. Forgive me for mentioning Stanford, but we have a major in human biology, which crosses the departments of biology, psychology, medicine, sociology and anthropology. We have a four-year major in science, technology, and values, whose classes are team-taught by a person from physics or engineering and one from the humanities. This is what we mean by placing the teaching of science into a new context. Even the Ph.D. level, instead of focusing one's study to a sharpening point, tends to broaden one's studies. Someone has noted that the fertility of hypothesis does not increase through specialization. The activities of various fields are found instead at the interfacing of sciences such as biology and chemistry, biology and physics, and other similar combinations.

Much of the present crisis in science and in science teaching is based on the relationship between knowledge and values. These were always separated in the science curriculum. Science was taught as a value-free subject in schools. The question most frequently raised now is "what are the social responsibilities of science?". I taught a doctoral seminar in science for one whole year which met once a week for three hours, and we used only the editorials of technical science journals. It was only necessary to read these editorials to see the debate going on about the responsibilities of science to society.

The question is raised "does science have a commitment to society, or only to itself? In fact, can value be separated at the practical level? Scientist and sociologist alike have observed that a great deal of conflict and turmoil that we experience in life results from a poverty of values, from too little that we really care about, and from a paucity of social commitments.

Probably the most serious criticism that can be made of American education is that kids come out not caring about anything. Nothing seems to be very important. We brought this on ourselves, those of us in educational fields, especially the scientists, because we made the subject value-free and told them that was the way to become objective. We never told them that data had a qualitative as well as quantitative dimension. Is it not strange in this period of history when we have the knowledge and the material resources to do about anything we wish that we are among the most confused in the world about what we ought to be doing? Values provide guidance and direction in the use of knowledge.

Unfortunately present programs for science education are both value-free and anti-idealistic. Science instruction is mostly concerned with matters of fact, ignorant of the end result, and this leads me to suggest that if science is to be meaningful for a higher level of human responsibility and rationality, then opportunity for students with worthy values must be given a high priority in the science courses. Now that does not mean that educational agencies should institute a particular set of values. On the contrary, what it means is that people should be allowed to consider alternative interpretations of data. A science program which lacks a consideration of values has only information to offer. There is no way a student can convert what he learns into wisdom.

Educational programs for centuries have been planned with the
idea that tomorrow will not be much different from today. We all have had those courses. One result of this action is that today's problems are perpetuated because we always select our curriculum content from what has happened in the past. How can we design a curriculum and goals for tomorrow, when those who wish to lead the future are defending the status quo? This generation of young people (I think this is probably the thing that they are clearest about) seeks an education that has the possibility of directing a world to something better than already exists. This issue is a very complex one, but the message is clear. Young people want an education for that period of time in which they will be spending most of their adult lives. They do not want an education that has the historical setting of their parents or even that of their teachers, for they will never live in those times.

A liberal education in science ought to prepare students to cope with a world of change. The future can no longer be taken on faith, but will require careful planning to avoid catastrophes. We've heard a lot about these catastrophes in the environmental sciences. Some are probably accurate and some aren't. But I think no one doubts that we have to pay more attention to the future, and that this will require an education that has a direction towards the future. We too often forget that the future is the only period of time of our whole life over which we actually have any control.

Our present mode of science teaching is on a collision course with the future because the student is permitted little opportunity to free himself of the present and to consider ways in which a more satisfying future for mankind might be planned. Science curricula are written as though the authors were looking into the rear view mirror of an automobile. Today's educational problems concern how best to teach and learn about the future, and how to reach from the here-and-now to the there-and-then. In planning educational programs for a future orientation, we do a great deal to shape that future and minimize the possibility that man himself may become a victim of his own neglect. A science program which neglects man's future is an essay on history.

We're moving into a period sometimes described as a post-industrial society in which learning and knowledge are likely to be the primary economic resources of the world, however, not in the sense of the knowledge explosion we have seen over the past quarter century. For decades we have simply been content to add more and more knowledge to the stockpile we already have without much regard to what is needed or how it will be used. In fact most scientists say "this is no concern of mine - I just uncover or offer new explanations." Consequently we have developed a tremendous chasm between the creation of knowledge and the utilization of knowledge.

Today we have access by one means or another to nearly all the knowledge that ever existed. Individually and collectively we know more than people have ever known before, but the startling result is increased ignorance. We know less about how to solve contemporary problems of life than in any time in man's history; witness our national and international disinterest, the disenchantment of youth with existing social goals, and the identity crisis, just to name a few. The whole purpose of education seems to me to be obvious: it should be to reduce ignorance, not to increase it. That's still admitting, however, that a person has to know twice as much in
this century to be considered ignorant as he did in the last century!

I suppose the one thing that has emerged and become clearest is that we've tried to solve our problems in society and in general on a straight line basis, without recognizing the many interactions and connections they have with each other. We've done this because this was the way people were trained. They majored in a particular field in college, they were specialists in some discipline, and they kept their eyes focused straight ahead—and missed the problem. The most active fields of research are not in the most highly refined specialities, as we indicated before, but at the interfaces of various sciences. In a similar way the problems of living are not resolved by discipline but through the integration of knowledge and the interrelated methods of knowing.

Over the past decade there has been a great emphasis in science teaching on the development of inquiry and discovery processes. I suppose everyone that wrote a curriculum in the past ten years ended up by saying that "this is to teach children to inquire and to discover", and they used a very loose definition of the word discovery. I've found teachers in the first grade having students discover principles of science, or so they claim, every time a magnet attracts something. I've heard them use the word "creative" for every random movement of a youngster with paint on his finger. Inquiry, if we stop to analyze it, is producer-oriented. It is what a scientist does.

The problems students must deal with, however, are real-life problems, and they are more task-oriented than experimental. Most people don't do experiments. They use data that has been generated to make judgments, and this is what we're looking for. Decision-making is a way of maximizing the meaning of information, not in finding right answers. It gives information the potency for action. During the 1960's where the educational emphasis was on how information is obtained in science through the process of inquiry and discovery, little or no attention was paid to increasing human capacity for resolving problems through the application of knowledge. This is the difference between knowledge in being and knowledge in action. What we're seeking for the '70's is an education in science that combines learning with actions, tempered with a new sense of human values.

As I see it, these are the emerging directions in science teaching as they relate to education for an enlightened citizenry in an age of science. We've never had an education in science to help people live in an age of science; we've taught them what the scientist knows, but not what the citizen must know to live in this age.

Now I'd like to consider very briefly some of the implications for planetarium educators. First, the accelerating rate at which new information is generated in science and its importance to life suggests the need to extend the range of educational agencies beyond schools. If you follow the educational literature, you will note that in the last year a great deal of emphasis has been put on the need to bring in more agencies to care for education. The schools simply cannot do it all; either they are not set up to do it all, or they don't have the resources. It takes 100,000 scientific and technical journals to report the research that is completed each year. The annual number of research articles reported is around 6 million studies (last year's figure), and
this century to be considered ignorant as he did in the last century!

I suppose the one thing that has emerged and become clearest is that we've tried to solve our problems in society and in general on a straight line basis, without recognizing the many interactions and connections they have with each other. We've done this because this was the way people were trained. They majored in a particular field in college, they were specialists in some discipline, and they kept their eyes focused straight ahead—and missed the problem. The most active fields of research are not in the most highly refined specialities, as we indicated before, but at the interfaces of various sciences. In a similar way the problems of living are not resolved by discipline but through the integration of knowledge and the interrelated methods of knowing.

Over the past decade there has been a great emphasis in science teaching on the development of inquiry and discovery processes. I suppose everyone that wrote a curriculum in the past ten years ended up by saying that "this is to teach children to inquire and to discover", and they used a very loose definition of the word discovery. I've found teachers in the first grade having students discover principles of science, or so they claim, every time a magnet attracts something. I've heard them use the word "creative" for every random movement of a youngster with paint on his finger. Inquiry, if we stop to analyze it, is producer-oriented. It is what a scientist does.

The problems students must deal with, however, are real-life problems, and they are more task-oriented than experimental. Most people don't do experiments. They use data that has been generated to make judgments, and this is what we're looking for. Decision-making is a way of maximizing the meaning of information, not in finding right answers. It gives information the potency for action. During the 1960's where the educational emphasis was on how information is obtained in science through the process of inquiry and discovery, little or no attention was paid to increasing human capacity for resolving problems through the application of knowledge. This is the difference between knowledge in being and knowledge in action. What we're seeking for the '70's is an education in science that combines learning with actions, tempered with a new sense of human values.

As I see it, these are the emerging directions in science teaching as they relate to education for an enlightened citizenry in an age of science. We've never had an education in science to help people live in an age of science; we've taught them what the scientist knows, but not what the citizen must know to live in this age.

Now I'd like to consider very briefly some of the implications for planetarium educators. First, the accelerating rate at which new information is generated in science and its importance to life suggests the need to extend the range of educational agencies beyond schools. If you follow the educational literature, you will note that in the last year a great deal of emphasis has been put on the need to bring in more agencies to care for education. The schools simply cannot do it all; either they are not set up to do it all, or they don't have the resources. It takes 100,000 scientific and technical journals to report the research that is completed each year. The annual number of research articles reported is around 6 million studies (last year's figure), and
there will be more this year. It has been necessary to generate a whole new science with its own journals called "Information Retrieval" in order to help the specialist keep up-to-date. The average citizen is so buffeted by this overload of knowledge that he has become the victim of charlatans, astrologers for example, and other kinds of entrepreneurs who claim to provide answers quickly and cheaply.

Schools can no longer manage the whole task of formal education and I think we might as well admit that. New sources for the transmission of information are needed. As I see it the planetarium provides one of these resources, along with museums, zoos, nature areas, observatories, parks, aquariums, and all other kinds of special facilities.

In this expanded role as a part of formal education there is need to reconsider goals. There is a difference between serving as a supplementary agency to schools, which many agencies such as museums and planetariums do, and assuming the major responsibility for a segment of the child's education. For the most part planetariums, museums and so forth have either served to reinforce the school's science curriculum or ignore it altogether. I'm suggesting that the situation be reversed and that the school be the supporting agency. There are 300,000 elementary school teachers in the United States who make up the staff of 65,000 public schools and 15,000 private elementary schools and preschools. My guess is that there are fewer than 100 teachers that know what you (as planetarium educators) know about astronomy, and that less than a dozen schools are equipped to the extent that you are to teach it in its best form. I feel that the relevant science topics should be taught by you in a framework of a planned sequential curriculum structure. The child should be able to return to the planetarium year after year and find programs which are carefully built on his previous visits and can extend his insight. That is what I mean by a formal education program. The planetarium program can then be reinforced by teachers. I see the planetarium director taking on the responsibility for the in-service education of our teachers through special programs. Many are already doing this; however, it is to supplement teachers in what they are doing and in their context rather than in the context of the planetarium. These programs may also serve as a means for instructing teacher aides and parents who have children in school.

One of the enterprises we're now working on in the field of education is helping parents be equally well informed on curriculum. I have spent time writing curriculum guides for parents about the courses their children are taking. If parents aren't informed, we're going to have children interacting with the new developments in science and the same things will occur that happened with the new math. When youngsters came home from the first grade talking about set theory, parents couldn't understand them and thus were against it.

It would be expected that schools have science programs which include topics on astronomy, and that planetarium and school program sequences should be coordinated. Here again, I believe much of the leadership needs to come from the planetarium staff. In-service education is a growing part of teacher education today. The art of on-the-job training will undoubtedly increase in future years. Here I see a major responsibility for all agencies that are outside the school. No one feels that you can educate a teacher now,
or during any four or five year period of time in a college or university, with the kinds of experience that they're going to need for the rest of their time. Coming back to colleges and universities doesn't help much. They need the kind of extended education that involves the resources of their own community. They need to learn to take advantage of local assets and be able to adapt the curriculum to suit the purposes of the area and the clientele.

If planetariums become an integral part of the total learning environment of a child, typically planetarium educators will need to pay more attention to the conditions of learning. The following suggestions are offered from my experience at Stanford over the last 25 or 30 years. First, the sequence of learning needs to be organized into some sort of hierarchy to go from one year to another. It's been my observation that the audience has too great a range for all to profit, or even come near profiting. Secondly, reduce the concept overload. Because so little time has been spent in museums and planetariums there has been a temptation to teach too much. Consequently, the youngster doesn't go with the one concept; there has been a concept overload. Probably the greatest thing we're attempting to do in education programs is to slow them down so that there's a chance to comprehend and a chance to understand. Thirdly, provide an opportunity for participation activities by children. Give them a chance to do something more than to just look and see. Finally, extend opportunities beyond the planetarium program to such areas as experiments, observations, readings, hobbies, and other kinds of reinforcing agencies.

In summary what all this 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 specially planned program built around a few concepts to extend learning, the interest goes for naught or for very little.

New goals for teaching science are developing rather clearly now, through all kinds of agencies: the American Association for the Advancement of Science, the National Science Foundation, even the National Academy of Science is paying attention to how scientists are being taught. I might add that the National Academy has even broken down its disciplinary lines and now accepts grants in terms of problems, not in terms of disciplines. Changes are taking place.

All of these changes are undergoing considerable debate to be sure. The nature of science and how it should be taught is the central theme of these debates. The major issues are providing access to information and determining through one's own efforts how to use what is learned for making rational decisions.

We have another problem in American life which I'd like to indicate briefly in closing. The future promises that we're going to have more leisure than we have now. If anyone thinks that we're going to have less unemployment in the future, I think they're mistaken. We'll probably average 50% by the year 2000, and those over 50 years of age will probably look forward to 100% leisure time. Right now we're not really faced with this problem, though society has observed it growing for several years. We have been saved from facing the problem in two ways. First T.V. manages to sop up about 1000 hours a year of adult life, and even more for children. Spectator sports take up the rest! These have been time sops, but
they're beginning to run thin.

We must now face the issue of how to make intellectual use of leisure time. This is a matter of major concern for an increasing number of people. They would like to enjoy the game of science not as producers but as serious observers, in much the way that the nobility of the middle ages did when they gave harbor to a scientist just because they were interested in what he was doing and enjoyed carrying on a dinner conversation over a glass of wine. Scientists, however, mostly tell about their achievements in what amounts to a secret language. In most cases the code is not even understood by other scientists if they're outside the fraternity of a particular discipline. To be sure the results of their thinking are published. Yes, they are published in one of the 100,000 technical journals now in print, but these have an average circulation of only 800 copies.

How does the average citizen contact this flow of information in different areas which might interest him? Suppose we take a look at modern astronomy. I'll begin modern astronomy, say, when the first V 2 rocket was launched on October 10, 1946. That is a good beginning point because that's just a quarter of a century ago. What's happened since 1946 in terms of space, the world, and outer space? We've gone from rockets to satellites, to space laboratories, and as we go into the 1970's we can look forward to the high energy astronomical observatory series that will be developed, and into the 1980's through a large space telescope program which is going to explore the size and structure of the universe.

Now this is the game that I'm speaking about, the game that an increasing number of people would like to be a part of intellectually.

This reminds me of the first federal grant that was made for science research in the United States—a $10 grant by Congress to study the transit of Venus. When Benjamin Franklin reported back, Congress decided that it was worth the money!

I have an idea that most people think we know a lot about the size and structure of the universe, yet we realize this is an unsolved question, or at least that there's little agreement about the answer.

The average man is largely cut off from all these exciting events. In the July 21, 1972 issue of Science there is an article called "Report on Astronomy – A New Golden Age". I would, as a biologist and an educator in my silver years, like to enjoy this golden age of astronomy, but I need a guide and I need an interpreter. This I see as an educational function of the planetarium: present a sizable percent 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.

We are at a turning point in history—turning from a laboring to a learning society. There are tremendous opportunities for educational agencies, planetariums and museums among others. Many are already seeing new visions for their own future, and foresee a new era for civilization.

(End)
THE SPACEARIUM
A Planetarium for the Smithsonian

by Charles G. Barbely, National Air and Space Museum, Smithsonian Institution

The National Air and Space Museum, seen from the Mall. The Spacearium is located in the third marble cube from left. Photo courtesy of author.

Joining the Smithsonian museums on the Mall in Washington is the new $41 million National Air and Space Museum. The building itself is complete, but closed to the public while exhibits and other facilities are installed and readied for opening Sunday, July 4. One of these facilities is the Albert Einstein Spacearium, a 70-foot diameter planetarium.

The three block long museum is located on the Independence Avenue side of the Mall, directly across from the National Gallery of Art. Designed by architect Gyo Obata of St. Louis, the building is a combination of marble and glass which provides an airy, open setting for some historic aircraft and spacecraft, while permitting the creation of carefully controlled exhibit environments in enclosed galleries. The building has four levels including a basement garage for public parking.

The ground and second levels are for public galleries, the Spacearium, and a large-film theater (see Figure 2). Offices, a library, Spacearium shop facilities, and a public cafeteria are on the third level.

Spacearium visitors will be carried by escalator to the second level holding area, where tickets may be purchased. Entry to the dome room is by one of two wide doorways opening to rising ramps. The ramps are necessary for the convenience of physically handicapped visitors and to allow a special effects projection gallery to run uninterrupted over the doorways. The seasoned planetarium visitor will note the low, seven-foot-eight-inch dome springline height which should help lessen the unseasoned visitor's "sitting-in-a-bowl" syndrome. The floor is level, and about 250 seats are placed in an "epiconcentric"
Figure 2. Second Floor Plan, National Air and Space Museum

arrangement; that is, the center of the concentric seating is offset from the center of the room. This seating plan bears a unidirectional quality, while giving most of the audience an easy view of 50% or more of the dome. At a Whitehouse dinner in summer 1975, President Walter Scheel of West Germany announced his country's gift to the Smithsonian of a Carl Zeiss Model VI planetarium instrument, along with approximately $300,000 for a digital control device and other equipment. The gift is part of Germany's commemoration of the American Revolution Bicentennial. The digital control device, or "computer" as it is more easily (albeit improperly) called, is being developed and fabricated by Gyrosystems, Inc. of Farmingdale, N.Y. In addition to controlling the planetarium instrument, the computer will operate up to 400 special effects projectors located in the projection gallery behind and slightly below the edge of the dome. When the complete instrument and control system is installed, it will be capable of manual control, automatic control from tape or a flexible disc, and combinations of various types of control -- Murphy's Law notwithstanding.

The mount of the planetarium instrument rests on an electric turntable, which is in turn mounted on an elevator platform. Thus, the instrument can be lowered below floor level, and the starfield can be moved in azimuth.

The dome is made of perforated aluminum and is supported by a frame which can bear a technician's weight at any point. A pivoting ladder arcs over the dome, and can be moved around on tracks for access to any point on the back of the dome. This accessibility is necessary for rear-dome visuals and for installation and maintenance of dome sound speakers.

The sound system will consist in part of eight large, bi-amplified theater-quality speakers over the projection gallery ceiling, assisted by 28 smaller speakers attached to dome support members at various places and heights. Speakers can be switched manually or by the computer to give the illusion of moving sound effects. Currently undergoing installation, the sound system will be capable of generating 2,040 watts of audio power.

The Spacearium's first show, Cosmic Awakening, is in production for the Bicentennial opening. It is a tour through history and the scientific revolutions that have altered our concept of the universe, with a look to the future, to the next cosmic awakening that may await us.

(End)
The Effectiveness of Constellation Figures

by Theodore V. Smith, Nova University, Fort Lauderdale, Florida

ABSTRACT
Two groups composed of both third and fourth grade students were each taught constellations by different methods. One group was shown only the constellation star field. The other group was shown in addition to the star field an overlay of the mythological constellation figure. A comparison of the group means failed to show significance (P > 0.05) when the subjects were evaluated by a paper and pencil test in the classroom or by using the planetarium sky.

INTRODUCTION
Mankind has long been intrigued by the stars and their motions. From earliest times children have asked their parents the question "What star is that?" Unfortunately, few people can answer such questions even though they may have made an effort to learn about the stars and constellations. Many people have visited an observatory, planetarium, or have turned to books on astronomy in order to acquire a basic knowledge of stars, but few go beyond knowing the Big Dipper. Rey (1962) states that: "There are plenty of books on the subject...but in one important point they seem to fail us: the way they represent the constellations."

Even without intending to, people see familiar shapes in clouds, trees, and mountains. "There is a good reason to believe that, long before recorded history began, man first found his way among the bewildering multitude of individual stars by seeing figures formed by star groups" (Rey 1962). In all Germanic languages but English the...
word for constellation is literally "star picture". Rey (1962) believes that the average person expects constellation charts to show groups of stars in the shapes of lions, whales, virgins, and so forth. Unfortunately, the charts show nothing of the sort and this discrepancy usually confuses the student. The result of this situation is that for most persons the constellations never come to life, the sky remains unfamiliar, they become discouraged, and eventually give up.

Rey (1962) attempted to remedy the situation. His book, The Stars, portrays the constellations in a new graphic way, as shapes which suggest what the names imply; it shows the groups of stars known as the Great Bear in the shape of a bear, the Whale in the shape of a whale, the Eagle as an eagle, and so on. Rey claims that these shapes are easy to remember, and once learned can be retraced in the sky.

In addition to the differences in the method of representation, there is a disagreement among those who teach constellations as to what is the best approach. There are two points of view. The purists believe that the best way to teach constellations is to use nothing but the real sky or an accurate representation which can be produced in the planetarium. The more extreme purists believe that even the planetarium is artificial and should not be used. Still, there are others, more moderately purists, who will accept photographs or accurate drawings of the star fields as being proper for the teaching of constellations. The other group, we shall call the media, believe that in addition to the real or accurate representation of the sky, some form of visual media is a tremendous aid in teaching constellations and therefore should be employed. The visual aid is usually in the form of an overlay or slide and appears as a superimposed mythological figure upon the star field.

The main point of dispute between the two groups is the effect of the instruction method on the student's ability to recognize constellations in the real sky. The purists feel that their method lessens the confusion in transferring to the real sky. They argue that the media method provides a cue which does not exist in the real world and students learning by the media method will do poorly when evaluated under the actual sky. The media group contends that their method creates clarity by introducing distinctly different stimuli. They also believe that the student is able to look at the real sky and recreate the overlay in his "mind's eye" and thus be able to recognize constellations better than one taught by the purists' methods (Rey 1962). Unfortunately, a search of the literature has not revealed any research which supports either position.

The intent of this study was to determine the effectiveness of using superimposed figures on the learning of constellations, using a modified graphic method (Rey 1962) in the classroom or planetarium.

REVIEW OF THE LITERATURE

Visual illustrations are rapidly becoming an almost universal means of instruction; slides, photographs, cartoons, transparencies, filmstrips, and sketches are now in use from kindergarten through college. Even though research has established that the use of carefully prepared and relevant visual aids can improve student achievement, there has been little attempt to determine the relative effectiveness of the various types of visual illustrations (Dwyer 1967). Presumably not all types will be equally efficient in promoting the learning of different educational
tasks. Justification for the use of various methods should be based on their distinctive contributions to specific types of learning. This paper is concerned with a specific visual illustration (superimposition) to a specific learning task (constellation recognition).

Literature is available on the improvement of student performance by the use of visual aids designed to complete oral instruction (Dwyer 1967). Yet, an extensive search of the literature shows that only a limited number of studies have been conducted on the effect that visual illustrations have on the teaching of astronomical topics. There is little objective data to guide teachers in obtaining the greatest possible learning value from the planetarium (Wright 1968). Therefore, further research is needed in order to provide those who present planetarium lectures or teach astronomy concepts in the classroom with an understanding of the effectiveness of various methods of instruction. The few research studies available in the area emphasize the current state of confusion and the need for this kind of evaluation research.

One of the first attempts to objectively evaluate the use of the planetarium in teaching astronomy was made by Tuttle (1966). He taught astronomy units concurrently in two sixth grade classes in which students were matched by I.Q., chronological age, and reading scores. One class was taught only in the planetarium and the other only in the classroom. The results, all in favor of the group receiving instruction in the planetarium, indicated: (1) a highly significant improvement in three-dimensional spatial relations ($P < 0.01$), (2) a significant difference ($P < 0.02$) for improvement in two-dimensional spatial relations, and (3) improvement in the acquisition of content ($P < 0.05$). This would appear to be very impressive evidence in favor of the planetarium.

However, since a small sample had been employed ($N = 64$), Tuttle (1966) designed a second experiment to evaluate the same factors as well as the importance of the frequency of the visits. This study involved 400 sixth grade students who were taught by different teachers using a unit outline to insure uniformity. Results of this study indicated no significant difference ($P > 0.05$) between any of the factors being considered.

There has been concern for the different conclusions reached in each of the studies. Tuttle attributed the nonsignificance of the second experiment to the variations in teaching between participating teachers. Tuttle's work raised a doubt as to the value of the planetarium experience.

Rosemergy (1967) found no significant difference in sixth grade students' learning of selected concepts regardless of whether they were taught in the planetarium or in the classroom. Paper and pencil pretest and posttest were employed to evaluate the students' knowledge of the sun's rising and setting in relationship to the moon's position, the phases of the moon, and the motion of the Big Dipper. Unfortunately, Rosemergy never isolated the planetarium as a single variable in the study and as a result his conclusions were severely weakened by the introduction of several confounding variables such as homework, classroom instruction and models.

In contrast to Rosemergy's study, Smith (1966) found that sixth grade students experiencing a classroom lecture-demonstration on selected astronomical concepts achieved significantly higher than did those experiencing a planetarium lecture-
demonstration of the same concepts. An instrument was developed to test the students' ability to recognize constellations. This instrument was designed such that the students were given the name of a constellation and then had to choose the constellations from a group of four drawings of constellations. While teaching constellations in the classroom, Smith used the allegorical description of constellations in the form of poster drawings, but in the planetarium he simply pointed to the region of the sky and indicated which stars comprised the constellations. Therefore, since Smith employed two vastly different teaching methods to compare the classroom setting to the planetarium, his conclusions can be questioned.

Wright (1968) found a significant difference on an astronomy achievement test \( (P < 0.01) \) between students who had attended the planetarium programs and students who had not attended the planetarium, with the latter group being superior. She also reported no significant difference in achievement between students who had special preparation and follow-up activities with the planetarium program and those who only experienced the planetarium program. In addition Wright found no difference in achievement as measured by the same instrument between students who had special preparation by the teacher and those prepared by the planetarium lecturer. In the experiment Wright attempted to present the same information to each of the groups. Unfortunately, the manner of presentation appears to be so varied between groups that a clear cut conclusion of the study is difficult to reach.

Reed (1972) found that in a comparison of the effectiveness of the planetarium and the combination of the classroom chalkboard and celestial globe that the classroom situation was superior \( (P < 0.05) \).

Studies by Reed (1970), and Soroka (1967) have also compared the planetarium environment with that of the regular classroom, but only Soroka reported significantly better results in teaching observational astronomy in the planetarium than in a conventional classroom.

Dean and Lauck (1972) were skeptical of all of the previously mentioned studies since in all cases, planar, two-dimensional, paper and pencil tests had been employed as measuring devices. They stated that a true test of whether or not a student has learned some elements of observational astronomy would have to be conducted out-of-doors using the real sky. Their study compared the teaching of astronomical lessons to one group using the planetarium and to another group using the classroom chalkboard and celestial globe. Dean and Lauck then individually tested each student orally under the real sky and concluded that the planetarium method was superior \( (P < 0.005) \).

At first their study seems to contradict the work by Reed (1970). However, each study had different behavioral objectives, treatment methods, and sample populations and thus a comparison between them is difficult.

In view of the apparent contradiction in the literature as to the value of different teaching methods in astronomy, it is appropriate that they be reexamined. This paper concentrates only on one technique which can be used either in the classroom or planetarium: the use of visual illustrations to teach constellations.

DEFINITION OF THE PROBLEM

The purpose of this study was to examine the effectiveness of teaching constellation star fields with and without the aid of superimposed
The null hypothesis to be tested was: the superimposing of graphical mythological constellation figures on constellation star fields during the teaching of these constellations will not affect the mean performance of the two groups in recognizing the star field when the figures are not present.

**METHOD**

The Sample: All the third and fourth grade boys and girls from a private school in Fort Lauderdale, Florida were available as subjects in this study. These students were chosen using a stratified random sampling procedure based on grade, self-report questionnaire, vision test, and a pretest score and placed either in treatment group T1 or T2. The groups can be considered to be equivalent to each other. The treatment group T1 contained 19 subjects and the treatment group T2 had 17 subjects. These groups do not contain the same number of subjects as a result of absenteeism at the time of treatment. If a subject was not present at the treatment, there was no way to include him in the testing sessions.

Instruments: In order to avoid some difficulties encountered in previous research, the present study employed not only a paper and pencil instrument in the classroom, but also assessed the students in the planetarium which accurately reproduced the real sky. Both the pre and post paper and pencil instruments consisted of an answer sheet and a series of constellation star fields, one constellation per page. The twelve star fields used in this study are called constellations even though one of them is not. They are listed below:

1. Orion
2. Leo
3. Gemini
4. Big Dipper
5. Cepheus
6. Ursa Major
7. Cassiopeia
8. Aquarius
9. Scorpius
10. Virgo
11. Boötes
12. Sagittarius

In the actual study the names were simplified in order to help the students remember them. For example Ursa Major was changed to the Great Bear and Gemini to the Twins. The answer sheet contained the names of the constellations in random groups of four. Each grouping corresponded to a particular constellation and the relationship was indicated by a letter. It was the task of the subjects to examine the constellation and select the correct name from the group of four. The subject responded by putting a check mark in the appropriate blank. Each paper and pencil instrument contained the constellations, but the order of presentation of the drawings and the answer groups for each instrument had been randomly selected. The test scores were computed such that a correct response was given a value of one and an incorrect response was zero. Thus, a subject naming all constellations correctly would receive a score of twelve.

The planetarium evaluation instrument consisted of only an answer sheet similar to the one used in the paper and pencil test. The stars on the planetarium dome replaced the drawings in the paper and pencil tests.

There was a self-report questionnaire to measure the subject's prior knowledge of constellations, stars, the planetarium, and to collect demographic data. To check the subjects' ability to see the presentation, a simple vision test consisting of a standard eye chart of various size letters was given prior to the sample selection, under identical conditions in which the subject was to view the slides or planetarium stars.

Procedure: Each group was given the vision test and then shown twelve
constellation star fields in the classroom. For each constellation the subjects were shown a slide of the constellation star field, told how to locate it and then a graphic stick figure of the constellation was drawn by the lecturer using a pointer to trace out the appropriate stars. These instructions were prerecorded in order to minimize the variation in the presentation. Group T1 was then asked to imagine the lines connecting the stars and to visualize the figure for fifteen seconds. Group T2 was similarly instructed except that after 5 of the 15 seconds had elapsed, the slide was removed and a second slide was presented for 10 seconds which contained in addition to the star field a graphic stick figure connecting the stars in the constellation.

After the presentation of the twelve constellations, each group of subjects was given a paper and pencil test of the constellations. Similar tests were given to the subjects on days 7 and 14 following the initial presentation in order to determine the effect of the treatment on retention. (These will be referred to as posttests 2 and 3 respectively, in the remainder of this paper.) The subjects were given neither information on their scores of the previous test nor the correct answers. Following the first paper and pencil test (posttest 1), both groups were taken to the planetarium together.

The subjects were permitted to sit in any of the 100 seats under the 40-foot dome. The planetarium instrument was a Spitz A3P. After the subjects became dark adapted, they were again given the vision test and then directed by means of an arrow pointer to the section of the sky containing a constellation. The subjects were then asked to select the name of the constellation on an answer sheet provided by the experimenter. The level of light intensity within the dome was then increased enough for the subjects to perform this task without losing much of their dark adaptation, and an overlay of the answer sheet was projected onto the dome to assist in its reading. This procedure was repeated until all twelve constellation star fields had been considered. The constellations in question were positioned as close as possible to azimuth 180° and altitude 45°.

Design and Analysis: For determination of whether the difference between the means of the two groups is probable on the basis of chance, a t test of significance at the 0.05 level was used (Kelly, Beggs, & McNeil 1969). To study the effect of the treatment over time, a two-factor analysis with repeated measures on one-factor analysis was performed (Winer 1971) via MANOVA, a computer library program which does multivariate analysis of variance with repeated measures.

RESULTS

After the treatments, both groups greatly increased their mean scores on posttest 1 and the planetarium test as shown in Figure 2. It is readily apparent that the treatments had an effect on the subjects' learning of constellations. Interestingly, it appears that the subjects had no preference for any of the star patterns other than the Big Dipper, which most everyone recognized.

The t test analysis conducted on the paper and pencil test immediately following the treatments was nonsignificant (t = 0.462, df = 35, P > 0.05). The same analysis on the planetarium scores was also nonsignificant (t = 0.284, df = 35, P > 0.05). The result of the repeated measures analysis demonstrated that the interaction effect of treatment and occasion was nonsignificant.
(df = 2.68, F = 0.48, P > 0.05), treatment effect was nonsignificant (df = 1.34, F = 0.04, P > 0.05) and the occasion effect was also nonsignificant (df = 2.68, F = 2.03, P > 0.05).

CONCLUSIONS

At present there exists a rather sharp division among those who teach constellations. There are those who feel that the use of visual illustrations to teach constellations is definitely successful, but then others state that the use of such an artificial device in the teaching of constellations will hinder the student's ability to recognize these star fields in the actual sky where no such aid exists. These statements reflect personal opinions and until this study, no concrete data existed to indicate which, if either of these points of view, is correct.

The analysis of the data obtained in this study supported the null hypothesis that the superim-
TABLE 1. MEANS AND STANDARD DEVIATIONS

<table>
<thead>
<tr>
<th>GROUP</th>
<th>TEST</th>
<th>P</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>Pre</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>(\bar{x})</td>
<td>6.31</td>
<td>7.42</td>
<td>7.10</td>
<td>6.73</td>
</tr>
<tr>
<td></td>
<td>(\sigma)</td>
<td>2.73</td>
<td>2.03</td>
<td>2.69</td>
<td>3.30</td>
<td>2.22</td>
</tr>
<tr>
<td>T1 (N=19)</td>
<td>(\bar{x})</td>
<td>6.06</td>
<td>6.94</td>
<td>7.23</td>
<td>6.52</td>
<td>4.35</td>
</tr>
<tr>
<td></td>
<td>(\sigma)</td>
<td>2.51</td>
<td>2.60</td>
<td>3.07</td>
<td>3.18</td>
<td>2.22</td>
</tr>
<tr>
<td>T2 (N=17)</td>
<td>(\bar{x})</td>
<td>7.42</td>
<td>2.03</td>
<td>6.94</td>
<td>7.23</td>
<td>6.52</td>
</tr>
<tr>
<td></td>
<td>(\sigma)</td>
<td>2.69</td>
<td>3.30</td>
<td>2.60</td>
<td>3.18</td>
<td>2.22</td>
</tr>
</tbody>
</table>

\(P = \) planetarium test  
\(1 = \) paper and pencil posttest 1  
\(2 = \) paper and pencil posttest 2  
\(3 = \) paper and pencil posttest 3  
\(Pre = \) paper and pencil pretest

posing of graphical mythological constellation figures on constellation star fields during the teaching of these constellations will not affect the mean performance of the two groups in recognizing the star field when the figures are not present.

This result is contrary to both the purists and media positions cited earlier. With respect to the particular population of subjects employed in this study, the use of visual illustrations neither helps nor hinders the subjects' ability to recognize star fields on star charts or in the planetarium sky. Since both treatments used in this study have the same effect upon the subjects, it would appear unnecessary for a classroom teacher or planetarium lecturer to use mythological graphic overlays in order to teach constellations. If one generalizes to the population at large, our results indicate that the lengthy preparation time and substantial expense currently required to produce

lectures dealing with constellations, and perhaps many other astronomical phenomena, may not be necessary.

This conclusion undoubtedly comes as a surprise to those planetarium lecturers who subscribe to the notion that a great sound and sight extravaganza is necessary to educate their clientele. It appears that some planetarium personnel are so theatrical and gadget-oriented that they may be the ones deriving the greatest satisfaction from the programs they present. These individuals justify their actions on the grounds that the affective domain generated in the planetarium by their use of elaborate auxiliary media promotes education.

The present study indicates that education or the transmittal of information can occur in a setting where little emphasis is placed on the affective domain and thus it seems that the effort required to produce this domain may be greatly reduced without affecting the cognitive domain.
It is reasonable to wonder why the planetarium test is slightly lower than posttest 1. The fact that the two tests are similar is remarkable considering the environment in which they were obtained. Higher scores can be expected on the paper and pencil test because Warneking (1970) has pointed out that a subject will do better on any evaluating instrument which more clearly reflects the mode of instruction than one that does not. Certainly the two-dimensional paper and pencil test resembles the two-dimensional slides much closer than does the three-dimensional planetarium sky. These subjects, while well experienced with the paper and pencil method of testing, had never been tested in a planetarium. When one considers this familiarity factor in conjunction with the unfamiliarity of the planetarium environment, it is reasonable to expect that the scores would differ by a much larger amount, and the fact that they do not is impressive in itself.

Further research should be conducted to determine when and under what conditions visual illustrations can be profitably utilized or omitted.

REFERENCES


Arizona State University.


(End)

THE EXOBIOLIGIST

What's an exobiologist? . . .

He studies what may or may not exist.

He is oft-inclined to meditate
On complex chains which replicate
And perform their choreography
In states of reversed entropy,

Stressed and strained by natural selection
In order to achieve perfection
For certain astro-eco niches
And evasions of macro-molecular snitches.

Although he thinks that sheer statistics
Show there's life 'round other stars,
Constraints of our earth-bound logistics
Direct attention first to Mars.

There, with dandy little scoop
He'll serve up super "chicken soup"
To dry and rusty Chryse turfs
And see if there's some life like earth's.

(We hope it would be found delicious--
Not disastrously pernicious!)

And then he'll add some CO$_2$
To see if there's a gaseous clue
For life which is on Mars unique
With biochemistry that's "Greek".

Perhaps unlike terrestrial cells
Whose nucleic acids twirl in L's,
Mars "DNA" is dextro-rotary
With right-handed amino-acid coterie.

In July of our Bicentennial year
Viking, we hope, will make it clear
What up to then remains unknown:

ARE WE, OR ARE WE NOT, - ALONE?

Jeanne Bishop
Mirror Movers for a Trip to the Planets

by Everett Q. Carr, Planetarium Director, Herkimer BOCES, Herkimer, New York

The World War I Flying Ace was committed to the third and fourth grade trip to the planets. But a static image of our hero would never do. Projecting a slide of the Ace onto a moving mirror would give the desired mobility, but no such mirror was available.

We did have a DC motor (Edmund #41,860--12 volt, variable speed and reversible) which together with a mirror, 1/2 x 1/2 aluminum angle, a few screws and some glue, put us in business.

Figure 1 shows the exploded view of the assembly. A total of seven pieces of 1/2 x 1/2 x 1/16 aluminum angle are required:

- 5" long - 1 required
- 1/2" long - 2 required
- 2 1/2" long - 2 required
- 5 1/2" long - 2 required

This is Reynolds Aluminum, a soft alloy which is easily hacksawed and filed. It takes self-tapping screws beautifully. The 5 1/2" long pieces...
are cut and bent at one end to get a sturdy mounting base.

The mirror was attached to the aluminum angle by double-sticky-backed tape, a piece mounted to the aluminum angle after cleaning the surface with sand paper and a second piece attached to the copper colored backing of the mirror. It is probably better to clamp the mirror mechanically, and I will do it to mine when and if it falls off.

The 1/2" (1) angles are bolted to the motor with #4-40 x 1/4" long round head screws, nuts, and washers. #6-32 x 1/4" long round head screws, nuts and washers tie the 2 1/2" long aluminum angle (2) to the vertical angle (3) and motor angle (1). After assembly, the holes of the vertical angle (3) can be spotted on the 1/2" plywood base and 1/2" round head #6 wood screws fasten the motor assembly down.

The use of a three section mount allows the mirror height to be adjusted for a range of projectors. Mine are rather tall Minoltas.

A piece of 1/2" wood dowel rod drilled for the 1/8" diameter motor shaft makes a hub which can be fastened with a self-tapping sheet metal or wood screw to the mirror angle and even tapped for a setscrew. A power supply is illustrated in Figure 2.

A double-pole, double-throw switch reverses the polarity of voltage to the motor.

About the mirror, we used a plain second surface float glass mirror cut from an 18" x 48" mirror we found on sale. The second surface mirror has a faint ghost. Maybe someday we'll get some first surface mirrors, but in the meantime we'll make do and ignore the ghosts. A coarse, black cardboard mask cuts slide edge glow.

The motor, from Edmund Scientific is worth special mention. It is reversible and has the high reduction gear chain. It also runs reasonably well on low voltage. I prefer it to AC clock motors even though I found it costs more. A 1/2 voltage power supply is diagrammed in Figure 3, and Figure 4 indicates how to assemble a variable speed unit.

The mirror assembly can be mounted on a board in a number of ways to move projector images across the sky. Cartoon characters fly, rockets take off, space ships meet, meteors careen, Vikings set down, and goblins and witches have a special magic.

The construction time with only a hacksaw, file, center punch, hand drill, screwdriver, and pliers is about three hours. The cost per unit is under $10. Utility? I built and use four of them. I'd build another pair but I can't squeeze more into the star projector island.

THE PLANETARIAN
The Campfire Analogy for Annual Motion

by Robert C. Tate, Harper Planetarium, Atlanta, Georgia

Teaching by analogy is consistent with theories of education commonly practiced by planetarium educators. Proof of this is found in the nature of the planetarium, which itself is an analogy for the real sky.

Other analogies are used from time to time in the planetarium, such as the precession of a top, which is analogous to the precession of the earth, or longitude and latitude, which is analogous to right ascension and declination. In all uses of analogies, the goal is to facilitate learning by pairing new material and processes which must be learned with similar material and processes which the learner has already mastered, or has experienced often in daily living. Learning theorists may spend hours describing the mental processes involved in this type of learning, but for the working planetarian, all that is important is that analogies facilitate learning.

The analogy of the campfire and annual motion has been in use for years. It is uncertain to the author where the analogy originated, and it has probably been published frequently, most recently by Abell (1975) in his astronomy text, Exploration of the Universe.

Essentially the analogy works like this. While sitting in a group around a campfire, an observer sees the fire in front of the person directly on the other side of the fire. If the observer moves around the campfire, however, it appears to him that the campfire has moved until it successively appears in front of each member of the group. This is analogous to what is observed as the earth revolves about the sun. The sun appears to move in front of successive constellations along the ecliptic. In the real case, the reference points are the constellations and the observer represents the earth. The fire is analogous to the sun.

In the Atlanta Public School System, the sixth level students study a unit on annual motion. The corresponding planetarium program concentrates on the changing seasons, and observations of the sun's altitude are made during each month of the year. To facilitate the explanation of the changing position of the sun with respect to the stars, the campfire analogy is used.

This analogy has special meaning for many of our sixth level students who have participated in a week-long camping experience, arranged through a special project of the school system, which pairs affluent and inner-city schools in an attempt to develop an understanding of other lifestyles among students. The campfire analogy is a vivid reminder of this experience and greatly facilitates the explanation of annual motion.

The enclosed sketches, produced by our staff artist, George Puckett, are used in the planetarium program. Note that the fire is dark in each sketch, since these reproductions are made to be photographed on Kodalith film. In the final result, the fire and other features will appear white against an opaque background, ready for projection in the planetarium. This is a most effective way to present the analogy, as the figures thus produced appear naturally on the horizon, around the fire, and beneath the stars. To accentuate the fire,
it is possible to carefully color in
the fire directly on the finished
slide using an orange felt-tipped pen
with a very fine point. It may be
necessary to apply a couple of coats
of ink to the emulsion side of the
film for complete coverage. White
out the arrow with typing correction
fluid if it is not desirable in your
planetarium.

Hopefully others will find the
use of these sketches and the campfire
analogy of value in teaching this
important, but difficult, relative
motion problem.

REFERENCE

Abell, G.O. 1975. Exploration of the
Universe, (New York, Holt, Rinehart
and Winston), p. 15.

(End)
American Indian Interest in the Sky as Indicated in Legend, Rock Art, Ceremonial and Modern Art

by Von Del Chamberlain, National Air and Space Museum, Smithsonian Institution

EDITOR: This article is an edited version of a paper presented in June 1973 at the inter-American meeting, "Science and Man in the Americas", organized jointly by Mexico's Consejo Nacional de Ciencia y Tecnologia (CONACYT) and the American Association for the Advancement of Science (AAAS). It was delivered during the session titled "Archaeoastronomy in Pre-Columbian America". While intended for a somewhat different group, the planetarium community should find a wealth of potential program material and references. For more information, see Archaeoastronomy in Pre-Columbian America, edited by A. F. Aveni, University of Texas Press, 1975.

I. Introduction

For the earth he drew a straight line,
For the sky a bow above it;
White the space between for day-time,
Piled with little stars for night-time;
On the left a point for sunrise,
On the right a point for sunset,
On the top a point for noontide,
And for rain and cloudy weather
Waving lines descending from it.
From Longfellow's Hiawatha

When we consider the intrigue and drama of the sky, it is not surprising that ancient humans from all lands left reminders of their interest in the realm above the landscape. Throughout the world we find symbolic drawings and carvings on stone surfaces which include figures indicative of the sky and its phenomena. We also find conceptual explanations of the origin and properties of the sky and its phenomena in the form of legends transmitted along the time column via selected human memory. This remembrance is often fragmentary and it likely has been continually modified according to the interpretations of and influences upon the individuals and groups involved. Most legends have been lost. A few survive and are published due to the efforts of diligent scholars interested in the flow of human ideas on the planet.

Art, ceremony, legends, beliefs and actions all indicate something of the motives of ancient and living people. Careful study of these combined factors, searching for relationships between them, should illuminate our interpretation of the astronomical knowledge and practices of the early Americans and other cultures.

This paper will examine selected primitive and contemporary American Indian art and legends. The coverage is general and will include comments on the following: (1) the sky itself and its relationship to the earth; (2) atmospheric phenomena; (3) the sun; (4) the moon; (5) planets and comets; (6) stars; (7) the Milky Way; (8) meteors, fireballs and meteorite falls.

II. The Sky

The Pueblo emergence myth, coming from Zuni about 1880 (1), strikingly resembles the classic Greek story of
creation. It begins with Awonawilona, "one who contains everything," who created light, the sun. Next came the sea which divided into Earth Mother and Sky Father. From the union of these all creatures arose. Sky Father then spread shining grains of maize above to become the brilliant stars. The setting was provided for the emergence of man from the bowels of Earth.

One of the best illustrations of Indian Sky art is the well known Navajo Father Sky - Mother Earth, portrayed in dry-painting (2). The Pueblo and Navajo emergence myths are very similar. Father Sky - Mother Earth depictions illustrate awareness of conceptual relationships between earth and sky realized by many Indian nations. The arms and legs of Father Sky and Mother Earth are crossed in symbolism of phenomena of nature relating these two aspects of the environment.

The most common Indian symbol representing the sky is reported to be the single or double arch (3,4). Another symbol (Hopi) for the sky is two sticks crossed at right angles (5). We might also find the sky represented in other forms, possibly including human and animal outlines as in the case of the Father Sky figure.

III. Atmospheric Phenomena

For apparent reasons ancient Americans were greatly concerned with atmospheric phenomena. Their mythology abounds in lightning and thunder stories and atmospheric pictography is abundant. Steward reported that zigzag and wavy line symbols were the most common of all classes of symbols he studied (6). These are generally interpreted to represent lightning, rain and water. Some of them are said to represent snakes. It is important to realize, however, that lightning and snakes have been frequently related in symbolic thought (7).

Contemporary and recent southwest U.S. kiva and kachina art often show a cross at the end of lightning symbols (8). The cross is used generally in Navajo dry-painting for various items which are brilliant (e.g. fireplaces, stars etc.) (9). As noted previously, crossed sticks are also used to represent the sky.

Cloud and rain symbols are common in both old and contemporary Indian art. A modern example is found in the silver jewelry piece (Hopi) shown on the cover. The jewelry is new, but the symbols are old.

Other atmospheric phenomena which might be identifiable in pictographs and petroglyphs are: (1) rainbows; (2) aurorae; (3) solar and lunar halos, sun-dogs and (4) various storm activity such as tornadoes.

The rainbow is frequently used in modern dry-painting and kiva art (10). It seems likely that symbols for this spectacular occurrence in the sky should appear in primitive art as well. It would likely consist of multiple arcs. Such symbols would be difficult to recognize since they could also represent so many other things.

The aurora would be even more difficult to recognize in symbolic form. Whatever symbols are used, they should predominate in extreme northern and southern latitudes.

Solar and lunar halos can be rather spectacular. Symbols for these might also be identifiable.

The following Wyandot legend illustrates the type of associations between earth, air and sky which the ancient Americans made (11).
Origin of Light

Wyandot

After the earth was formed on Big Turtle's shell, there was not enough light, so the animals said. Big Turtle called a council. When the council met, Big Turtle said that because the island had been made for the woman, there should be more light. Someone said that a light hung in the sky would be well. Then Small Turtle at once answered, "If I could climb into the sky, I could gather together some of the lightning, and make a ball of it." Big Turtle said, "Oh, yes. Try to climb up. You have great power."

At once Small Turtle made medicine, and soon there was a great storm. A cloud full of lightning rolled down towards the council, with a great noise. There were broken rocks and trees in the cloud. It came so near that Small Turtle climbed into the cloud, and went upward with it.

When she reached the Sky Land, Small Turtle gathered much lightning together. She made a ball out of it, and hung it in the sky. After that there was light on the island because the sun shown. Small Turtle also made moon.

The cloud path taken by Turtle into the sky is clearly a tornado. Here we have the frequent symbolic relationship between fire, lightning, sun, and other luminous objects of the sky.

IV. The Sun

One by one
The stars are lighted by the sun
Before he retires to his lodge for rest.
It is his last duty of the day.
Otoe song about the stars (12)

The early Americans had good reason to worship the sun. They watched it carefully and were extremely sensitive to its seasonal shifting in the sky. Modern Earthlings could well afford to become as alert and appreciative of the day star.

Great numbers of sun legends originated in America. They are found in essentially every book on Indian legends (13,14). It is also very well known that Indian ceremonials frequently involve Sun mythology. Stephen's observations of solar ceremony, in the Hopi Journal, indicate the careful observations of the sun made by Pueblo groups and the total awareness these people had of solar changes.

Sun disks are found in primitive art throughout the world (15). Examples are shown in Figures 1 and 2. Steward reported the sun disk to be one of the most common symbols in western U.S. pictography (6). The rising and setting sun as well as complete disks occur.

Noting Indian sensitivity to the sun and the natural drama of a total solar eclipse, this event would be expected to occur in primi-
FIGURE 1. "ASTRONOMICAL SYMBOL BOULDER"
FIGURE 2. "SKY WALL" IN FERN CAVE
Figure 2: "Sky wall" in Fern Cave, Lava Beds National Monument. (A): Suns and clusters of circles (stars?). (B): "Star groups" with crescent and "star". Note small "sun" in cluster at center and human figures at bottom right. (C): Additional figures on wall. (D): Note suns enclosed in circles.

tive art and legend. A recent example is significant. The Dakota Winter Count for the year 1869-70 has been represented by pictographs illustrating the total solar eclipse of August 7, 1869 which was total in Dakota country. (Editor: A "winter count" is a pictographic calendar kept by many of the Plains Indians. Drawn originally on animal hide, one outstanding event was depicted for each year. (Years were generally reckoned by the winter season.) These picture calendars thus made it possible for the Indians to count forward and backward in time, analogous to our numbered calendar years.) Figure 3 shows sketches of the pictographs published by Mallery (16). The figure marked "A" is reported to represent an eclipse of the moon (17). Its similarity to the other figures leads to the suspicion that it also represents the solar eclipse and that the identification as a lunar eclipse record is in error.

How might eclipses be depicted? One can look at the many pictographs in the northeast U.S. which resemble sundisks enclosed in circles (see Figure 2D) and similar figures elsewhere and wonder if they might represent total solar eclipses, the circle signifying the corona. Crescent, which are reported to be rare in pictography, could also represent partial eclipses or partial phases of total eclipses. Since some nations believed that the eclipse was caused by monsters darkening the sun (17,18), the event might be pictured in this way. Grant (19) published a photograph of a pictograph which he reported represents an evil supernatural spirit holding the sun in its mouth. Perhaps this represents an eclipse. Solar eclipses might also be shown simply as a solid disk with or without a coronal halo.

V. The Moon

It is strange that the crescent is not more common in pictographs and petroglyphs in America since legends from many Indian nations tell the story of the observational relationship of the moon and sun. Add to this the obvious degree of interest in the moon indicated by Indian lunar calendars (20) and it seems improbable that the moon would not be more common in primitive art.

Of course the crescent is not the only possible depiction of the moon. The circle can represent a variety of physical objects including the sun and moon. The moon, and other astronomical objects, might also be represented in human motifs and perhaps in a variety of other
forms. Still the most frequent art symbol for the moon throughout the world is the crescent.

The combined crescent and star symbol is very common worldwide. It occurs, for example, on several national flags. It also occurs in several instances in recent and contemporary Indian art. Hopi Journal contains a sketch of a kiva wall design which includes a crescent and stars (21) and Plate XIV of Volume I shows Ute shields which include two crescents, obviously representing the moon. One of these is referred to as "Big Star" and is represented as a crescent and star. Perhaps this is another depiction of the supernova of 1054 A.D. Emerson has published drawings of Indian mounds which contain crescent and crescent-with-star features (22). Dry-painting and contemporary kiva art frequently employ the crescent and crescent with star.

VI. Planets and Comets

The sun has two daughters. There are twenty men who kill these daughters, and after fifty days they return to life. A saying of California Indians (23).

Except for "Morning and Evening Star", planet mythology and art are not very common in recorded American Indian literature. From the frequent mention of "Morning and Evening Star" in legends (24) it seems reasonable to expect that Jupiter, Mars and Saturn would have also been important in primitive rituals.

It would seem difficult to be able to recognize planet symbols in primitive art since they would likely resemble star symbols. They might, however, be set apart in some way from the stars. It seems possible, for example, that the cross enclosed by a circle in the Canyon de Chelly shows an elongated feature which resembles a supernova of 1054 A.D. Emerson has published drawings of Indian mounds which contain crescent and crescent-with-star features (22). Dry-painting and contemporary kiva art frequently employ the crescent and crescent with star.

Figure 4: Three "star ceilings" at Canyon de Chelly. (A): note cross enclosed in circle. (B): a small ceiling with dot pattern. (C) and (D) are of same ceiling. Note elongated features which radiate in "Meteor shower" fashion.

"star ceiling" shown in Figure 4 might represent a planet. It could, of course, just as well represent a particular star, nova, or any other item which was of special interest to the artist(s). If the ceiling figures can be related to particular parts of the sky (i.e., if they are actually star maps), it will be possible to narrow down the alternatives.

Bright comets should have attracted considerable attention among the Indians. There have been many bright comets during the past several hundred years. Depictions of comets should be easier to identify than many other astronomical objects. Of course there will always be the confusion in art between figures representing comets and brilliant fireballs.

The Dakota Winter Count described by Praus (25) shows a figure for the year 1909 which looks like it could well represent a comet (Figure 5).

Figure 5: A possible Halley's Comet pictograph (reported as "Evening Star Visible in Daytime") from Dakota Winter Count for winter of 1909. Reproduced from Praus' publication (25).
The caption is titled, "Evening Star Seen in Daytime." The picture might well represent Halley's Comet which was visible during the spring of 1910 rather than daytime observation of Venus which is not nearly as spectacular and can be seen during daylight with great difficulty at every occurrence of greatest brilliancy.

Grant (26) uses the term "comet" to describe elements of Chumash paintings. The author feels that these figures more nearly resemble a fireball event than a comet.

VII. Stars

The stars have always been important in mythology of all lands. Legends abound concerning their origin and groupings. Every culture seems to have had its own constellations. However, except for a few groups of stars (Taurus, Ursa Major, Orion), American Indian constellations are not well known. In many instances the stars are not identified and the constellations are vague. Very little work seems to have been done attempting to identify the stars referred to in various recorded legends. A few attempts have been made, but often not with the assistance of people who know the sky well (27). Certainly this is a fertile field for individuals who do know the sky well and enjoy a challenge.

How might we recognize star symbols in primitive art? The best guide seems to be the symbols currently used in surviving Indian practices. The simplest possibility is patterns of dots. These are sometimes used in Hopi art (28) and in Navajo dry-paintings (2). Gourd rattles containing groups of holes representing stars are used by the Navajos (29). There are indications that dot patterns have been used for stars in early times. Figure 4 shows a Canyon de Chelly ceiling with a pattern of dots.

Patterns of small circles might also represent stars. A beautiful painted wall in Fern Cave at Lava Beds National Monument is a likely example of this. Portions of this wall are shown in Figure 2. Note the subtle human figures at the bottom right of Figure 2b. The scene above takes on great beauty if we interpret these figures as the artists beholding the heavens, the inspiration for their work. Note also the small "sun disk" in the one cluster of circles. This indicates the possibility that symbols which have consistently been reported as "suns" might sometimes actually represent stars. Refer back to Figure 1. Could the many "suns" on this boulder containing the three crescents actually represent stars? Figure 6 shows the beautiful crescent and "star" recently found at Chaco Canyon. But is this really a crescent and star? Or is it a depiction of the sun and moon? Or perhaps Venus and the moon? We will probably never know for sure, but we should at least analyze the various possibilities. Figure 2 shows other features on the same wall at Fern Cave. The majority of "sun" symbols are larger than the "star" circles. Some of these have curious circles around them. Why? What does the outer circle represent? The many seemingly astronomical symbols on this one wall make it of special interest in archaeoastronomy as is the "astronomical symbol boulder" at Symbol Bridge (Figure 1).

Another symbol often used to represent stars is the small cross. We find these on kachinas (30) and in dry-painting. The "star ceilings" at Canyon de Chelly and nearby locations have already been mentioned several times (Figure 4). It was suggested by De Harport (31) that
these interesting groupings of crosses (and dots) were night sky depictions. They became known as "Planetarium Sites" since they remind one of an ancient version of the modern planetarium. The term is inappropriate since the basic word in "planetarium" is "planet". It is suggested that the term "star ceiling" be used for these and similar depictions. These ceilings seem to clearly represent star groups.

Another symbol which is naturally suggestive of a star is the multi-rayed point of the type in Figure 6. Other more abstract symbols might also represent stars.

It is exciting to contemplate the possibility that the early Americans observed and recorded supernova events. Such events may have had considerable influence on primitive groups. It is reported that the supernova of 1054 A.D. was important in the history of Mesa Verde (32). Several Indian legends mention "Great Star". Work is needed by ethnologists to test the idea that some of these might have resulted from the supernova event. Since naked-eye supernovae are rare events, records of them are useful for precise indication of time.

Figure 6: Crescent and star pictograph with artist "signature" at Chaco Canyon National Monument.
VIII. The Milky Way

The Prairie is dark
But across the sky
Is a trail of light.
It is the ghost pathway
Of the departed warriors.

Otoe Song of the Milky Way (33)

The concept so nicely stated in this Otoe song is probably the best known Indian idea about the Milky Way. Other concepts are stated in various sources (34). Stephen noted that the double arch symbol was used by the Hopi as a symbol for the Milky Way (35). It would be exciting to be able to identify ancient American drawings representing what is now known to be the disk of our own galaxy seen from inside. It would be so very interesting to be able to bring together coordinated information on the concepts of those who long ago stood on this same land with inquisitive minds tuning in on galactic photons, stimulating their light sensitive organs.

IX. Meteors, Fireballs and Meteorite Fall

When a star falls from the sky it leaves a fiery trail.
It does not die.
Its shade goes back to its own place to shine again.
The Indians sometimes find the small stars where they have fallen in the grass.

Menomini Indians (36)

Meteors

The common faint meteor was likely of some interest to ancient Indians. It probably took its place along with other elements of the physical world, becoming part of the fabric of ceremonial practices.

Meteor Showers

When meteors are visible in large numbers during a period of hours or days, they always attract great attention. The following Ojibwa legend may allude to the meteor shower event (37).

At one time an orphan boy whose uncle was very unkind to him ran away. He ran a long way. He ran until night. Then because he was afraid of wild animals, he climbed into a tree in the forest. It was a high pine tree, and he climbed into the forked branches of it.

A person came to him from the upper sky. He said, "Follow me. Step in my trail. I have seen how badly you are treated." Then at once as the boy stepped in his trail, he rose higher and higher into the upper sky.

Then the person put twelve arrows into his hands. He said, "There are evil manitoes in the sky. Go to war against them. Shoot them with your bow and arrows."

The boy went into the northern part of the upper sky. Soon he saw a manito and shot at him. But that one's magic was too strong. Therefore the shot failed. There was only a single streak of lightning in the northern sky, yet there was no storm, and not even a cloud.

Eleven times the boy thus failed to kill a manito, and thus he had but one arrow left. He held this in his hands a long while, looking around. Now these evil manitoes had very strong medicine. They could change their form in a moment. But they feared the boy's arrows because they were also strong magic. And because they had been given to him by a good
manito, they had power to kill.

At last the boy saw the chief of the evil manitoes. He drew his bow and shot his last arrow; but the chief saw it coming. At once he changed himself into a rock. And the arrow buried itself in a crack of the rock. The chief was very angry. He cried, "Now your arrows are all gone! And because you have dared to shoot at me, you shall become the trail of your arrow."

Thus at once he changed the boy into Nashik-a-wasa, the Lone Lightning.

Emerson (38) suggests that this account concerns "summer lightning." It also contains elements which seem to allude to the aurora. If so, the auroral elements are probably the manitoes rather than the arrows shot at them. The description leads one to speculate that the story might have been inspired by a meteor shower. The arrows can be assumed to emanate from one location toward different parts of the sky. One of the dramatic elements of a

---

Figure 7: Reproduction of Dakota Winter Count depictions of the Leonid meteor shower of Nov. 1833. A through F from Mallery's article (16). G from Praus' article (25).
The meteor shower is the fact that the members of the shower define a radiant. The "Lone Lightning" story alludes to such a radiant.

We do have examples of meteor shower records among the Indians. Mallery's (39) publication on the Dakota Winter Count shows six illustrations of the famous Leonid shower of 1833. Another is recorded by Praus (40). These are sketched in Figure 7. This shower aroused much attention throughout the world.

**Fireballs**

When we realize the spectacular nature of a brilliant fireball, especially one which produces meteorite fall, it becomes clear that this type of event would have produced emotional response by early man. Indeed, the phenomenon of meteorite fall can be one of the most impressive of all natural events (41). Anyone interested in human response to natural phenomena should become well acquainted with this occurrence. Unfortunately it remains an event which most people, even scientists, are not generally well schooled in. The author has no question that this event will be found to have significantly entered into ceremony, art, and legend. The following is one example of the fireball in legend (42).

**Burning Star Jumps Into the Lake**

The two Indians who related this story to Bon Whealdon in 1924 thought that Burning Star was a meteor that had plunged into Flathead Lake long ago.

The world was very young when this story took place. It was before our grandfathers' grandfathers' days, but there were people who saw these things. They saw a burning star race through the air and jump into the lake now called Flathead Lake.

One darkness, when the people were in their tipis, they heard a star shrieking in terrible pain. Going outside to see why it was making such crying, they saw that it was burning up. The light of the flames brightened all the sky and the land as if it were day instead of night.

The people saw Star running swiftly down to the lake and jump into the deep water near Wild Horse Island. Immediately a thick cloud rose from the water and hung over the lake.

Our people were very much frightened and would not go near the shore. "The Water Mystery," they said, "has reached out with its strong power, has pulled the Star from Skyland, and has taken it into the lake. If we go near it, it will pull us in also."

But the Mystery People of the Lake, the Canoe People, said, "No, it is not the Water Mystery which pulled Star, for water mysteries have no influence over sky and land mysteries. Foolish Salish, do you not know this? We, too, saw Star burning in the sky, and we heard its cry of pain as it jumped into the lake to put out its flames. Not being made of fear, we paddled our canoes close. The water was warm, and many, many cooked fish floated on the waves."

Tribes that lived many sleeps away also saw Burning Star and its light. Only the Mystery People of the Lake were not afraid. So our fathers sometimes called them "the Fool People." Perhaps they meant "the fool-hardy people."

These are true words.  

This is an excellent account of a fireball event, describing both the visible and audible
phenomena. It is possible, but not certain, that a meteorite actually fell into the lake. People not thoroughly familiar with meteorite falls are always prone to misinterpret the event. Usually there is confusion about where the object(s), if any, reached ground level. One cannot conclude from this type of report that meteorites actually landed as the account infers. Modern reports of fireballs and meteorite falls always suffer from this type of confusion. But the account is entirely representative of observation of a spectacular fireball event. The information contained in the account is so nearly like modern reports that one wonders just how far we have come in educating people about natural phenomena.

Fireballs have been depicted in Indian art. Again we turn to the Dakota Winter Counts for the most conclusive records. Figure 8 shows sketches which are reported to depict an event in 1821-22 (43). Praus reported another winter count record of a fireball event in 1903 (44). The winter count pictograph is simply

Figure 8: Reproductions of Dakota Winter Count pictographs of fireball events. A through F for winter 1821-22; G for winter of 1903. F and G are from Praus' article (25), others from Mallery's article (16).
shown as a star (Figure 8G).

**Meteorite Fall**

It is interesting to note that some American Indians shared the concept with the Greeks and others that certain types of stones (e.g., flint) had come from the sky (45). Awareness of fireball and meteorite fall events likely contributed to this belief. But the fact that meteorites have been found in ruins and burial mounds, indicates that Indians did apparently recognize some true meteorites. Several examples follow.

The Winona meteorite was found in 1928 enclosed in a covered cyst in the vicinity of ruins near Winona, Arizona (46). This is a stony meteorite and is not likely to have been selected as a valuable possession without knowledge of its celestial origin.

The Mesa Verde meteorite was found in 1922 in the ruins of the Sun Shrine House (47). An iron meteorite worked into an axe head was found in a ruin in New Mexico (47). The Camp Verde iron was found wrapped in a feather blanket (48).

A small stony-iron meteorite, the Pajoaque meteorite, was found in a pottery bowl, its condition indicating the possibility that it was an observed fall and that it was carried for some time by its owner(s) (49).

Meteorite material was found accompanied by other ornamental objects on an altar associated with the Turner Mound near Anderson, Ohio (50). Additional ornaments made of meteoritic iron were found in connection with a skeleton and altar in the Hopewell Mound, Ross County, Ohio.

The Chilcoot iron was purchased from a Chilcoot Indian of Alaska and reportedly was observed to fall and retained by the Indians for about 100 years before its sale (51). The large Casa Grandes iron meteorite was found wrapped like a mummy in ruins of the Montezuma Indians (52).

The Iron Creek meteorite was referred to as "Manito-stone" and said to be regularly visited by the Cree and Blackfeet until it was moved in 1892 (53). Similarly Nininger reports that Comanche Indians paid homage to the Wichita County (Texas) meteorite, leaving beads, arrowheads and tobacco at the site (51).

**X. Conclusions**

Our intellect drives us to attempt to establish bonds of identity with our brethren who walked and enjoyed the land before us. We turn our eyes skyward, finding great satisfaction in experiencing the same stimuli in at least partial awareness of the thoughts of earlier men, extended through time and mental toil, transposing simple skyworld legends into descriptions of steady state, big bang or oscillating cosmogonies.

To satisfy our appetite we should well strive to coordinate information in order to achieve more complete and valid interpretations of the primitive mind. Only by comparing information from living descendents of the early Americans and extending this back in time can we hope to fully appreciate the evidences which whisper the astronomical languages of the past from the ground and rocks. Concentrated and coordinated analyses of contemporary and primitive art and mythology, combined with computer digested observational data should help us evaluate the astronomical concepts of the early Americans.

All of us who are intrigued with the challenge of explaining the actions and remnants of past cultures ought to become thoroughly familiar with sky events and objects.
The Dakota Winter Counts suggest the possibility of finding similar calendars on stone. The "star ceilings" at Canyon de Chelly, coupled with the fact that star maps have been produced on stone in other parts of the world, suggest that American Indians might also have made such sky depictions. The possibility of locating such items, though remote, are far too exciting to ignore.

People interested in Archaeoastronomy are encouraged to communicate ideas and results of research to the education community. It is especially appropriate that we provide well written and illustrated summaries to planetarium educators and outdoor education specialists. Sky theaters can be used in the heart of metropolitan centers to simulate ancient observations of the sky.

Naturalists have the unique opportunity to stand with people in the precise location on the planet where the ancients stood, look out to the stars, see what they saw, ask the questions which they asked, and attempt to recapture their feelings by empathetic interpretation of their actions as they traced the pigment on the walls.

One year ago the author participated in such a program; the first to be held at night in the Great Kiva at Chetro Kettle in Chaco Canyon. We lit the flame in the kiva fireplace. The audience entered, coming from various cities and towns throughout the country. The light of Sun faded into dark of Night. The stars slowly pulsed into view where once the ceiling covered Sky. We talked of the people who long before warmed the stone we sat on. We looked together at the stars. One faint star, we now call Beta Cephei, was singled out. We reasoned with modern astronomers about its 980-light-year distance, then let our minds drift along its beam of light back to the time when the photons stimulating our eyes and brains left that remote place. We almost thought we could hear the voices amid the crackle of fire, and see their shadows as the flame danced with them; the kiva once more lived the purpose for which it was so carefully constructed, and the stars rolled overhead to mark continuance of universal processes leading to birth and death and silence of the decaying walls. With greater affinity for the past, we left the kiva in the footprints of the ancients, slightly changed by our deliberations on the heavens.

References and Notes


7. D.G. Brinton, Myths of the New World, A Treatise on the Symbolism and Mythology of the Red Race
8. E.C. Parsons, *op. cit.* (5), plates V, VI, VII.


10. Ibid. Also D. Vallasenor, *op. cit.* (2), pp. 34-40.


15. J.H. Steward, *op. cit.* (6), includes many sun symbols, e.g. figures 2, 4, 5, 9, 38, 75, 76, 79, 81, 82.


17. Ibid., p. 125.


19. C. Grant, *The Rock Paintings of the Chumash*, (Univ. of Calif. Press, 1965), Figure 84, p. 92.


21. E.C. Parsons, *op. cit.* (5), Vol. 1, p. 233, Figure 143.


26. C. Grant, *op. cit.* (19), Figure 25 and p. 80.


29. B. Haile, *op. cit.* (27), p. 13. This entire reference illustrates the use of dots to represent stars.

30. E.C. Parsons, *op. cit.* (5),
Vol. 1, pp. 163, 205, 263, 429, 563, plate VIII. See also N. Feder, American Indian Art, Harry N. Abrams, Inc., 1965, plates 34, 80, 86. Plate 80 illustrates both the use of dots and cross. See also W. Tomkins, op cit, p. 79 on the use of crosses for stars.


32. Personal correspondence with naturalists at Mesa Verde.


37. Ibid., pp. 198-9.


42. E.E. Clark, op cit. (34), pp. 95-6.


44. A. Praus, op cit. (25), p. 27.


continued on page 123
A Report on IAU Commission 46:

The Teaching of Astronomy

by Dorothy E. Beetle, Norwood City Schools Planetarium, Norwood, Ohio

During the Twelfth General Assembly of the International Astronomical Union in 1964, Dr. M.G.J. Minnaert presented a detailed report on the teaching of astronomy in different parts of the world. The wide latitude he pictured and the discouraging aspects of attempting to train young astronomers in developing countries, prompted the astronomers present to create a special commission on the teaching of astronomy. This commission, designated IAU Commission 46, is composed of one member from each nation adhering to the IAU who is particularly interested in the teaching of astronomy.

Commission 46 seeks to encourage, promote and develop the teaching of astronomy at all levels in all parts of the world. Surveys made by M.G.J. Minnaert (now deceased), E. Schatzman and E. Miller show that astronomy education varies widely from country to country and even within schools of a single country. We are well aware of that here in the United States.

In the primary, secondary and high schools, what astronomy is taught depends upon standards set by the ministry of education of each country. This varies from almost a total lack of astronomical subject matter, to the personal interest of an individual teacher, to a regular elementary course given as a separate subject. In colleges and universities the teaching of astronomy depends upon tradition, on the general organization of courses in the physical sciences, and on the interests and capabilities of available astronomers.

The commission has no means of changing the astronomy teaching program of any school or country. The task it has set itself is to encourage the teaching of astronomy, advise in planning suitable study programs at various levels, and transmit information from experienced teachers. It also organizes specific projects aimed at helping astronomy teachers and students in all parts of the world. It collaborates with UNESCO and the Committee on Science Teaching of the International Council of Scientific Unions (ICSU). The commission does not provide fellowships nor organize the exchange of astronomers; the latter is the province of IAU Commission 38.

To accomplish its goals the commission acts in the following ways:

1. It serves as an information center for any matter that concerns astronomy education. Mimeographed letters are circulated to commission members and interested persons.

2. Astronomers are asked to prepare lecture notes on their main courses for the use of students at small universities which lack experts to teach these courses.

3. Information is gathered and exchanged for exercises in the laboratory and at the student's telescope.

4. The preparation of astronomy teaching aids for all school levels...
is encouraged as in the Harvard Physics Project and the Nuffield Project in Great Britain.

5. Commission members are asked to prepare pamphlets suitable for their own countries on career possibilities and educational requirements of an astronomer.

6. It assists in arranging courses on selected subjects for young pre and post doctoral astronomers; these to be offered during their vacations on a national, regional and international scale. Several courses on a less advanced level for future astronomers who would not otherwise have such training have been arranged. In-service training for teachers is encouraged.

7. It recommends that basic modern astronomy texts, available in several languages and at low cost should be given fast worldwide distribution.

8. It encourages the education of the public and non-science majors through open houses at observatories, lectures, popular articles and radio and television programs.

9. An extended list of world observatories is being prepared in collaboration with other IAU commissions.

10. The commission and the Science Teaching Division of UNESCO are jointly planning programs of astronomy education in developing countries.

To summarize the accomplishments and goals, Commission 46 has issued a paper, "Report on the Development and the Present State of Astronomy Education in Different Countries-1970-1973". It is edited by Edith Müller, President of the commission during that time. Twenty-eight countries outlined the state of astronomy teaching in their country from primary grades through the university level.

Reporting nations can be roughly divided into three groups: A. A few astronomical concepts are taught in science classes below the college level. B. Astronomy concepts are introduced in lessons in the elementary grades. On the secondary level astronomy is included in earth or physical science material. C. Separate courses in astronomy are offered on the secondary level. Education committees are preparing or are using material such as the Junior Secondary Science Project in Australia.

A further note on some activities: The commission is gathering lists of material most needed for astronomy teaching. It is publicizing what extra plates, books and reprints some colleges and observatories have which can be used on loan or as a gift. A list of educational material and teaching aids and where to obtain them has been compiled. It is drawing up guidelines to distinguish between education of astronomers and education in astronomy to encourage the public to take an intelligent interest in the subject.

Consistently through the commission’s report runs the theme of the need for more astronomy instruction for teachers. Until elementary and science teachers know more astronomy, lip service to the improvement of instruction will continue. Astronomy education continues to center around easily visualized ideas such as models of the solar system, constellations, and some earth motions. Informed teachers are necessary to spark the teaching of astronomy.

As fellow planetarians we are part of the astronomy education picture. Given far more to work with than many
countries, I trust our planetariums are sparking an intelligent understanding of the skies, inspiring, and challenging some to take up astronomy as a career.

(Editor: For further information contact the current Commission 46 President: Dr. D. McNally / University of London Observatory / Mill Hill Park / London, N.W. 7, United Kingdom.)

Times Are Tough

Upon request for GLPA/ISPE membership dues renewal, Stan Wineland of Findlay, Ohio sent the following reply:

Dear Sir:

In reply to your request to send a check I wish to inform you that the present condition of my bank account makes it almost impossible. My shattered financial condition is due to Federal laws, State laws, brother-in-laws, sister-in-laws and outlaws.

Through these laws I am compelled to pay an income tax, amusement tax, head tax, school tax, excise tax, motor tax, gas tax, food tax, water tax, real estate tax, poor tax and tobacco tax. Even my brains are taxed. I am required to get a business license, car license, truck license, liquor license, cabaret license, dine and dance license, and juke box license, not to mention a marriage and a dog license.

I am also required to contribute to every society and organization which the genius of man is capable of bringing to life--to women's relief and gold digger's relief. Also to every hospital and charitable institution in the city, including the Community Chest, the Red Cross, the black Cross, the Purple Cross and the double cross.

For my own safety I am required to carry life insurance, property insurance, burglar insurance, tornado insurance, accident insurance, auto insurance, business insurance, earthquake insurance, unemployment insurance, old age insurance, fire insurance, and workman's compensation insurance.

Before opening my mail each day we pause in silent prayer for strength to face the day's new forms and requirements.

My business is so governed that it is no easy matter for me to find out who owns it. I am inspected, suspected, disrespected, rejected, dejected, examined, re-examined, informed, required, summoned, fined, commanded and compelled, until I provide an inexhaustible supply of money for every known need, desire or hope of the human race.

Simply because I refuse to donate to something or other I am boycotted, talked about, lied about, held up and held down, and robbed until I am almost ruined.

I can tell you truthfully that except for the miracle that happened I could not enclose this check. The wolf that comes to my door just had pups in my kitchen. I sold the pups and here is the money.
Nobody's Perfect...

We all have our favorite horror story about a planetarium which was designed and built by architects and builders who didn't quite know just what this "planetarium" place was all about. For example, Stephen Smith of Arlington County Public Schools Planetarium tells us that his planetarium was built with glass doors! Norm Sperling of Duncan Planetarium at Princeton Day School knows one in which heavy black curtains solved the problem of the carefully placed windows. Rich Calvert of the El Paso, Texas schools relates that one planetarium projector has plexiglass walls for the pit in which it rests, so that the light from the room below very nicely flows into the planetarium chamber. Robert Tate, PLANETARIAN from Harper High School Planetarium in Atlanta, is pleased to report that the builders who wanted to put a beam horizontally inside the dome for reinforcement, were gently persuaded to change their solution to the problem. Hear the one about the planetarium which has a bathroom just on the other side of the wall of the chamber, or the school facility with the funny electrical wiring so that whenever the school bell rings, it sets off the cove lights? My own planetarium was not a planetarium to begin with, and has hot water pipes running along two walls, gurgling merrily in the quiet darkness (Haven't you ever heard a babbling brook outside under the stars?). When my sun's image gets into the northeast or northwest, near the horizon, as for a summer sun in the middle latitudes, it disappears behind something up there on the projector. My comments go something like this: "My goodness! It looks as if the setting sun has gone behind a cloud! Let's see if it reappears just before it sets!"

Have I left any out? Let me hear from you. After all, nobody's perfect.

Jane's Corner

by Jane P. Geoghegan

Send your "happenings" to Jane Geoghegan, 4100 W. Grace St., Richmond, Va. 23230

Overheard

Chuck Vukin, PLANETARIAN from the Alexander Brest Planetarium in Jacksonville, Florida knows the frustration one can experience from an annoying light leak in the planetarium. But he has developed the ultimate in special effects gadgets to alleviate the problem; he calls it the "traveling light leak projector".

Norman Dean, PLANETARIAN in Bel Air, Maryland shares the following with us:

"Many colleges and universities are conducting courses for career planetarium personnel. It may be wondered how a college could distinguish the potential planetarium director from the potential research astronomer. A suggestion follows: A student is told a date has been arranged for him/her with Cher Bono/Burt Reynolds and a college student of similar description is stationed a strategic distance away. When near enough to tell the difference, the astronomer resents being fooled and goes back to his dormitory. The planetarium director, realizing that a reasonable facsimile can be a valuable thing, proceeds to go out on the arranged date."

Norman also explains how he once became editor of the MAPS newsletter: At a meeting, someone held up some news material and said, "Who wants this grim burden?" Norman thought he said "Who
wants gin and bourbon?"

Michael Zeilik, of the Harvard College Observatory, believes that "geologists are astronomers who never got off the ground". Ouch! Michael has a sign on his office door: "Celestial Mechanic for Hire (We can fix quantum defects While-U-Wait) . . . Perturbations smoothed out . . . Precession slowed down . . . Orbits planned for long vacations."

You don't have to have a planetarium to be a PLANETARIAN! George Puckett, who works for the Atlanta Board of Education as a layout artist, shares his true PLANETARIAN nature in the following cartoons:

"SO YOU THINK YOU CAN HANDLE OUR PLANETARIUM, MR. XLYP?"

ANCIENT MAN WAS GUIDED BY THE STARS.

WAXING MOON

"MR. MELLISH, I THINK WE CAN DISPENSE WITH THE HOOPLA AND JUST SWEEP THE FLOOR."
Considerations for Planetarium Educators

by John J. Soroka, Cranbrook Institute of Science, Bloomfield Hills, Michigan

Author's Note: The following article was written over 2 years ago. Since that time the writer has mellowed, shifted priorities, and achieved a new perspective. Please consider the article in this context. (March 1976)

When I, sitting, heard the astronomer, where he lectured with much applause, in the lecture room,
How soon, unaccountable, I became tired and sick;
Till rising and gliding out, I wander'd off by myself,
In the mystical and moist night-air, and from time to time,
Look'd up in perfect silence at the stars.

Walt Whitman
When I Heard the Learn'd Astronomer

The above verse is most appropriate for a group of educators of the 1970's involved with science education for students in grades K - 12, college, and adults. Traditionally, I suppose, most of us tend to teach in the same manner that we were taught. As successful students of a rigorous and demanding discipline, we have built up over the years a body of knowledge which allows us to deal intellectually with new information and refined ideas in skillful ways. Our success has enabled us to assume an authoritarian role and, potentially, a unique position in the educational enterprise. From our place behind the console we are in a position to dispense either knowledge-based facts, or high order concepts, old hat to us, but new, and at times bewildering, to the learner. If we were to analyze objectively our instructional methods, demonstrations, and visual aids, the writer believes that one could show that they are used mainly to reinforce the lecturer's role as the authority or teller. We tend to deal mainly with verification of existing theories, or carefully controlled demonstrations and exercises in a step by step fashion to produce desired results. It appears that we are caught up in the presentation and description of the rational development of selected theoretical models, and in some manner hope to transmit the essence of this method of discovery to the intellectual processes of our visitors.

Our advanced students, like ourselves, have both command of the intellectual processes and the motivation to assimilate and to internalize these ideas. However the majority of our beginners, average students, and adult patrons tend to deal with facts and concepts in concrete ways; that is, they are unable to consider all possibilities as well as the given combinations, systematically excluding some, in solving problems.

It is not suggested that we discard that which has been successful, nor deny the emerging expertise which we have brought to the teaching of astronomy and science. However, it is postulated that much of the effort thus far expended has been devoted to describing the history or accumulation of a body of knowledge.

The writer's present educational concerns appear to be related more closely to our apparent success than with any sense of failure. Appearances can be deceptive. Much has
changed in the past five years. The buoyant force of the '60's which gave to us expansion and public support has subsided. We have lost, temporarily at least, the momentum which provided us with a certainty, a sureness which was one of the great sources of our creativity and vitality. It is time to reexamine some of the basic educational assumptions which we have accepted rather blindly from a pompous and elite tradition, and to reorder our educational goals and objectives. Of primary concern should be the better understanding of our adult and student learners, their intellectual processes and levels, goals, and values. What we achieve probably will not be new, but our priorities will be new, or at least their order will be new. We will bring to our students new and skillful techniques, and the creation of a greater variety of learning situations based not on a body of science or a single discipline, but on the needs and capabilities of the learner. We must not let ourselves be persuaded that we have to wait for direction from some future, systematized research program. There is an existing basis for our reordering, and we must begin to act upon what we now know.

If one is to accept the premise that the function of the planetarium educator, exclusive of classroom and administrative duties, is to disseminate information and interpret astronomical and related concepts to a wide range of children and adults, then it follows that the planetarium must have some function other than that of a classroom with the normally available reference materials and audio-visual paraphernalia. In terms of the "E" in ISPE, it is the writer's opinion that the education function, if it exists, has never been precisely described or objectively substantiated. It is suggested that this is one of the reasons for a decline of our interest in educational planetarium programs and a trend toward entertainment and mysticism. During the years of planetarium growth and renewed public interest in science and technology in the 1960's, the lack of definite objectives and publicly stated purposes by the planetarium community did not appear to be of major concern as there were always more students and adults to fill the chambers and to see and hear of the wonders of astronomy, science and rocketry.

However, if the 1970's and 1980's are to be years of reentrenchment and reevaluation of goals and values, then one must wonder if the planetarium profession will have the ability to serve the specific needs of science education and the general public relative to a new set of priorities. It is in this regard that the profession must look to its own stated purposes and proven educational base. It is doubtful if the installations, programs, and publicly declared policies of the past twenty years will be appropriate to the experiences and attitudes of the coming years in which creativity, initiative, and the individual will be of greater importance.

There has been a decided shift from the rather humanistic and idealistic traditions of education to issues of a political and economic nature. Good teaching is still recognized, but of greater importance is what has been learned and how much. Since the goal of teaching is to produce some type of learner achievement, one should be primarily concerned with the abilities of the teacher and the improvement in methods of instruction. However, it is more and more apparent that educationists no longer will be able to speak of competency and improvement in simple behavioristic terms. The day will be shortly upon us when the general public will demand some measurable and demonstrable improvement in the
nation's schools. Taking into consideration all of the implications of the above statement, the educational community will have to provide the answers from a rigorous and analytic research program. A level of research must be reached where one can demonstrate that a specific teaching behavior results in variability of learning. When this level is reached, public confidence in education will be reestablished.

Implicit to this model is the availability of data from research and development of programs to improve teaching competency, curriculum and student learning.

Specific disciplines and methods of instruction will be investigated by using existing research data. Planetarium education has little specific data to support its claim as an effective teaching device. An analysis of the literature relevant to the planetarium from 1960 to 1973 is summarized from Reed's (1972, 1973) annotated bibliographies:

Doctoral dissertations............18
Educational Articles...............59
Individual Programs,
  Outlines, and/or Scripts.........19
Descriptions of Installations
  and Programs......................80
Technical and Auxillaries........28
Historical and Associations......20

Two forces exist in modern society which are driving the educational enterprise to change. A press for accountability comes from business and industry, and from the general public through the various state legislatures. With increasing budgets and limited funds, educators are required to relate input (money, personnel, buildings, resources) to output (student achievement related to the goals of the society). The second force which is compelling educational change is the need for personalization. In the depersonalized society, the student becomes a paper to grade or a name on a roll. Vance Packard charges that we have become a "Nation of Strangers."

Now we hear a cry for individuality, freedom, independence and recognition. The demands for accountability which are present today contain a completely legitimate but often frustrating request: we must account for how well we have achieved the goals that we have set forth with the resources available to us. The essential questions themselves are quite reasonable and acceptable. The general public continues an interest in education and through their ability to pay bond issues and levies, are asking for some proof that the educational system is doing what it is supposed to do. It is necessary that the system demonstrate that a relationship exists between the money put in, student time, expertise of educators, and the result of this process, the human beings that emerge.

James E. Allen, former U.S. Commissioner of Education, made the following comments in an article in the 1972 winter issue of the College Board Review: "The push for accountability is inevitable. The circumstances of our times--loss of public confidence, taxpayer revolt, student unrest, neglect of the disadvantaged, and demands for social justice--have forced accountability to the very top of the list of priorities. Even with the maximum exercise of its power, the public can only deserve and demand action. Government and the profession have to provide it, and the real push must come from those sources. The government is responsible for creating those conditions in which good education can flourish, and the profession is responsible for producing good education within the conditions."

Paul Hurd (1970) stated that the major educational problem is how to prepare young people to cope with an
intellectual and cultural environment characterized by rapid change. For centuries, the science curriculum has been designed with the idea that tomorrow would not be much different from yesterday. Conventionally, young people have been educated for the present. This, in a modern, science-oriented society, is education for a world that never exists for the student. To educate for change is to focus on the future. Therefore, the teacher has to teach more than he knows and for times he has not yet experienced. "The consequences of modern science have made myths of traditional educational goals in science and rendered obsolete large amounts of subject matter in our courses." (Hurd 1970).

As has been said many times and by many people, the major goal of science education is to develop scientifically literate and personally concerned individuals with a high competency in rational thought and action. Scientific literacy involves the development of attitudes, process skills, and concepts necessary to meet the more general goals of all education. Above all, the school must develop a dynamic, changing curriculum which will allow the student to learn under his own initiative, and a motivation within the student to do so.

To promote scientific literacy, science curricula must contain a balanced consideration among conceptual schemes, science concepts, science processes including rational thought processes, the social aspects of science and technology, and values deriving from science. Emphases on values, social aspects of science and technology, and moral education must be part of today’s science curriculum.

Learning by discovery is a complex issue. There is a controversy about how much and what kind of guidance ought to be provided to the students in the learning situation. Those favoring learning by discovery advocate the teaching of broad principles and problem-solving through minimal teacher guidance and maximal opportunity for exploration and trial-and-error on the part of the student. Those preferring guided learning emphasize the importance of carefully sequencing experience through maximal guidance and stress the importance of basic associations in the service of eventual mastering of principles and problem-solving. (Schwab 1967).

Presently a number of science curriculum projects use the inquiry method. The writer considers inquiry an outgrowth of discovery. Inquiry is the art of asking the right questions at the right time. Schwab (1967) states that "inquiry begins in virtual ignorance; ignorance, however cannot originate an inquiry." The student becomes involved in the inquiry approach by sensing a problem and he begins to hypothesize. The student must use his faculties and technological resources to investigate the problem he has encountered. The conclusions that he draws from his investigation will help him to gather various facts and principles into a body of knowledge which will allow him to understand the basic structure of science, and to realize that similar behaviors can be applied to future problems.

For the student the most important result of learning through inquiry is a change in attitudes toward knowledge. As he engages in the dialogue of inquiry, he begins to view knowledge as tentative rather than absolute, and he considers all knowledge claims as being subject to continuous revision and confirmation. As he tries to provide his own answers to difficult problems about man and the environment,
he begins to understand the complexity of verifying knowledge and the processes involved in it. (Massilas 1969).

It is not the purpose of this paper to discuss the various curriculum projects nor the foundations upon which they are based. However, some recent studies have shown that all students do not have the ability or perception to be successful in struggling with strange concepts or high level integrated processes. It is to these students, perhaps the majority, that teachers must address themselves. Programs must be adapted to allow students to undertake their studies at various starting levels and proceed at their own rate.

In a paper presented for discussion at the annual meeting of the National Association for Research in Science Teaching, April 1974, Ann Howe undertook a review of the literature to examine the factors associated with intellectual development during adolescence, and to consider what the implications of these factors might be for curricula and teaching methods in secondary school science. She stated:

"The present secondary science curriculum is based on the structure of science and to a large extent ignores the structure of the adolescent intellect. A major change in point of view will be required if science instruction is to promote intellectual growth for all, or even a majority of secondary students."

"One of the strongest impressions to emerge from reading the literature on formal operations is the vast differences between adolescents in intellectual achievement and ability. Instruction cannot possibly bring about learning unless it takes these differences into account. The high level of interest, even preoccupation, with the idea of Piagetian stages and the performance of certain tasks has obscured the overall thrust of Piaget's work and led to a notion that we have to wait until an adolescent becomes 'formal operational' and then begin certain kinds of instruction. On the contrary, we should be devising instructional methods and promoting attitudes that will help students move forward from wherever they are. The literature comes through clearly on the point that intellectual development is gradual during adolescence, that there are important factors outside of the control of the school, but that the schools have an important role in this development."

She further listed seven major implications from her review of the literature.

1. There is a wide divergence in ability to perform formal operational and other similar tasks. The need is for a program which will allow all adolescents to make progress in the development of reasoning ability.

2. Teachers should not wait for students to become "formal operational". "It may never happen."

3. The ability to solve problems which require higher reasoning ability is not a sudden acquisition which will immediately generalize to other problems of the same logical structure. A student's cognitive operational level is likely to differ from subject matter to subject matter, particularly during the junior high school period.

4. Most instruction, especially that below the junior year, should be in a concrete operational mode. This does not mean that it should all take place in the laboratory, but that problems should be posed in concrete terms, approached from different angles, and that students should be engaged directly with the content. The aim is the transformation of overt action into mental operations, the building of a mental structure which can assimilate new
concepts and, eventually, think in abstractions and generalizations.

5. The content of a problem may be more important than the structure of the problem. The wisdom of trying to teach disembodied "processes of science" without regard to content should be given another look.

6. Much more needs to be known about the relation of reading and language ability to intellectual development beyond childhood.

7. We need much more knowledge of the details of how important concepts are acquired.

She concludes with a caution not to think solely in terms of formal operations, and that formal logic seems too tight a container for the broad range of reasoning powers which are possible.

There are a number of additional studies which have given some validity to the concern of the national science curricula's appropriateness to all students in the secondary schools.

Marek and Renner (1972) report a study which attempted to answer the question, "Can high school biology students exercise the type of thinking which allows them to separate variables, see the implication of one factor in another process, use the principle of exclusion, and reason with the 'if... then... therefore...)' construct?" Jean Piaget in Psychology of Intelligence has called a person who is able to reason with these factors a formal operational thinker. According to Beard (Lawson 1974), a formal operational thinker "makes a succession of hypotheses which he expresses in propositions and proceeds to test them... he begins to look for general properties which enable him to give exhaustive definitions, to state general laws..." This person is, in other words, a hypothesizer.

In the Biological Science Curriculum Study "Web of Life" exercise, the student is asked to do exactly that—form hypotheses about his observations. Results of research conducted on students working with this exercise indicate that 73% of tenth grade students cannot do formal operational thinking (Marek and Renner 1972).

In another study, Lawson (1974) found that many students in BSCS, Chem Study, and Project Physics were not formal operational, and concluded that a substantial portion of the secondary school curriculum subject matter is not suitable in terms of the intellectual level of the learner. (Table 1).

The biology sample investigated showed nearly 65% of the students still largely at the concrete level of intellectual development. Since these students were found to be unable to develop appreciable understanding of formal abstract concepts, it appears for them a science course which deals with abstractions and "basic" unifying themes is inappropriate.

In our eagerness to update the science curriculum during the 1960's one very important dimension apparently was left out—the learner. When the school planetarium curricula were developed in the 1960's, curriculum guides were developed around existing school programs by committees of administrators, teachers and planetarium specialists. Planetarium programs were written to present facts, concepts, and general scientific principles in major content areas in either spiral or semi-spiral programs.

These somewhat traditional presentations of facts with the use of a wide range of audio-visual materials has been and will continue to be one of the important aspects of teaching. However we have little evidence to support the appropriateness of presenting certain facts and concepts at their assigned levels.
Is it possible for a majority of primary or intermediate students to do more than sit and watch, much less understand, the intricate motions of the sun, developed during presentations on the seasons? Is it possible for a sixth grade student to be able to read, interpret, and form a mental image of the moon-earth system from a projected slide of the sun, moon, earth and lunar phases? At what level are we presenting conceptual schemes such as cosmology, stellar evolution, and distance-magnitude? If a seventh grade student cannot come to grip with the concept of density, how can we assume that he can deal with the inverse-square law, solar and lunar eclipses, retrograde motion, and the Christmas conjunction?

Of the eighteen doctoral dissertations pertaining to planetarium education reviewed by the writer, eight were comparative studies, and six were pertaining to questionnaires and surveys. There is little supporting evidence from this rather slim collection of research projects that the planetarium is an effective teaching tool, much less a superior method of instruction.

Planetarium programs have developed in many diverse ways over the past twenty years in the public and private schools. However most of the programs claim some form of interdisciplinary application. I believe that the use of the term interdisciplinary is inappropriate and that most of the planetarium programming in public and private schools is actually coordinated programming resulting from an attempt by the developers to unify traditional subject-centered concepts in some spiral form of the general curriculum.

David H. Ost (1975) discussed the move toward the fusing of disciplines, conceptual schemes and
instructural procedures. Many favorite terms are used to describe the various planetarium programs, but most are lacking operational definitions and thus cause misunderstanding and poor communication. According to Ost:

INTERDISCIPLINARY--Courses of study which merge, for purposes of instructional expediency, two or more bodies of knowledge. This implies that the instructors have not conceptually integrated the content from their respective disciplines and consequently team teach.

UNIFIED--Programs within which unifying themes or concepts are developed. Various disciplines of the natural and physical sciences take major themes and build conceptually upon them. An example of this is the concept of energy and could be studied from biological, geological, or chemical dimensions.

INTEGRATED--A term most often used in connection with mathematics and science. Perhaps this is simply a more sophisticated form of an interdisciplin ary program. An example of an integrated science and mathematics program would usually involve the teaching of applied mathematics for the solving of scientific problems.

CORRELATED--A term used to describe attempts to relate skills or concepts from one discipline to the other. The disciplines retain a separate identity. The usual rationale behind such a program is to increase the relevancy to the students or to provide appropriate skills when needed.

COORDINATED--Programs which attempt to remove redundancies and to focus on conceptual schemes set in a traditional spiral curriculum with different courses treating the material with differing degrees of sophistication.

COMPREHENSIVE PROBLEM SOLVING--Relatively new approach which is based on the "unit concept". The student defines a comprehensive problem and is asked to apply various skills and knowledges from science, mathematics and social studies in an attempt to optimize some solution. The student is able to enter completely into the problem, to enter and to exit at his own level of competency, and requires no predetermined knowledge but rather can either apply what knowledge he has available to him or develop new knowledge necessary for solving the problem or working towards a tentative solution.

Assuming a consensus could be reached that planetarium programming is of a coordinated nature, that is, intermediary between traditional lecture and unified programs, one could then list the various separate topics and disciplines in which the planetarium facility has some application. A comprehensive list was developed and published by Major Stanley F. Powers (1973).

Planetarium presentations of these topics have involved various teaching strategies or combinations of strategies. Four major methods of instruction are (Voss):

Science As a Product (traditional)
A. Objectives.
1. Learning is memorized and verbalized.
2. Students learn "about" science.
3. Science is taught as a rhetoric of conclusions.
4. Science is expository.
B. Characteristics.
1. Facts, concepts, principles are learned from the text.
2. Deductive approach.
3. Usually a chapter by chapter approach.
4. Lecture, recitation, verification, laboratory.
5. Teacher usually authoritarian--serves to clarify and explain subject matter.
6. Teacher serves to tell about
7. Science is descriptive and illustrative.
8. Teacher-centered learning.

Science As a Process
A. Objectives.
1. Students "learn how to learn".
2. Tests involve critical thinking, evaluation, synthesis, application.
3. Students develop and improve attitudes.
4. Students develop skills of science.
B. Characteristics.
1. Learning from activity, centered about laboratory.
2. Inductive, discovery, open-ended approach.
3. Teacher-guided discovery.
4. Science is more quantitative and investigative.
5. Process skills are emphasized.
a. Observing.
b. Inferring.
c. Predicting.
d. Measuring.
e. Communicating.
f. Classifying.
g. Recognizing and using space-time relations.
h. Recognizing and using numbers and number relations.
i. Identifying problems.
j. Formulating hypotheses.
k. Setting up controlled experiments.
l. Identifying assumptions.
m. Graphing results.
n. Interpreting data.
o. Making operational definitions.
p. Controlling and manipulating variables.
q. Formulating conclusions and models.
r. Developing new problems from conclusions.

Science As Inquiry
A. Objectives.
1. Science becomes a "narrative of inquiry".
2. Student assumes a behavior of being able to do; independent problem solving.
3. A future scientist.
B. Characteristics.
1. Process of exploring and validating alternatives.
2. Students utilize process and product in analyzing scientific research.
3. Teacher may initiate problem.
4. Students investigate scientific phenomena.
5. Student-centered learning and discovering science.

When we look at most of our existing planetarium programs in light of the four teaching methods, the writer believes that we are able to identify elements of each method at some level of our graded school programs. It would be fair to state that the majority of the time is spent in the traditional format dealing with facts and the accumulation of scientific knowledge. This
reliance stems from the development of elaborate curriculum guides for K-12 programs. The curriculum guides generally outline units to be presented by the classroom teacher. It should be noted that in many cases the selection of units is determined by those areas of instruction in which the planetarium facility is thought to be most effective. This is in itself a paradox since a part of the curriculum is being specified by the capabilities of a machine, and not by the abilities and interests of the student.

Emphasis has been placed on content and student activities prior to the planetarium visit, and follow-up activities upon the students' return to the classroom. This places the burden of instruction with the classroom teacher and relegates the planetarium presentation to a summarization of those concepts thought most effectively demonstrated in the planetarium chamber.

Time after time, planetarium educators are at a loss to explain the classroom teacher's lack of understanding of the curriculum guide and his inability to present rather simple concepts in the classroom. From the writer's experience, teachers' classroom presentations often center around drill and review type sessions at the elementary and junior high school levels so that students will be able to respond to low level questioning by the planetarium lecturer, and to ask pertinent questions relative to the subject under discussion.

The classroom teachers' apparent difficulties with the curriculum guides no longer comes as a surprise to the writer. For the past year much of his time has been expended on the instruction and supervision of secondary science student teachers. From observations and testing, the writer has come to the conclusion that a great number of student teachers are not formal thinkers, and are not able to develop an understanding of abstract astronomical and related concepts. If this is true for secondary student teachers trained in a scientific discipline, surely one could assume that this would be valid for a large number, if not a majority, of elementary teachers with a minimum of training in the formal sciences and experimental techniques.

Lawson (1974) lists four possible alternatives for the adjustment of the curriculum to better fit the intellectual level of the learner, and the writer suggests that in a number of cases we could include the classroom teacher.

1. A careful reevaluation of the major content of the science courses in an attempt to better fit that content to the level of the learner.

2. A careful evaluation of teaching procedures and sequencing of materials to help lead the learner from concrete to formal thinking patterns.

3. The use of curricular materials in the elementary and junior high schools which will confront the students with first-hand experiences and concrete problems.

4. The development of separate courses at the secondary level designed only for the concrete thinkers. This alternative carries with it the need for ability grouping which has numerous drawbacks familiar to all of us.

When we consider those problems that face us, it is easy to speak continuously in negative terms. Much of what we are about is effective and educationally sound. Adjustments that must be made do not necessitate radical departures from the tried and true, but require an evaluation, and where the existing programs and curriculum guides are found to be inadequate, a redesigning or
restructuring. (Although to be truthful, perhaps the best use of a planetarium curriculum guide in excess of 1/2 inch in thickness is for the elevation of a Carousel.)

In assessing or evaluating existing programs, it is not necessary, nor would it be practical, to construct comprehensive devices which would be applicable to all planetarium installations. Of the eighty descriptions of planetarium facilities and programs in Reed's bibliographies (1972, 73), each appears to be unique in its design and the function it serves in its community. This is further born out by the results of the surveys conducted by Mattson (1970) and Dean (1971). These surveys indicated the great diversity in planetarium installations relative to equipment, personnel, funds, programs, and location. It is the responsibility of the planetarium to assess its own program and to report the finding to the planetarium community. The regional associations and ISPE can be, and should be, the distribution centers for this information.

It is true that these mini-research projects will be subject to criticism as to research models, statistical treatments, and sampling techniques. However, if enough data is made available from hundreds of planetariums, the profession could then begin to formulate a body of supporting data for what is being done in the planetarium, its effectiveness at the level it is being presented, and its relevancy to the student and community. Perhaps this specific data could then be treated in a more rigorous manner.

If an installation can show that a traditional program presenting facts and knowledge about the development of scientific thought at the eighth grade produces understanding by the students and is considered relevant, this is important and should be reported. If the presentation of a program utilizing the process of interpreting graphs at the third grade level is found to be inappropriate, but effective at the ninth grade, this is important and should be reported. If a presentation centered around the concept of matter relative to stellar structure is determined to be ineffective at grade five, but well understood and relevant to physics students, this should be reported.

What we do not need are more complex comparative studies of teaching techniques contrasting planetarium instruction to various experimental and control groups.

The planetarium is an audio-visual teaching aid, and as with overhead, slide, and movie projectors, the machine is as effective as we choose to make it. If it is not productive, it is not the fault of the machine—unless it is another PR 12.

After twenty years of expansion and development, it is time we began to find out what we are about. Those concepts we teach are important and germane to us. Now all we have to do is demonstrate to ourselves and to our students that they can be learned, and are relevant.

BIBLIOGRAPHY


Lawson, Anton E. April 1974. "Relationships of Concrete and Formal Operational Science Subject Matter and the Developmental Level of the Learner." At the National


Schwab, Joseph L. December 27, 1967. Invited Address to the American Association for the Advancement of Science, Division Q (Education) National Meeting, New York.


Indian Sky Art, continued from page 106


52. Ibid., p. 8.

Dome Geometry: 
An Exercise in Compromise

by O. Richard Norton, Grace H. Flandrau Planetarium, University of Arizona, Tucson

Until quite recently, planetariums have been designed with dome horizon lines somewhere between 8 to 10 feet above the theater floor. There were good practical reasons for this. Most building codes required 7 to 7 1/2-foot-high entrance and exit ways for optimum traffic flow. The planetarium instrument's latitude axis, which lies on the same plane as the horizon line, purposely placed the projector (and projection dome) out of reach of the spectators. Moreover, a high horizon line made horizon objects much more visible to the audience, and anyone leaving the theater during a presentation could do so without obstructing the screen. (Elevators didn't exist in planetarium designs in the early days.)

The most obvious drawback of the high horizon line was the feeling it produced of being "in a hole in the ground" and having to look above the horizontal to see the horizon. The horizon by definition should be horizontal to the observer's line of sight. Historically, this effect became increasingly apparent when skylines were introduced into the planetarium production. It became intolerable when spherical motion picture projection (the atmospherium) was introduced into the planetarium theater in 1963. Thus,
a means had to be found to lower the horizon line but maintain the desirable features of the high horizon line.

Three alternative solutions to the problem exist, each compromising some of the desirable features of the high horizon line. I refer to these solutions as follows: the tilted dome, the hyperhemisphere, and the minimum horizon system. Each will be discussed here as separate entities, but it will become obvious that each possesses some of the advantages of the others.

The Tilted Dome

Although the first tilted dome to be constructed in the United States was installed at the Pacific Science Center in 1960, it was not a true planetarium, since it primarily functioned as a motion picture theater using spherical projection. The dome is 80 feet in diameter and is tilted 15°. The first true planetarium theater using the tilted dome concept appeared with the completion of the Reuben Fleet Space Theater in San Diego. Figure 1 illustrates the geometry of this 76-foot dome theater. The tilt is about 25°, bringing the dome edge almost to the floor.

With a tilted dome a number of modifications of the basic planetarium theater design become necessary. Since the dome covers nearly one-half of the wall space below the normal horizon line, the seating must be directional as in a standard movie theater. In this situation, the screen lies well below the observer's horizontal line of sight, thus necessitating the use of steeply tiered seating for optimum unobstructed viewing. Only about two-thirds of the normal number of seats (circular seating pattern) can be fit into the theater with this design. Furthermore, a true astronomical horizon no longer exists, since that portion of the dome behind the observer is substantially above his line of sight, and correspondingly below his line of sight in front. Only the Spitz STS projector is designed to produce a skewed horizon line. (Actually, any pinhole projector, such as the Spitz A4 and 512, which uses a horizon cup around the Xenon arc light source, can produce a tilted horizon merely by weighting the cup to balance in the desired skewed position.) Zeiss-type instruments such as the Minolta/Viewlex, Goto, or Zeiss which use weighted "eyelids" over the projection lenses cannot produce a tilted horizon without extensive and rather expensive design changes to the 32 horizon cutoff mechanisms.

Special effects projection is restricted to points behind the seated audience, which is the most desirable projecting position. Complete 360° horizon scenes as in conventional theaters are not possible, however, and generally, not as many special effects projectors can be utilized in this geometry due to space limitations. However, this limitation is minimal for large theaters such as the Fleet Space Theater.

The Hyperhemisphere

The Eugene Cernan Space Center of Triton College near Chicago uses the hyperhemisphere concept. Here, a standard hemispherical projection screen is extended on one side to the floor (Figure 2). Since this geometry maintains a horizontal dome configuration, a true astronomical horizon is maintained. Thus, a standard planetarium projector with the conventional horizon cutoff system can be used. When using the planetarium projector as a teaching instrument, it is desirable to obstruct the extended part of the
dome to maintain the integrity of the dome horizon.

Virtually all planetarium instruments possess horizon cutoff problems. Zeiss-type instruments have eyelids that stick at certain instrument latitudes, while Spitz-type systems produce a correct horizon cutoff at only one latitude. A dark wall beneath the dome horizon helps to maintain an apparent horizon even though star images may be projecting there due to the above problems. To cover the extended portion of the dome with a dark covering under these circumstances is necessary. To produce stars within the extended area for space effects, the horizon cup surrounding the Xenon arc must be modified by either weighting the cup as earlier described, or cutting out a section of the cup corresponding to the angle of the extended dome below the horizontal. The latter may prove to be difficult since most Xenon arc lamps have small fisheye lenses over the arc that limit the projection angle to 180°.

As with the tilted dome geometry, the seating arrangement in the hyperhemisphere must be directional and tiered. To prevent the back row of seats from being within the starfield, the horizon line must be placed quite high. This produces the "hole in the ground" feeling mentioned earlier when using the planetarium in the conventional manner.

Both the tilted dome and hyperhemisphere concepts present dome maintenance problems, since the extended portion of the dome is subject to the hands of the public. To avoid this problem an "off limits" section of the theater must be established that limits public access.
to this area.

Spherical projection in the hyperhemisphere can be a true 180° using a circular film format. To cover the extended dome, however, the projector must be tilted in a forward direction by an amount equivalent to the angle of the extended dome (28° for Triton College). Of course, filming with spherical lenses must be done at the same angle as that of projection to maintain horizontal horizons. It is interesting to note that the spherical projector does not have to be positioned in the center of the dome theater. Though it is true that distortionless pictures can be obtained only from projection at the geometrical center of the dome, it is likewise true that the viewer must be positioned at the point of projection to see a distortionless picture. This, of course, is impossible. It is therefore pointless to project at the geometrical center of the dome. Projecting from a point removed from the center by as much as 25% of the dome radius does not noticeably affect the image quality. Since the planetarium projector must be used in the central position, the logistical advantage of an off-center spherical projector position is obvious.

The Minimum Horizon

The third alternative geometry, adopted at the Grace H. Flandrau Planetarium of the University of Arizona, utilizes the lowest horizon line possible, consistent with
optimum visibility of the projected images, ease of ingress and egress, optimum projection geometry for the planetarium, atmospherium and auxiliary projectors, and maintenance of the astronomical horizon. Figure 3 illustrates the geometry of the minimum horizon system. Ideally, the viewing plane of the "seated" eye should be coincident with the horizon plane. Though in practice this is not possible, it can be very closely approximated. The average observer's eye level when seated is about 42 inches above the floor level. The minimum height of the dome horizon is dictated by this value. The observer's head, supported by a high-backed chair, is about 48 inches above the floor.

At the Flandrau Planetarium a projection gallery immediately behind the last row of seats, houses the auxiliary projectors and projects through an opening one foot wide. One foot above the top of this opening, or a total of 6 feet above the floor level, is the minimum horizon level. A seated observer viewing the horizon from 50 feet lifts his eye level only 3° above true horizontal. This angle closely approximates a true horizon. If the horizon is viewed by a standing observer (as it will be in the University of Arizona's academic program), the true horizon level to the viewer is essentially 0°. By alternating the seat positions in each row, visibility of the horizon, though not perfect, is possible. The problem of tiered seating is therefore avoided in this design.

To enter the theater, it is necessary to pass through the dome at the 7-foot level and climb a sloping ramp to the 6-foot level of the theater floor. Thus, ingress and egress, as in the preceding two geometries, is somewhat awkward in that the audience must move to the center of the theater to exit down the ramps. An alternative approach would be to provide sloping passageways behind the last row of seats leading to the exits. This results, however, in a loss of seats to make room for the passageway and places the dome screen within easy "touching" access of the public. Moreover, anyone leaving the theater before the program ends could obstruct images projected from the projection gallery.

The minimum horizon geometry places the planetarium projector in a vulnerable position since the latitude axis can be no higher than the dome horizon (6 feet). The instrument obscures less sky in this position, however, and if on an elevator, it can be raised or lowered out of reach of probing hands before and after the program.

The atmospherium projector is placed about 6 feet off center toward the console side of the theater. Off-center distortions are minimized by tilting the projector such that the optical axis of the projection lens passes through the center of the dome. These are the options with which one is confronted when selecting a dome geometry best suited to his program. In all cases, there is really no "best way". All three represent exercises in compromise. In the final analysis, the choice must be tailored to the total program philosophy and the equipment available.

(End)

Since the advent of ISPE and the publication of its journal, planetarium articles in other journals have practically ceased to exist. This situation could be attributed to the planetarium community’s embrace of their new organization and journal.

The majority of the articles that appeared this past year (1973) were of a research nature. The research articles continue to show a need for a conceptual framework within which to develop purposeful instructional strategies. They also show a need for planetarium researchers who will carry on continuing research projects.

The following planetarium related articles appeared during the academic year 1973-1974:

Akey, James Miles. "The Behavioral Selection of Planetarium Concepts Appropriate for Second Grade Students." Unpublished doctoral dissertation, University of Northern Colorado, 1973. A One-Group Pretest-Posttest Design was used to test the appropriateness of 56 behavioral objectives used in three planetarium programs presented to second graders. The programs dealt with an "introduction to the sky" and the "sun’s family." A pretest was administered immediately following each program and again two weeks later as a test of retention. The second graders understood 39 of the 56 concepts in the pretest. An increased understanding was indicated for 39 concepts in the posttest analysis. The retention test showed that 52 of the 56 concepts were significantly retained. A correlation was reported between the concepts retained and the time spent postteaching the concepts.

Bondurant, R. L. "Planetarium Art: Using the Sky to Motivate Works of Art." Arts and Activities, 74 (September 1973), pp. 32-34. The planetarium can be used to motivate pieces of art.

Reed, George. "The Planetarium Versus the Classroom--An Inquiry into Earlier Implications." School Science and Mathematics, 73 (October 1973), pp. 553-555. This is a report of the follow-up of a study that was reported in the May 1972 issue of the same journal. The Posttest-Only Control Group Design with the Randomized-Group Technique was used with 82 college freshman receiving the classroom chalkboard-celestial globe treatment and 77 college freshman receiving the "lights up-lights down" classroom planetarium treatment.

The results showed no difference in the attainment or retention of the cognitive behavioral objectives between the two teaching situations. No differences were found in the attainment of the affective behavioral objectives. The conclusion of this study is that the planetarium is most effective when it is used in a classroom learning situation.

Ridkey, Robert W. "A Study of Planetarium Effectiveness on Student Achievement, Perceptions and Retention." Unpublished doctoral dissertation, Syracuse University, 1973. The purpose of the study was to determine the effect of planetarium instruction on junior high and college students in terms of their immediate attainment, retention and attitude toward presented concepts. Three groups were used: an all planetarium instruction group, an all activity instruction group, and a group that experienced a combination of activity and planetarium instruction. The con-
Conclusions were: (1) content learning in the planetarium is enhanced by an orientation session, (2) the combined activity and planetarium approach proved to be the most effective teaching approach at the junior high level, and (3) the planetarium groups were the only groups to show positive perception changes. These findings are supported by past research.


This is a summary presentation of the above dissertation. "These findings further suggest that it would be of greater benefit to develop planetarium experiences that deal primarily in the affective domain."


Details are presented for the construction of a 12-foot diameter geodesic dome that can be used with a Spitz Junior Projector.


The main purpose of this study was "to determine the relative effectiveness of the planetarium, through analysis of changes among second grade children, in attaining the perceived goals of planetarium educators." A total of 986 second graders were divided into three groups: a classroom astronomy unit group, a classroom astronomy unit and planetarium group, and a group that received no astronomy instruction or planetarium experience. Each group was given a posttest of 30 multiple choice and drawing items related to the goal areas. The findings were that the two instructed groups attained the goals of the planetarium educators. It was also found that increased performance took place when the planetarium visit took place during the last part of an astronomy unit.


An attempt was made to "evaluate what is known through research as to the actual role of the school and college associated planetarium in education" in the areas of perceived goals and the attainment of those goals. The conclusion was that "in general, the planetarium session as typically experienced in present schools and universities does not produce changes significantly greater than that which can be obtained in ordinary classrooms without the planetarium projector."


An extensive review of research literature from 1922 to 1972 is given for elementary, secondary and college level studies. Many planetarium studies are mentioned. With regard to the planetarium studies, it is recommended that research be carried out to develop instructional strategies for planetarium presentations. A large bibliography is included with the article.

(End)