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Telling the Stars: A Quantitative Approach to Assessing the Use of Folk Tales in Science Education.

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Telling the Stars:

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by
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ABSTRACT

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This research examines the impact of paired folk tales and science explanations on students in third through sixth grades who viewed program modules from the SkyTeller Project of Lynn Moroney and the Lunar and Planetary Institute of Houston, Texas. The audience consisted of over 3500 students in eight locations in the United States. Because few quantitative studies have been conducted to examine the use of stories in science education, the development of an instrument to assess students' attitudes toward science and stories forms a major part of this research. During the final stage of testing, the revised instrument and methods found significant increase in positive attitude toward science after the presentations. Questionnaires, telephone calls, and on-site visits with program presenters and teachers confirmed quantitative results. Despite the difficulties of conducting large-scale studies and the traditionally small response compliance, quantitative assessment can provide useful information for evaluating storytelling media.

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CHAPTER 1

INTRODUCTION

Stories and Involvement

Picture a group of students in a science classroom. The teacher is giving a lecture, perhaps explaining the difference between planetary revolution and rotation. The students follow along in the textbook. They are taking notes, for they have been warned that these concepts are part of the state testing in science. Now picture this same group of students an hour later with a storyteller. Their eyes are on the storyteller, or perhaps they have taken on that far-away look as they see the story unfold in their minds. They are relaxed, listening, sometimes glancing at each other to share the humor of the story. Although in the first class the students seem to be busy taking notes and receiving information, in the second class the students are actively engaged with the presentation. Later many of them will repeat the story to friends who were not there. We might find one or two students recounting the revolution/rotation discussion. How can we bring the involvement of storytelling into the science classroom? How would we judge the impact of such an effort?

The use of stories can enhance a learning environment, particularly in science. A common mode of presentation in science education—such as the one described above—is based on the paradigm of the science essay. It is rich in facts, with all inferences and conclusions clearly delineated. The role of the student in such a situation is to receive and store the information presented. Yet if the student is to actually be a scientist, then the student must become more active, imagining how things might occur, designing experiments, using data to create inferences and form conclusions (see, for example, Popper, 1968, a classic discussion of the active role of the scientific mind). The science essay is a means of communication between scientists, but it does not represent the mental activity necessary to be a scientist.

Stories, on the other hand, encourage active imagination on the part of the audience. The listeners create pictures, make inferences, think what might come next, and fill in the story so that it forms a connected whole. By becoming involved in the process of co-creating the story, listeners form a strong relationship to the narrative (Sobol, 1999).

The marriage of science and story is familiar work for Lynn Moroney of Oklahoma City, OK. For many years she has used traditional sky lore in planetarium presentations. Unable to clone herself, she did the next best thing: she formed an alliance with the Lunar and Planetary Institute (LPI) in Houston, Texas, to produce the media versions of stories alongside science explanations. SkyTeller Project, funded by the National Science Foundation, addressed the educational challenges inherent in the science paradigm. To engage students in studying space science, this project produced 12 to 15 minute astronomy program modules that pair traditional stories and science stories for use in programs in small and portable planetariums.

The project includes 10 program modules, with two of these modules available during the first year of this study, and six modules available during the second year (see Appendix A for a list of program modules). Each module features a Native American story about a topic in astronomy, followed by a science narrative that makes use of the imagery set up in the traditional story. The traditional stories set the mind for an active role. The science narratives convey concepts within a story framework rather than through the tightly worded fact and inference mode of the science essay. The traditional story is solely a vocal track, but the science narrative has illustrations. The stories were initially provided on a CD with the vocal track and slides in a Microsoft PowerPoint presentation. Due to compatibility and portability issues with the PowerPoint program, one module was placed on a DVD, and the final product is entirely in DVD movie format. A resource guide gives references for further study and suggests follow-up activities. Because recorded media makes each viewing nearly identical, the SkyTeller project offers a unique, replicable opportunity to study the impact of stories in science.

Review of Related Literature

Although very little has been written about the use of folk tales in science education, research conducted in related areas led me to believe that the use of stories would have a positive effect on students' science attitude. It has been well established by socio-linguists and media theorists Chafe (1982), Tannen (1982), Ong (1982/2002), and McLuhan (1962) that oral language fosters greater involvement than written text. Rader (1982) noted that detachment is particularly characteristic of scientific-style texts. More recently, Sturm (2000) described a special kind of involvement in live storytelling as a form of trance and surveyed the factors that promote and detract from that state. Such factors as the storyteller's vocal style, rhythm, and psychological involvement, as well as the activation of the listener's memories, characterize the unique way that storytelling engages an audience. In this project, the storyteller was not physically present to the students, so movements, facial expression, costume, and gesture, which Sturm noted can either help or hinder the trance, could not be a factor. Vocal style, rhythm, and the use of imagery remained as elements of engagement.

Further argument for the importance of stories came from Schank and Berman (2002). Arguing not from empirical evidence but from cognitive theories, they asserted that "our knowledge is constructed of stories in various forms" (p. 311). In support of their claim, they note the importance of making scenes and connected scripts to "lessen the burden of understanding new events" (p. 293). Strange and Leung's (1999) research showed that both factual and fictional stories are stored in memory in the same way. By pairing traditional stories with science stories, the SkyTellers Project might ease the resistance often encountered in absorbing the abstract concepts of science.

That science education is a particularly fertile field for the use of stories has been shown theoretically and anecdotally. Several authors saw the need to go beyond a traditional presentation of facts and theories. Martin and Brouwer (1993) argued that we need to abandon the common notion of science as completely rational and objective, replacing it with a situated view of science as exploration by individuals and teams of individuals. The creative role of the scientist was discussed at length in Popper (1968), who held that the formation of theories is not a logical process. Work by Ellis (2001) and by Daisey and Dabney (1997) focused on personal stories and biographical stories that have been used to show the struggles and triumphs of scientists and not just the scientific facts. Although scientists ideally stay removed from their experiments, these authors see the human, working scientist as integral to understanding science.

The scientist in action is an interesting topic, but other story genres may also engage students. Osborne (1998) reported increased emotional and intellectual involvement when she had her first grade students create and discuss dinosaur stories. Rather than focusing on other people doing science, she engaged her first grade students through an interplay of creativity and rationality in the stories. Even beyond the creative aspect, stories are beneficial in capturing the student mind. Kalchman (1998) used stories in astronomy to ground conceptualization in familiar experiences. Recognition of the familiar is one of the aspects Tannen (1989) cited as a factor creating involvement. Thus stories go beyond a strictly factual presentation in science first because science itself is more than facts, and second to involve students by connecting visually and conceptually to what the students already know. Because these discussions have relied on theory and anecdotal evidence, it is important to discover whether any quantifiable effects support the use of stories in science education.

Within this context, the study of student attitudes toward science can be useful. The attitudes of students toward science change with the students' ages. Greenfield (1996, 1997) found that younger students have more positive attitudes toward science than older students. By studying students in the transition age, this research assessed the effect of stories on science attitude at a critical developmental stage. Because attitude toward science can be a signal of future interest and study (*Science Indicators 1985*, cited by Beveridge & Rudell, 1988), the effects may have long-range consequences.

Folktales have been used in science education less often than personal and imaginative stories. Lebofsky and Lebofsky (1996) used folktales for the dual purpose of exposing students to literature from another culture and creating an opportunity to talk about science concepts. Science has long set itself in opposition to myths and legends, positing itself as the rigorous pursuit of truth, in contrast to myth's sheer fancy. Lebofsky and Lebofsky stayed somewhat within that tradition by carefully correcting notions from the stories they used. By contrast, Ellis (1999) praised newer children's books that connect rather than contrast myth and science. The SkyTeller Project worked from the platform of respect and connection of myth and science as well. Its use of traditional folklore to introduce science topics represents an area in need of detailed studies.

The SkyTeller modules use traditional stories, but, as media productions, they differ significantly from having a storyteller present to tell the stories. Gerbner (1997) proposed that our world is created by stories. What we hear shapes our ideas and our perceptions. He called communication "the nutrient culture…of mental life" (Gerbner, 1977, p. 205). His many studies of the television and movies showed that media are effective in enculturation, but that media also create a more passive audience. His concerns lay mainly in the content and the control of media, but the concern about passivity must be acknowledged.

McLuhan (1969) noted that as we become accustomed to media, the technology fades into the background where we are unconscious of its role. He pointed to the fragmentation and detachment that result from the pervasiveness of media and the paucity of personal interactions. McLuhan (1962) points out that audiences used to traditional storytelling are fully engaged in the telling and want to participate, even during media productions. Although the SkyTeller modules invite active imagination, they do not invite vocal or physical participation during the program.[1]

McLuhan (1962) urged us to rediscover the value of tradition "as an organic habit of re-creating what has been received and is handed on" (p. 10). The use of traditional stories in the SkyTeller modules celebrates what has been handed down, but the mediated nature of the project prevents the constant re-creating of stories which naturally occurs in traditional storytelling. Ong (1985/2002) described many differences between storytelling in primary oral cultures and storytelling in a highly literate society. Aside from physical and vocal participation, the stories themselves have different characteristics. For example, an oral culture expects and depends on

[1] During presentation of a SkyTeller module where the scientist used an orange to illustrate mechanics of moon phases, the instructions for imaginary movement of the orange caused students to stretch out their arms and move the hand holding the imaginary orange/moon. Teachers chided them for this bodily participation.

repetition of words and phrases, but a literary culture expects non-repetition. In an unpublished paper (Meyers, n.d.), I transcribed two traditional stories on the SkyTeller media and examined them for Ong's oral/literate distinctions. One story fit squarely in the primary oral tradition, but the other was literary. In a highly literate culture, these distinctions are hardly noticeable because they are part of the framework of thought. In any primarily oral subculture within the United States, the distinctions may be significant.

Ong (1985/2002) noted that secondary oral performances create group unity within the audience, much as primary oral performances do. The group created by a present storyteller is small but intimate, limited to those within the sound of the teller's voice. The group audience created by media can be large and widely scattered, as in McLuhan's (1989) "global village." We do not expect a global SkyTeller village, but SkyTeller programs are group experiences that may form community within a school or across a school district. A handful of live storytellers and scientists could not create the space science audience who will experience the 1,000 DVD's produced by the SkyTeller Project.

A separate dimension of primary orality is the warmth and interaction between the storyteller and the audience. Through bodily and intentional presence, the narrator becomes an anchor and a guide. Sobol (1999) found this "heightened presence" (p. 35) integral to the storytelling revival in America. Whereas media provides breadth to the community, the unmediated storyteller provides deeper connections.

SkyTeller stories represent ancient oral traditions reset within the secondarily oral contexts of contemporary media and mediated education. Like most contexts in which contemporary storytelling has come to flourish, the SkyTeller Project blends old and new elements. Although we intend with this study to advance our understanding of the uses of storytelling, it is essential to bear in mind that the living storyteller is not present to the audience in these interventions. No interplay between storyteller and audience occurs. As media events, the SkyTeller modules have the experimental advantages of replicability and controllability, as well as providing a wide audience for this research. Although we acknowledge the differences between live and mediated storytelling, with the SkyTellers project we can begin to work toward quantitative methods of assessing the effects of using stories in science education.

What is evident from the related literature is that the use of stories in science classes is theoretically grounded and practically functional. Because stories encourage involvement on many levels, they may help students take in the more abstract concepts of science. Several genres of stories have been used in science. Folk tales have been less common than other genres due to the sense of myth as false or primitive, but that notion is changing. Notably absent from the literature are controlled studies that assess the actual experience of stories in science education. Starting from the theoretical groundwork in the literature, this study seeks to forge a new path into quantitative assessment of the use of folk tales in science education.

The Research Problem

The purpose of this study was to develop a method to assess whether using stories along with science explanations helps students to engage with space science. The SkyTeller Project was designed to provide high-quality science programming in astronomy and space science in order to stimulate interest in science. My study evaluated the interest evoked by the programs by examining attitudes and responses to the programs.

The assessment method was chosen to fit within the objectives of the SkyTeller Project. Project director Stephen Mackwell did not want us to use questions of fact on our surveys because he wanted the students to enjoy the experience without feeling they were being quizzed on the program. Several SkyTeller Committee members expressed doubt that the students would learn or retain information from exposure to single 12 minute modules. To assess the success of the project goal of engaging students, we devised a student attitude survey to gauge the students' enthusiasm. I used on-site visits as well as teacher and presenter questionnaires and interviews employing both quantitative and qualitative evaluation methods.

Research Questions

The following research questions guided the study's analysis:

1) Will students in grades 3 through 6 complete the attitude survey reliably?

2) Will there be a difference in student attitudes before and after experiencing a SkyTeller module?

3) Will teacher and presenter qualitative responses fit the quantitative findings from the student surveys?

Null Hypotheses

The research questions led to the following null hypotheses:

Null Hypothesis 1: Students in grades 3 through 6 do not answer the survey reliably (Cronbach's Alpha $\leq .7$).

Null Hypothesis 2: No significant difference ($p > .05$) occurs between the pretest before the SkyTeller module and the posttest after experiencing the SkyTeller module.

Null Hypothesis 3: Qualitative responses from teachers and presenters do not match the quantitative results from the student surveys.

Delimitations

The SkyTeller Project media were a product of the Lunar and Planetary Institute of Houston, Texas (LPI). LPI was responsible for the content and quality of the media and the resource guide as well as the validity of the science component. My research was an evaluation of that project.

This study was a case study of students in third through sixth grades in eight locations in four states. The locations indicate some demographic variability (high and low income brackets, majority and minority students), but complete demographic data about the students was not collected. The subject group may not match the cultural, racial, and socioeconomic patterns in other areas of the country.

The subjects for this study were students whose teachers and/or principals elected to have them experience the SkyTeller program modules. The results may not be applicable to students in other age groups or in other schools. Although the large number of students surveyed might indicate that the results could be generalized to the entire population in this age group in the United States, the subject group may be idiosyncratic because their schools showed interest in the SkyTeller Project and in participating in educational research. Because no control group of planetarium attendees was surveyed, the research findings may be the result of attending any planetarium program and not specifically the story-and-science narratives of the SkyTeller Project.

The SkyTeller Project used recorded media to present stories and science explanations. The traditional stories were recorded by professional storytellers, but presentation in person by a storyteller might dramatically alter the responses to the attitude surveys. Although I do not think the mediated nature of the stories studied changes the usefulness of an attitude survey for assessment of stories and storytelling, the level of change in attitude cannot be considered indicative of the attitude change that might occur with a live storyteller.

Students in the subject group experienced one to three program modules. The results of their attitude surveys may not reflect the attitudes of students who experience a larger set of programs.

Because this project included only Native American folk tales, we studied only Native American stories paired with science narratives. Folk tales from different cultures might meet with different responses.

Definition of Terms

Traditional stories: All the stories used in the SkyTeller program modules are of Native American origin. All modules except one cite written references from folk tale collections that are written records of stories in the oral tradition. The stories have been adapted by the storytellers to fit their own styles of storytelling, but are not new creations.

Science stories/narratives/explanations: These three terms are used interchangeably in this study. The science presentations varied greatly in the presence of literate story elements such as time sequence and rising and falling action, but they all had topical unity and situational grounding characteristic of both oral and literate storytelling traditions.

Program module: A program module is one track on the SkyTeller media. Each track on the SkyTeller media paired a traditional story with a science explanation on one topic of space science (see Appendix A for a list of topics). The science portion also included slides as visual aids. In many cases, the program modules were experienced as part of a longer planetarium presentation.

*Portable planetarium*s: Inflatable domes, such as the ones made by StarLab, hold about 30 people and can be brought into schools, libraries, and other locations. Some responders used the term *Skylab* when referring to these portable domes.

Assumptions

The results of this study rely on the assumption that the presentations were close enough to be considered repetitions of the same event. Tracking the variables of group, location, type of room, grade, and module allowed analysis of variance in the results due to those variables. Aside from the tracked variables, other differences are presumed negligible.

Importance of the Study

Stephen Mackwell, the director of the Lunar and Planetary Institute, said, "I begin to see that story opens the mind so that we are able to hear and take things in. So story makes a gateway to the mind for science" (SkyTeller Meeting notes by Meyers, 2003). Storytellers and story-lovers alike experience the power of stories, but detailed studies of the impact of stories in education are few in number. We lack sufficient evidence for our claims of the effectiveness of stories, particularly in science education. Only by careful study of story events will we be able to judge whether stories are a positive influence in science education. The SkyTeller Project, by providing storytelling media, created a replicable event which could be tested in several locations, offering the possibility for controlled study and extensive data collection. The large number of subjects in this study allowed thorough testing of the evaluation instrument and methods, increasing the likelihood that the process will be applicable to other studies of the effects of stories in education.

CHAPTER 2

RESEARCH METHOD AND RESULTS

Research Design

Timeline

The research for this study was conducted in three distinct stages. During Stage 1, September, 2003, to May, 2004, we developed and tested the evaluation instruments. Early versions of the student survey were reviewed by faculty in the field of science education at East Tennessee State University (ETSU) and by the SkyTeller Team. We tested the student survey as a pre- and posttest with 105 students in two locations and also recorded responses from the program presenters. We then analyzed the data from the test cases. In Stage 2, May to June, 2004, we disseminated the student surveys and the less formal teacher and presenter response forms to five sites. Those sites used the two available program modules in numerous programs, returning student surveys for 290 students in four locations. The student responses were analyzed and compared to the teacher and presenter responses. For Stage 3, December, 2004, to March, 2005, we changed one statement on the student survey and revised the protocol, allowing for more complete data coding methods. Six program modules were available during Stage 3. We received surveys from nearly 2000 students. Teacher and presenter responses were again collated. The method, results, and analysis for each stage of the study are detailed in this chapter.

Test Sites

Through collaboration with the SkyTeller Committee, test sites were elicited from Texas, New Mexico, Illinois, and Tennessee. These sites included small fixed planetariums, portable planetariums, and classrooms. (See Appendix B for a list of the test sites.) All sites agreed to use

SkyTeller modules and give feedback including verbal and written assessments, as well as administering surveys to their students. The sites were allowed to choose from available modules to fit the educational needs of the audiences.

Target Audience

Although the Lunar and Planetary Institute did not specify a target audience for the SkyTeller programs, this research used a target audience of school children in grades three through six. We felt that school groups would allow more control of variable circumstances. At the same time, school audiences attending at their teachers' choice would provide more diversity of attitude compared to audiences comprised of individuals who chose to attend a program on space science. We used the student attitude survey in grades three through six because the test requires reading and responding to both positive and negative statements. Testing older students with the survey would be both possible and valuable, but planetarium directors advised us that they have few groups of students in the higher grades due to the more intense schedules of older students.

Evaluation Instruments

The qualitative component consisted of both numeric assessment and open-ended written responses from the teachers and presenters (see Appendix C for the response forms), as well as telephone and on-site interviews with teachers and planetarium directors. The results of these written and verbal responses were tabulated and the comments listed (see Appendix D for the summaries).

For the quantitative study, students in grades three through six were given a 10 statement attitude survey using a four level Likert type scale. The survey contained statements about attitude toward science and about attitude toward stories (see Appendix E for the student surveys). To maintain anonymity, no names were collected. The same survey was administered before and after viewing a program that included one of the SkyTeller program modules. All locations were directed to administer the pretest three days to a week before viewing the modules, but this protocol was not always followed. The posttest was administered after the program either by the presenter or by the classroom teacher.

Exemption from Full Internal Review

This research was conducted in schools and planetariums, which are common educational settings. Because stories are already used in education, this study does not introduce unknown practices. Under these circumstances, consent forms from each student would be required only if we collected identifying information. Such information was irrelevant to the study, and consent forms would have proven unwieldy for the large numbers of students involved in this study. We included no identifying information in the surveys or in the teacher response forms. The presenters formed part of our investigation team, so their names and locations were recorded in order to allow follow-up conversations about the programs. The project plan and all forms were read by a subcommittee of the ETSU Institutional Review Board and found exempt from full review and from the need for consent forms IRB No. c04-179e with revised procedures reviewed 11/24/04).

Design Summary

During the course of this study, both the material under study and the research methods evolved considerably. The instrument was tested and data were analyzed at three separate points, with subsequent protocol and survey revisions made in response to both the success and the limitations of the data. At each stage I learned more about the process and was able to apply that learning to the next stage. The SkyTeller program modules were evolving, too. (See Appendix A for a list of modules available during each stage.) Responding to the feedback during Stage 1 and Stage 2, major changes were made in the first two modules before Stage 3. In addition, four new modules were completed and available for inclusion in the study. During Stage 3, media problems forced the change from a CD in PowerPoint format to a DVD formatted for use with any DVD player. Test site changes could not be avoided. Although we worked with a total of eight sites, the number of sites participating in each stage changed according to their ability to use the programs during that test period. The large size and evolving nature of this study produced numerous logistic challenges but ultimately enhanced the quality of the research. In the following sections, I will detail the methods and results as well as track the changes in each stage.

Stage 1: Developing and Testing the Student Survey

Method

Because the goal of the SkyTeller Project was to increase interest and enthusiasm for space science, the evaluation needed to demonstrate whether or not attitudes in the target audience improved. We designed a 10 statement Likert scale attitude survey. For each statement, the student chose from four options: “I strongly agree,” “I agree,” “I disagree,” or “I strongly disagree.” We used both positive and negative statements as a countercheck method to assure that students were reading the statements and not just giving a single default answer for all the statements. Half the statements (2, 3, 4, 6, 9) were written as statements about science, and the other half (1, 5, 7, 8, 10) addressed attitude toward story. The attitude survey used for Stages 1 and 2 can be found in Appendix E. With just two modules available, the initial protocol called for inclusion of both modules in each show.

In Spring of 2004, we conducted a field test of the survey and the protocol. The survey was given to 105 students in two locations to study whether the test was eliciting reliable information using the Likert scale. Both available SkyTeller modules were used in each program. Identical surveys were given before and after the programs. The classroom teachers administered the first survey several days before the program, and the second survey was given in the planetarium after the program. Each survey was coded with a survey number, the date, the site, and an indicator marking it as a pretest or a posttest. All codings and responses on the surveys were then entered into a spreadsheet. Using the Statistical Program for Social Sciences (SPSS), we ran Exploratory Factor Analysis (EFA) to examine significance of the survey as a whole. EFA is used to determine whether statements can be meaningfully grouped and considered together. We also ran reliability tests of the scale of all statements and of the science and story components. In addition, presenters' written notes and telephone interviews were recorded.

Results

Presenter Responses

All the presentations were met with initial enthusiasm. Students listened to the traditional story and were excited when the first slides appeared on the dome during the science narrative. From planetarium presenters' notes and my own on-site observation, we found the students got quite restless by the end of the second module. One presenter reported nearly half the students were not paying attention to the science portion of the second module. Both presenters said that the second module needed to be revised, and that more visual aids were needed during the science narratives of both modules. Both presenters had to shorten their normal presentations, with two modules leaving little time for discussing the night sky and answering questions. One presenter reported some student resistance to taking the posttest. The other presenter reported that some in his audience (which included many students for whom English was their second language) had difficulty reading the posttest.

Student Responses

To study the student survey, we needed 10 surveys per statement, or a total of 100 surveys. From our field tests, we received a total of 202 surveys, with fewer posttests than pretests returned. When incomplete or double-marked surveys were eliminated, we had 177 valid surveys (97 pre, 80 post). For the sake of testing the instrument, pre- and posttests were combined into a single group.

Reliability of the survey as a whole. Statistical studies showed that students responded to statements consistently, giving support for the significance of the instrument. Exploratory Factor Analysis (EFA) looks for consistency in the way that statements are answered and identifies groups of statements (called factors or components) that load together, meaning that they were given similar marks across the test population. Failure to identify components would indicate that the survey as a whole had no significance. EFA for Stage 1 had excellent inter-item connections, showing that students were reading and responding to the content of the statements. Although we expected two components or statement groups, three components were extracted, with a high degree of consistency in the answers within each component. Table 1 shows the Stage 1 EFA component matrix yielding three scales. The values (between -1 and 1) indicate how closely the responses to each statement matched other statement responses in each of the three components.

For a sample this size, any value more than .500 loads that statement on the given component or scale.

Table 1
Scales Derived from Stage 1 Student Surveys

	Component		
Statement	1 Science	2 Story	3 -
1	.322	.769[a]	.068
2	.252	-.024	.860[a]
3	.754[a]	.018	.092
4	.702[a]	.265	.114
5	-.009	.500[a]	.641[a]
6	.618[a]	.100	.083
7	.194	.805[a]	-.029
8	.731[a]	.278	-.013
9	.565[a]	.225	.277
10	.128	.579[a]	.311

Note. $N = 177$
Extraction Method: Principal Component Analysis.
Rotation Method: Varimax with Kaiser Normalization.
[a]Statement loads on given component.

The component analysis closely aligned with the original designations of statements as science or story statements. Component 1, hereafter called science attitude, loaded statements 3, 4, 6, 8, and 9. Component 2, hereafter called story attitude, loaded statements 1, 5, 7, and 10. Oblimin rotation method also produced three components and loaded the statements in the same components.[2] EFA indicated that students were responding to science statements and story statements with good consistency.

Two anomalies are notable. Component 3 grouped statement 2, “Science is too hard for me,” and statement 5, “Sometimes I like to hear the same story again,” which have no apparent connection. Because statement 5 was also answered consistently with the other story questions, it can be considered part of story attitude. Statement 8, “I would like to hear a story about the planets and other things in the sky,” brought responses consistent with the responses to the science statements but not to the story statements, although we had intended it as one of the five story attitude statements. The loading of statement 8 on science attitude shows how important EFA can be in determining which statement responses are actually connected. Despite these anomalies, the fact that all 10 statements loaded strongly in one of the three components indicated that the instrument worked well in our field test.

Reliability of the answer scale. We found that the scores from the survey provide usable information. Analysis of the field test showed that all the statements could be considered significant. All the statements on the survey added to the reliability of the test answers scored as a whole. In addition, both science attitude and story attitude produced reliable scales. Reliability tests in SPSS look for internal consistency in responses to a group of statements or questions. The calculation of that consistency is Cronbach’s Alpha, which should be at least .7 to consider any set of statements reliable. The analysis also reports what happens to Cronbach’s Alpha if we remove any statement from consideration, indicating whether that statement helps or hinders the internal consistency of the set of statements.

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[2] The Varimax and Oblimin procedures rotate the graph of the answers in different directions to see which answers group together.

The overall attitude scale, as well as science attitude and story attitude scales, produced good results. The results of the reliability tests can be seen in Table 2. The scale of the test as a whole (Overall) had excellent reliability. Removing any of the 10 statements would make a less reliable scale. The scale of science attitude was very reliable, and the scale story attitude was essentially reliable. Component 3 (statements 2 and 5) was not a reliable scale on its own, although the statements added to the reliability of the survey overall. The analysis had thus shown three reliable measures: the overall attitude, science attitude, and story attitude.

Table 2
Reliability of Stage 1 Scales

Scale				
Component	Name	Statements	Cronbach's Alpha	Better if any statement deleted
-	Overall	all	.800[a]	no
1	Science	3,4,6,8,9	.749[a]	no
2	Story	1,5,7,10	.696[b]	no
3	none	2,5	.509	-

Note. $N = 177$
[a]Reliable at the .700 level.
[b]Closely approaching reliability.

Analysis

The observations of the presenters were relayed to the SkyTeller Team and those producing the program modules. In subsequent versions of the first two modules and in all later modules, the science portions included many more slides. The second module, The Sun, was rewritten and rerecorded for more clarity. These changes were not in effect during Stage 2, however, because the revised version had not yet been disseminated.

The lack of time during the planetarium program for the usual sky observations and questions was a problem our research protocol needed to address. For the sake of a better educational experience for the students, we changed the protocol for subsequent stages to include just one SkyTeller module within a more standard planetarium show. The reported difficulties some students seemed to have reading the survey might be expected to yield scattered answers on the EFA, but the students did answer the surveys in a consistent and reliable way.

With all statements loading in three components, we judged that the students were responding to the test statements appropriately. The high reliability of the test overall as well as of the science and story components indicated that we could expect usable data in the form of overall attitude, science attitude, and story attitude. The field test indicated we had a good survey and could proceed to collect data in a wider audience during Stage 2.

Stage 2: Looking for Change in Attitude

Method

We now had the opportunity to collect data using the survey. During Stage 2 (May to June, 2004), we encouraged use of the first two program modules to a wide variety of audiences in fixed and portable planetarium settings. We contacted planetariums that host shows, planetariums that bring portable planetariums to schools to present programs, and a school district and individual schools that indicated they had portable planetariums available that they could use to show the SkyTeller modules in their schools. We agreed that audiences would include adults and students both in and out of the target grades, but that student attitude surveys would be used only for students in the target grades. My goal was to get 400 students to participate in the survey because that number can be considered representative of the general population (Leedy & Ormrod, 2001). Each location received the SkyTeller CD (in PowerPoint format), the Resource Guide, instructions, and all evaluation forms: the student survey, teacher attitude survey, teacher program evaluation, and presenter response form (see Appendixes C and E).

For audiences in the target group of third through sixth grades, the protocol called for student pretests and teacher attitude surveys to be given several days before viewing the programs. The student posttests were to be given either in the planetarium after the show or given to the teachers for administration once they returned to the classroom. Teachers were asked to send the posttests and their program evaluations to the planetarium, who forwarded the pre- and posttests to me along with the other evaluation forms. Presenters were asked to fill out one response form for each program in which they used a SkyTeller module, whether or not the audience was in the target group. I interviewed most presenters by phone before and after the programs.

Just as rules are made to be broken, often protocol went out the window in the excitement of getting the programs underway. In May and June of 2004, 37 school audiences viewed programs with SkyTeller modules. Most of the programs in Stage 2 were presented in small fixed and portable planetariums. Some presentations were in a standard classroom using a computer screen and speakers, although the schools had previously indicated that they could get a portable dome. I received 32 presenter response forms, 23 teacher attitude surveys, and 21 teacher program evaluations. Because we had encouraged wide use of the modules, most of the audiences were not in our target age group for the student attitude surveys. Target audiences comprised nine groups at four sites, returning a total of 274 pretests and 290 posttests. A fifth site returned surveys after the deadline. Because these late surveys showed the names of the students, in violation of our IRB agreement, the surveys were destroyed and the data were not recorded.

The teacher and presenter responses we received from test sites were collated. The student surveys were coded by group, room, site, and module to allow us to examine the effect of these variables. All data were entered into spreadsheet files, and the student data were analyzed using SPSS. We then evaluated the effectiveness of the instrument as we had in the Stage 1 field test. We also examined the means and the differences from pretest to posttest to determine whether there were overall differences or differences in response to the module, site, group, grade, or type of room used. Where possible, teacher and presenter notes were compared to student responses.

Results

Presenter and Teacher Responses

The presenters' written responses (see Appendix D) and interviews indicated a mixed reaction to the first two modules. On a numerical scale, the presenters gave the modules high marks. Yet only 18 of the 32 programs represented in these responses used a complete module. In seven of the programs, presenters used only the traditional folk tale, relating that they thought the science portion was too difficult for kindergarten and first grade students. In another seven programs, presenters replaced the science portion with a science portion of their own design, again saying that the SkyTeller module science portion was too difficult for young children. However, all programs returning surveys in our target audience showed an entire module.

Although we had distributed materials with the understanding that the programs would occur in fixed or portable planetariums, we received information from three locations that showed the modules on computers in their classrooms. Some classrooms used two modules, some used one. These locations used the modules alone without any supplementary material or discussion. Because the presenter was the teacher in these programs, some programs are represented by presenter forms, some by teacher forms, some by both forms. Two classrooms returned attitude surveys, one classroom only the teacher and presenter forms. The classroom presenter forms showed lower marks for the programs than did the planetariums, with marks on the program, the module, and the use of the module in the program having means between 3.0 and 3.3 on a scale of 5 compared to 4.5 to 4.9 for the fixed and portable planetarium presenters.

Most of the presenters said in their interviews that they felt the modules should have more visual aids. Two said the quality of the graphics could be improved. One suggested using photographs instead of computer graphics for the slides. The other said animation of the pictures would help a lot and suggested that it is well within current technology limits. One classroom presenter's response form said that we needed "more pictures and less folklore," underscoring the need for preparing teachers and audiences for the design of these modules.

Volume problems were reported by both classroom presenters and portable planetarium presenters. For some, the entire modules were barely audible. Others said particular science or story portions were too soft, noting that some vocal tracks were more difficult to hear than others. Both of these types of presentations used computers with computer speakers, whereas the fixed planetariums used sound systems with built-in amplifiers. Again we wondered whether the difficulties with sound would show up in lower student attitude scales.

We had hoped to gain significant quantitative information from the teacher attitude surveys and their evaluations after the programs. However, with only 23 attitude surveys and 21 program evaluations, we could not even test the reliability of the instruments. The frequencies and means of their answers, as well as their comments, can be seen in Appendix F. The majority of responders were science teachers who reported positive attitudes on their interest in science, their ability to teach science, and their ability to use stories in science. They echoed the presenters' complaints about sound problems from computer speakers, and many wanted more and better pictures. Like the presenters, the numeric scores were high, with all teachers reporting that their students enjoyed the programs. On the open response questions, the comments about what they liked about the program were enthusiastic. The positive answers were more numerous than the answers to what they liked least, with several denying there was anything they did not like.

Overall, the Stage 2 teacher and presenter responses were very positive, with reservations about technical issues and about the complexity of the science narrative, particularly in module 2, The Sun. Although the small number of returns prevented them from being used for quantitative analysis, they provided qualitative information about their impressions of what worked and what did not work in the programs. They also yielded information for comparison with student data.

Student Responses

Like the teachers and the presenters, the students showed interest in the programs. On the surveys, students responded well to the content of the statements and to the Likert scale format. Using 482 valid surveys (243 pre, 239 post), all indicators of the validity of the instrument improved from the field test. We found that failing to match the pre- and posttests was a design flaw that prevented investigating significance in the attitude changes. Nevertheless, the way the changes matched the teacher and presenter responses showed that the instrument had a trend toward providing information responsive to the quality of the programs. Programs where I had been alerted of problems often were reflected in lowered attitude scales from pre- to posttests. Some adjustments were needed, but the evaluation protocol showed promise.

Reliability of the survey and of the answer scales. Students again answered the pre- and posttests consistently, yielding three reliable scales for analysis: overall attitude, science attitude, and story attitude. Because of the possibility of changes from pre- to posttests, I ran both EFA and reliability tests using pretests and posttests as separate groups. EFA again indicated students were answering consistently within three components on both pre- and posttests, confirmed by both Varimax and Oblimin rotations.

Science attitude and story attitude retained the same statements as we found in Stage 1, but in Stage 2 component 3 consisted entirely of statement 2, "Science is too hard for me" (Table 3 shows the Varimax rotation of the posttest, indicating the three components extracted). On the pretest statement 6 came close to loading on component 3 (but with a higher number on the science attitude scale), and on the posttest statement 7 came close to loading on component 3 (but with a higher number on story attitude). Because statements 3 and 7 loaded differently on pre- and posttests, we saw component 3 as consisting entirely of statement 2. Students' answers to statement 2 had very little to do with their answers on the science scale or the story scale.

Table 3
Scales Derived from Stage 2 Student Posttests

Statement	Component 1 Science	Component 2 Story	Component 3 -
1	.259	.761[a]	-.005
2	.056	-.033	.940[a]
3	.823[a]	.157	.054
4	.797[a]	.290	.064
5	.110	.791[a]	.016
6	.555[a]	.321	.273
7	.110	.575[a]	.448
8	.821[a]	.227	.011
9	.825[a]	.071	-.006
10	.269	.697[a]	-.030

Note. Extraction Method: Principal Component Analysis.
Rotation Method: Varimax with Kaiser Normalization.
[a]Statement loads on given component.

Discarding Component 3, we tested the reliability of the first two components and of the survey as a whole. The overall scale, the science attitude scale (statements 3, 4, 6, 8, 9), and the story attitude scale (statements 1, 5, 7, 10) yielded reliable information (Cronbach's Alpha ≥ .7) indicating internal consistency on each scale. Table 4 shows reliability results on all three scales in the pretests and the posttests.

Although the story attitude scale was slightly low on the pretest, it was well within range on the posttest. Unlike the Stage 1 field test, both the pretest and posttest overall scales would have been marginally better without statement 2. With statement 2, the overall scale still fell well within the acceptable range, and generally no statement should be eliminated unless it would make a major improvement in reliability. All three scales yielded reliable information for this study and no statements needed to be eliminated from further analyses of this stage.

Table 4
Reliability of Stage 2 Scales for Pretest and Posttest

Scale				
Component	Name	Statements	Cronbach's Alpha	Better if any statement deleted
		Pretest ($N = 243$)		
-	Overall	all	.781[a]	.790 w/o 2
1	Science	3,4,6,8,9	.784[a]	no
2	Story	1,5,7,10	.693[b]	no
		Posttest ($N = 238$)		
-	Overall	all	.828[a]	.848 w/o 2
1	Science	3,4,6,8,9	.857[a]	.867 w/o 6
2	Story	1,5,7,10	.724[a]	no

[a]Reliable at the .700 level.
[b]Closely approaching reliability.

Student attitude changes. Before viewing the programs, most students gave positive responses on the pretest, with over 50% positive answers on each statement. Yet the highest and lowest marks on each statement left room for change, with no statement showing more than 38% at "I strongly agree" and none more than 20% at "I strongly disagree."[3] After the programs the

[3] The Frequencies tables (F1 and F2) show the number of students who chose each of the four Likert scale answers for each question. For the sake of having a consistent scale, I reversed the agree/disagree coding on questions 2 and 7, which were negative questions, on all other analyses.

overall attitude and the science attitude both improved slightly, and the story attitude was slightly down. As Table 5 shows, the changes for all three scales were smaller than the margins of error.

Table 5
Means for Pretest and Posttest Scales in Stage 2

	Pretest $N = 243$		Posttest $N = 239$		
Scale	Mean	*SD*	Mean	*SD*	Change in mean
Overall	2.910 ± .033	.517	2.914 ± .037	.571	.004 ± .050
Science	2.798 ± .043	.668	2.817 ± .048	.737	.018 ± .064
Story	3.020 ± .040	.617	3.015 ± .043	.665	-.005 ± .059

Note. SD = Standard Deviation.
$p > .05$ for changes in all scales.

A t-test compares the means of the whole group to chance variations in means. Because I had not paired the pre- and posttests, I had to treat the two sets of responses as independent variables. I compared the pretests to the posttests overall and on the science and story scales using independent samples t-tests. These t-tests confirmed that none of the scales showed significant pre to post difference (p > .05).

A more sensitive analysis of the differences would have been a paired-samples t-test, which compares each student's pre- and posttests rather than just comparing the means of the whole group. The independent samples test assumes there is no connection between the pretest and the posttest. It sometimes misses significant differences that the paired-samples test shows. Because we had collected no names or other personal identification, we could not compare each student's pre- and posttests. In fact, number of pretests (243) differed from the number of posttests (238). It is possible that students who had been present on the day of the pretest did not attend the planetarium program, or that other students were present for the program but not on the day of the pretest. We had overlapping but not identical groups of students. Our protocol in Stage 2 precluded use of the more powerful paired-samples t-test to look for significant changes.

Although we could not find any significant pre to post differences in our group as a whole, we wanted to see whether there were any significant differences between groups, at different grade levels, for different program modules or for different rooms. All these factors had been coded into the database along with the responses to the survey statements. Because we had not paired pre- and posttests, we could not calculate the difference from the first test to the second for each student. Rather than analyzing variances across that one dependent variable (UNIANOVA), we used multivariate analysis of variance (MANOVA) to compare means on pretests and on posttests in different rooms, different sites, different grades, and different program modules.

The room (fixed planetarium, portable planetarium, or classroom) made no significant difference ($p > .05$) from pre- to posttests. In the initial analysis of variance, the module ($p < .021$), the grade ($p < .010$), and the presentation group ($p < .032$) appeared to make significant differences on the total scale. The story scale differences appeared significant by module ($p < .026$) and grade ($p < .012$) but not by group ($p > .05$).

While working on Stage 3 data, I began to question the data from Stage 2. A discussion with Dr. J. Blake Snider convinced me to change the method for handling missing answers. In the original analyses for Stage 2, we had ignored statements that a student skipped or marked two answers, but retained the other answers from that student. Dr. Snider pointed out that when a student skips a line or double-marks an answer, we cannot be sure what to make of the answers before and after that statement. We cannot be sure where the student got off track or when the student got on track again. Unless a student responds to every statement appropriately with one mark, we do not know which answers go with which statements. A more acceptable way to handle surveys with mistakes is to eliminate the whole survey from consideration. I removed all inconsistent surveys from my Stage 2 data base and redid all the studies we had done previously. All information reported in this study (other than the initial MANOVA reported above) follows the revised elimination method.

In most analyses, the new elimination method made minor differences in the quantities reported but did not change the significance of any major findings. In the MANOVA tests of variance due to different conditions under study, most of the significance we originally found faded back into the realm of what could be caused by chance. The room, the module, and the group showed no significant effects ($p > .05$) on any of the three scales when comparing pretest to posttest. On the overall scale, the grade made a significant difference ($F = 2.596$, $p < .037$) in the rise or fall of the posttest means. The science attitude ($p < .076$) and the story attitude ($p < .056$) did not show significant differences by grade. The plot of the pre- to posttest means (Figure 1) shows grade 6 with a steep drop in attitude, while grades 4 and 5 showed a marked increase. One classroom with a mixed group of 4th and 5th grades also showed a moderate drop in attitude.

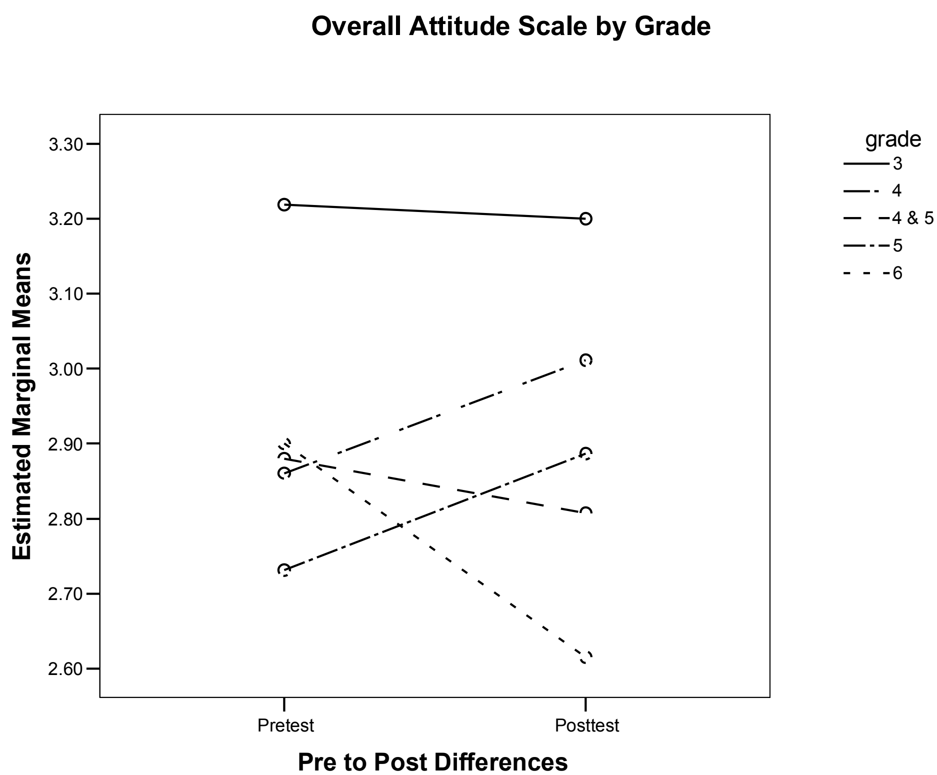

Figure 1. Graph of Stage 2 Overall Pretest to Posttest Change by Grade

We did not examine the significance of any one grade's pre- and posttests, but a drop of nearly .3 in the sixth grade group seems noteworthy. This group was our only sixth grade group in Stage 2, and the only group who saw the Sun module only. Several teachers and presenters had complained that the Sun module's science explanation was much too complex, and that it needed more slides because the concepts were quite difficult to visualize. Of the sixth grade/Sun module group, the presenter wrote, "Even 6th graders looked for more visuals, but they seemed very attentive to the storyline. Long pauses in the 'science' story were a distraction!" (See Table D2).

Analysis

The Stage 2 study showed the strong and weak points in my evaluation protocol and in the program modules. In Stage 2, we reject null hypothesis 1 because the students did answer the survey in a reliable way. The most important finding from this stage was that I needed to find a way to pair my pretests and posttests in order to track the changes of each student. Without paired samples, we did not find significant pre- to posttest changes. We cannot reject null hypothesis 2 for Stage 2. For this stage of the study overall differences from pre- to posttest were most likely due to chance and not to experiencing the SkyTellers modules.

Even without pairing the tests, the study supported continued use of the attitude survey. The students answered the surveys consistently enough to yield three reliable scales: overall attitude, science attitude, and story attitude. Statement 2 ("Science is too hard for me") was problematic because it did not correlate with either science attitude or story attitude. My impression is that this statement was not answered on the basis of attitude toward science but on the basis of self-image. Because that was not a factor I was interested in evaluating in this study, Statement 2 needed to be replaced in Stage 3 student surveys. Changing that statement to a clear science statement and changing the protocol to pair pre- and posttests seemed to show promise of a better evaluation tool.

The studies of between-subjects effects warranted further study. The grade 6 Sun module program indicated the need to watch for differences in attitude across all the modules we were to use for Stage 3. It also showed the possibility that grade 6 might be too old for either the SkyTeller modules or the student survey. Differences between grades would be studied again in Stage 3.

The teacher and presenter response forms were useful primarily as qualitative evidence. Teacher attitude surveys were not analyzed statistically (other than calculating means) because of the small number returned. I decided to eliminate it in future studies. The open-ended questions on both the teacher and the presenter response forms gave a place to record unexpected problems and interesting impressions. With some simplifications, both of those forms were retained. Because some presenters used the modules for many programs, many of the presenter forms were repetitive. To simplify the presenter's job in the evaluation process, I decided to ask for just one form from each presenter, with space to note any unusual situations in individual presentations or program modules. Interviews with two of the presenters were also useful, but the short time-frame of this study did not allow interviews with all presenters. Providing a place for teachers and presenters to record their impressions seemed valuable in providing positive and negative feedback in qualitative form.

In particular, complaints about the small number of visual effects, the complexity of the Sun module science section, and the sound level were relayed to the Lunar and Planetary Institute. They used the feedback to make changes in these first two program modules and in their plans for future modules. Open-ended questions provided important information which was not covered by quantitative tools. In addition, we reject null hypothesis 3 because teachers and presenters pointed out difficulties in programs which could affect the students' responses.

Stage 2 was a learning stage for both LPI and for me. LPI changed the modules, and I changed statement 2 and my protocol. We looked to Stage 3 for further testing of the modules and of my hypotheses.

Stage 3: The Paired-Samples Study

Method

In Stage 3 (December, 2004, to February, 2005), we distributed the simplified presenter and teacher response forms and the revised student surveys. Statement 2 was replaced with a new statement, “I don’t like science,” which was less ambiguous than the previous statement, “Science is too hard for me.” The new student protocol created a paired-response study. We revised the survey page to include names so that teachers or presenters could match pre- and posttests, staple them together, then cut off the names. They could then submit them to us without any information identifying the respondents. This change allowed us to enter pre- and posttests as one record for each student. Using SPSS, we repeated the EFA and reliability tests, between-subjects effects, and we were able to run a paired-samples two-tailed t-test to compare each student’s pre- and post-data.

Six program modules (revised versions of the first two and four additional modules) were available during Stage 3. The number of slides used in the science portion of the modules had been greatly increased, pushing PowerPoint beyond its limits when different versions of PowerPoint were used at different sites. On the SkyTeller CD’s, the slides did not match the vocal track, and the vocal track skipped and stopped in mid-sentence. LPI produced one program module on DVD, the format that was used for the final product.

Having lost portability and replicability on the majority of the Stage 3 modules, our sites were limited to three. All sites used either small fixed or portable planetariums. One site used an LPI computer to skirt the portability issue. One site used only the DVD program module. Another site conducted a trial program using the September 2004 PowerPoint CD for module 4, the

Seasons. When that proved unsatisfactory due to the lack of coordination between audio and visual tracks, they used an intermediate version of the second program module, the Sun. This version was completed in May but was not part of Stage 2 testing. Because that version differed little from the Stage 3 version, the surveys were considered usable for the paired study. In addition to site, room, grade, and program, which were tracked in Stage 2, the version was added to the data base for analysis of between-subjects effects.

Nearly 2,000 students took part in the Stage 3 study. One site submitted surveys from approximately 1,000 students from one grade viewing one module. I used only 400 of those surveys for three reasons: 1) the excessive time required to key in that much data by hand, 2) the desire not to have that one limited-exposure group overwhelm the data from the other sites, and 3) protocol concerns. That site violated protocol by giving pretests immediately before the program rather than distributing them for the teachers to give a few days before. The posttests were then given immediately after the program, making the time difference between the two tests only about 45 minutes. I included them in the study but also compared their results to the rest. Because they were the only third graders in Stage 3, analyzing the variance between grades would tell me if this group did not fit the general trend.

Approximately 1,000 students at two other sites viewed SkyTeller programs. We had hoped to do a longitudinal study with three shows at each of two schools, but that turned out to be impossible given the media problems and the school schedules. Using a portable planetarium, one school had two showings two months apart, with pre- and posttests given for each showing. With approximately 650 students at that site, I received 469 valid pre- and posttests for the first show. I was able to follow 293 subjects with valid pretests and posttests for both programs. Some classes turned in no surveys, some turned in pretests without posttests or posttests without pretests, some turned in surveys for one program but not the other. The linear modeling to follow students through four tests was too complex to be completed for this study but will be reserved for later investigation. Because I felt the data from the second show might be different from a first show experience, I did not include the data from the second show in the data analyzed in this stage.

As in Stage 2, the teacher and presenter responses were summarized. The answers from valid student surveys were entered into an Excel spreadsheet along with the site, type of room (fixed or portable planetarium), grade, module, and the media version (May 2004 CD, September 2004 CD, January 2005 DVD). The posttest answers were entered on the same record as the matched pretest so that each student's changes could be tracked. Using SPSS, we conducted EFA, reliability tests, paired samples t-tests, and univariate analysis of variance. We also studied the frequencies of the answers on individual statements on both the pretest and the posttest (see Table F2).

Results

Presenter and Teacher Responses

Five of the six program modules available (all but Day & Night) were used during Stage 3. Five presenters gave approximately 80 shows in our test audience of 3rd through 6th grades. As in Stage 2, the presenters were enthusiastic about the SkyTeller modules. On a scale of 1 to 5, with 5 the highest, the mean audience interest rated by the presenters was 4.5. One presenter said that the modules need better graphics or animation. Another said the slides would be improved by wipe and fade methods in the slides. All presenters expressed an interest in using more SkyTeller modules. Presenters reported that the students were quiet and attentive during the programs. Audibility was again noted as a problem in the StarLab. The fixed planetariums have amplifiers to produce enough sound for the larger audiences (see Table D5.)

We received 38 teacher response forms from two locations. The teachers gave high ratings on five items relating to their own reactions and their students' reactions to the programs. Using an Agree/Disagree scale of 1 to 5 (with 1 being the highest), the teachers' responses averaged between 1.5 and 1.39 on the program questions. They described the programs as unique, different, interesting, engaging (see Table D6). To my query what they liked least about the program, teachers said there were not enough visuals, the volume was too low in the StarLab, the science story was "a little too young," and "it could have been a little longer." One asked for more information about "Native American storytelling vs. scientific knowledge." Several teachers said they had not read the resource guide or visited the SkyTellers website because they did not have time. Some teachers reported that they did not receive a resource guide, sometimes in cases where I know the guides were distributed.

My observations of programs and my conversations with presenters and teachers confirmed the excitement generated by the SkyTeller programs. Presenters at both fixed planetariums told me that the modules kept the interest of even the rowdier students. One science teacher told me "This is the way science should be taught."

I was not able to gauge the usefulness of the resource guide due to lack of its use. During one on-site visit where the teachers had received the resource guide several days early, not one teacher had looked at it prior to the program. The media presentation took precedence over the written text.

Overall, the program modules generated positive responses from both teachers and presenters. They said the audiences reacted positively to the programs. Now we turn to the responses from the students themselves.

Student Responses

Revising statement 2 and pairing the tests were both beneficial to the student survey results. For each case, we now had the pretest answers and the posttest answers as two dependent variables for each student. More importantly, pairing the samples allowed the calculation of a variable for the difference between the pretests and posttests for each case. That variable allowed us to test the significance of the changes across the entire study population.

The three sites for Stage 3 yielded 884 valid pairs of pre- and posttests when incomplete or invalid entries were removed. With more than three times the number of surveys we had in Stage 2, our chances for finding significant differences increased. As in the previous stages, we tested the consistency and reliability of the survey before turning to a study of the changes in attitude.

Reliability of the survey and of the answer scales. With the new statement 2, the survey resolved to two factors: science and story. EFA extracted two components rather than the three components found in Stage 2. Statement 2 ("I don't like science") loaded well with the science scale, as we hoped it would. Running EFA on pretests and posttests separately, in both Varimax and Oblimin rotations, I obtained two components consisting of the same statements in all four analyses. (Table 6 shows the component loadings for the posttest in the Varimax rotation.)

Component 1, science attitude, consisted of statements 2, 3, 4, 6, 8, 9. Component 2, story attitude, included statements 1, 5, 7, 10, as it had in the first two stages. Statement 8 ("I would like to hear a story about planets and other things in the sky") was answered consistently with the science statements rather than with the story statements. I would have preferred five statements on each scale for balance, but I did not want to risk changing a statement that had proved valid in the previous stages.

Table 6
Scales Derived from Stage 3 Student Posttests

	Component	
Statement	1 Science	2 Story
1	.284	.693[a]
2	.525[a]	.095
3	.739[a]	.268
4	.797[a]	.196
5	.017	.721[a]
6	.721[a]	.074
7	.224	.610[a]
8	.732[a]	.297
9	.758[a]	.147
10	.168	.728[a]

Note. Extraction Method: Principal Component Analysis.
Rotation Method: Varimax with Kaiser Normalization.
[a]Statement loads on given component.

The important result in EFA of Stage 3 was that all 10 statements loaded onto one of the two scales. Further analyses could be done on those scales without having to look at any statement separately. The components correlated at .4, suggesting that the two scales are related but not overlapping.

Reliability of the test overall and of the science scale was very good (Cronbach's Alpha > .700), especially on the posttests. Story attitude was a bit low, but tended toward reliability. Table 7 shows the reliability of the test overall and of both components extracted by EFA.

Table 7
Reliability of Stage 3 Scales for Pretest and Posttest

Scale				
Component	Name	Statements	Cronbach's Alpha	Better if any statement deleted
		Pretest		
-	Overall	all	.776[a]	no
1	Science	2,3,4,6,8,9	.777[a]	.793 w/o 2
2	Story	1,5,7,10	.628[b]	no
		Posttest		
-	Overall	all	.826[a]	.830 w/o 5
1	Science	2,3,4,6,8,9	.830[a]	.842 w/o 2
2	Story	1,5,7,10	.670[b]	no

Note. N = 884.
[a]Reliable at the .700 level. [b]Approaching reliability.

We can see from these analyses that the students answered the overall test and the science statements with a high degree of consistency. For some of the scales, the Alpha was marginally better with a statement deleted, but the improvement was not enough to justify removing the statement. Stage 3 surveys produced strong scales using all statements and using science attitude statements, but a weaker scale for story attitude. Together, EFA and reliability analyses supported the validity of the survey with this study population.

Student attitude changes in paired responses. With a larger test population and matched pre- and posttests, we found a small but significant increase in attitude on all three scales (see Table 8). On story attitude, the likelihood that the increase is due to chance is less than 2 in 100. On science attitude and overall attitude, the chance is less than 1 in 1000—a highly significant result. Science attitude increased more than story attitude, and thus also more than the overall scale. Students taking the posttest had improved attitude toward science.

Table 8
Means for Pretest and Posttest Scales in Stage 3

	Pretest		Posttest		
Scale	Mean	*SD*	Mean	*SD*	Change in Mean
Overall	3.038 ± .038	.516	3.104 ± .030	.566	.066 ± .013**
Science	3.041 ± .028	.623	3.124 ± .021	.665	.083 ± .015**
Story	3.035 ± .068	.605	3.075 ± .053	.643	.040 ± .017*

Note. *SD* = Standard Deviation. $N = 884$.
*$p < .018$ **$p < .001$

Examining the overall and science attitude differences between the sites, the grades, and the modules, we found no significant differences in Stage 3. We ran the univariate analysis of variance (UNIANOVA) using the variable we created to track the pre- to posttest change across all cases in the test population. The analyses for different sites, grades, and modules showed no significant effects from these factors. Similarly, using a variable for the pre to post science attitude change, the UNIANOVA showed no significant differences by site, grade, or module. Unlike Stage 2, where grade made a significant difference, with grade 6 showing a notable drop in attitude, this larger sample showed a small rise in attitude for grade 6, but at a level similar to the changes in other grades. The positive response to the programs was fairly consistent across all sites, grades, and modules.

Analysis

Stage 3 showed the attitude survey capable of tracking changes in attitude after experiencing a program with a SkyTeller module. We reject null hypothesis 1 for Stage 3. Students handled the survey well.

Moreover, students' attitude toward science improved. The science scale was reliable and showed a small but significant increase in attitude. The story attitude change is not as clear. The answers to the four statements in the story scale were not quite consistent enough to be considered reliable, although the two-tailed t-test showed the increase to be significant. The problem with the story scale may be due to the smaller number of statements in that scale. The word "story" is also somewhat ambiguous and could apply to a wide variety of situations. Because the overall attitude change was positive, significant, and reliable, we reject null hypothesis 2.

Presenters and teachers were enthusiastic about the program modules, making it likely that the modules will be used in the future. Complaints about the number and quality of the visual effects indicated problems that may have affected the students' responses but did not prevent students from responding positively. Other concerns were the simplicity of some of the traditional stories and/or science narratives and the lack of consistency of level. Because most of the comments were positive, matching the positive student response, we reject null hypothesis 3.

Analysis of the Research as a Whole

All elements of this study evolved over the course of the three stages. Once I saw the response rate from teachers, I simplified their forms as much as possible. I wanted to make the presenters' job as easy as possible. I simplified their forms and asked for one overall response rather than one for each program. They liked the pairing of traditional stories and science narrative and made useful recommendations for changes. Keeping the sites testing and sticking to the protocol proved a challenge throughout the study.

The student survey met with initial success in EFA and reliability studies. In Stage 1, I did not fully grasp the import of the third component which seemed impossible to specify. After seeing it as a lone element in Stage 2 studies, I understood that statement 2 was not useful to me, even though it added to reliability of the overall scale. It added neither to the story scale nor to the science scale, and the overall scale was reliable without it. In Stage 3, the revised statement 2 clearly loaded with science, leaving the expected scales of science and story.

When we looked at the change in student attitude from pretest to posttest, I understood the limitations of a study that does not pair samples. The pretest and posttest are truly not independent samples. Conducting the MANOVA and independent samples t-tests required making assumptions of independence between groups which were not truly independent. The design protocol in Stage 3 was far more elegant, yielding a nice set of dependent variables for the changes in attitude. The new design allowed paired samples t-tests and UNIANOVAs.

The changes in Stage 2 pre- to posttests were quite small—too small to be significant. In Stage 3, the changes were higher and the large number of participants helped to bring significance to the difference. The revised modules in Stage 3 may have caused a larger improvement in attitude. Because of presenter responses, more visuals were added to all modules, and for Stage 3, the Sun module was rewritten for simplicity and clarity. In the Stage 3 student survey, the revised statement 2 solved the problems with the original statement 2, although it still left the survey slightly unbalanced, with four story attitude statements and six science attitude statements. From the standpoint of evaluation, the important result of the evolving student survey and protocol is that we were able to show student appreciation of the programs through quantitative means.

CHAPTER 3

CONCLUSIONS AND INDICATIONS FOR FURTHER STUDY

The SkyTellers Project Impact

Programs using the SkyTeller modules met considerable interest and excitement in presenters, teachers, students, and public audiences. The qualitative responses from presenters and teachers were valuable as clear, immediate feedback about the program modules which I relayed to LPI. The call for more visuals resulted in far more pictures in the Stage 3 modules. I have seen the final DVD, and I noted that the call for more consistency from traditional story to science narrative was met by greater clarity in the later modules. In addition, the qualitative study provided information to compare to the quantitative study of student attitudes.

The fact that most teachers ignored the resource guide increased the importance of the media presentation. With so little time for outside study of materials, teachers need as much as possible included in the programs themselves. People who chose these programs for their secondary orality qualities did not return to the literary document to find activities or to improve their space science backgrounds.

In the paired student attitude surveys we found a way to study the effects of the use of stories in science by quantitative means. The significance of the survey was born out by the ability of factor analysis to reduce the survey to its science and story components. The internal consistency of the answers was shown by reliability studies, with Cronbach's Alpha > .700 on the overall scale and the science scale, and approaching that mark on the story scale. We reject the first null hypothesis. Students in 3rd through 6th grades responded to the statements on the attitude survey and answered reliably.

The second research question, whether students would show significant improvement in attitude, had negative results in Stage 2 but positive results in Stage 3. In Stage 2 results, the negligible attitude change and the significant variance by grade level indicated that the initial versions of the programs were not as well-received as later versions. The complexity of the Sun science narrative and the very small number of visuals in the first versions of the modules were sufficient to prevent significant attitude change. The significant attitude improvement shown in Stage 3 was due in part to evaluation design changes and to the larger study population, but pointed more clearly to the greatly improved SkyTeller modules. We reject the second null hypothesis for Stage 3. Students showed significant change in attitude ($p < .001$) both overall and in science. Because the story scale did not quite meet reliability standards, the improvement in story attitude cannot be completely supported. The most important finding for the SkyTellers Project was the improvement in science attitude after watching the programs.

The third research question, whether the level of presenter and teacher responses would match the students' responses, is much harder to judge. For the most part, the presenter and teacher responses were qualitative data. The few quantifiable questions were typical of informal evaluations rather than rigorous tests. The all-positive questions with numeric responses tend to elicit positive responses, and they did in most cases. The open-ended questions, asking what they liked best and least, brought more answers on what they liked best than on what they liked least. With the exception of concerns about the number and style of visual aids and about the simplicity or complexity of particular traditional and science portions, the responses were enthusiastic. The student overall and science attitude scales increased after the show, indicating the presenters and teachers were not at odds with the students' responses.

The small quantity of the attitude increases may indicate that the students were not as excited as presenters and teachers thought, but my on-site observations corroborated the presenter and teacher judgments. I find it more likely that the attitude survey did not catch the full impact of the student response. The reasons for that deficit may include an age-related hesitancy to respond positively on paper. Some presenters reported that students did not want to take the second survey, making survey boredom a possible factor. The instrument could have been longer and more interesting, or the time lapse between pre- and posttest greater. In any case, this question entails the difficult task of comparing qualitative data to quantitative data. Because the overall responses of presenters, teachers, and students were positive, we reject the third null hypothesis. The presenter and teacher responses confirmed the student survey results.

Suggestions for Further Study

The use of attitude surveys shows promise for studying the use of stories in science and other educational fields. A good attitude, if it persists, may lead to lifelong interest. More quantitative research in storytelling would help support our intuitive experiences of the value of stories.

The SkyTellers Project offers many more opportunities for study. The lack of a control group for this study makes it impossible to tell whether the attitude changes came from the SkyTellers modules or from attending a planetarium show. The attitude survey proved capable of finding changes, so using it with control audiences in non-SkyTellers planetarium shows could address that question.

Now that the other four modules are available, a follow-up study would be appropriate for evaluation of the entire set of programs. An additional factor which might prove interesting is the question of gender-based response. Tracking the gender of the students would allow analysis of variance by gender, which then could be compared to other discussions of science and gender.

In data already collected for this study, analysis of the responses of students followed through two separate shows would be helpful to assess more long-term effects of the shows. We might also benefit from repeating the survey with some of the school audiences to assess persistence of interest in space science. I recommend that future studies focus on science attitude and not on story attitude. The stories are the treatment, and the educational goal is not to improve attitude toward story, but to improve attitude toward science. I think the students could answer 15 – 20 statements, thus giving depth and adding the chance for more significant changes.

For a short survey, a large population is essential for finding significance. The general rule of field-testing with 10 responses per statement requires a fairly large number of test subjects just to assess the survey. I recommend that storytelling researchers look for large audiences or for sustained programs (allowing a larger interval from pre- to posttest), and that the test be designed with a larger field of appropriate statements. Quantity helps significance.

An interesting follow up to this study would be a comparison of planetarium shows with SkyTeller modules to shows with a storyteller and/or a space scientist present. The SkyTellers Project allows the modules to reach a large number of audiences, so their value is not in question. The question of mediated vs. live storytelling needs assessment so that we can judge what effect the presence of a storyteller might have. We have moved from orality to literacy to the secondary orality of media productions. Just as the oral/literate distinction merited extensive study, the move to mediated storytelling also merits examination.

One SkyTeller Team member used the SkyTeller modules to teach space science to university-enrolled pre-service teachers. Space science is often neglected in teacher education, a fact that was verified by discussions with teachers in other locations. The SkyTeller researcher tested teacher acquisition of facts and concepts. He verbally reported that his study met with success and that the teachers were interested in the program modules. His work has not yet been published, nor has he sent me any data or further information about his study. Whether stories aid the acquisition of knowledge is another factor worthy of study, though it was outside the confines that were given by the Lunar and Planetary Institute for my evaluation.

I hope to see many more studies of the use of stories in science and in other fields of education. The promise of engagement can be studied by quantitative means, with benefit to all storytellers and educators. Once clear goals are set for a given application of stories, an attitude survey can examine the realization of those goals. I hope that this study provides incentive and guidance for others interested in storytelling research.

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APPENDIXES

Appendix A

SkyTeller Modules Available During Each Study Stage

Stage 1:	Day and Night
	The Sun
Stage 2:	Day and Night
	The Sun
Stage 3:	Day and Night (revised)
	The Sun (revised)
	Seasons
	Lunar Phases
	Meteors
	Polaris, the Pole Star
Final DVD:	Day and Night
	Seasons
	Moon Phases
	Meteors
	Sun
	Stars
	Galaxies
	Constellations
	Polaris
	Solar System

Appendix B

Test Sites

East Tennessee State University Planetarium, Johnson City, TN

Brazosport Nature Center and Planetarium, Clute, TX

LodeStar Astronomy Center, Albuquerque, NM

Bales Intermediate School, Friendswood Independent School District, Friendswood, TX

Cimarron Elementary School, Galena Park Independent School District, Houston, TX

Green Valley Elementary School, Galena Park Independent School District, Houston, TX

Tice Elementary School, Galena Park Independent School District, Houston, TX

Baker Demonstration School/National-Louis University, Evanston, IL

Appendix C

Presenter and Teacher Response Forms

Stage 2 Presenter Response Form

SkyTellers Project

Presenter's Response Please fill out one for each program given.

Name____

Location____

Date____

Audience (circle one) school after-school program other_________

grade/age range__________________

Program topic____

SkyTeller module used (circle one) Day/Night the Sun

While running the SkyTeller module, did you add elements such as visuals or music?
If so, please describe:

Did you refer to the SkyTeller stories and/or images during the rest of your program/lesson?

Please give an outline of your program today.

How did the audience respond to the total program? Uninterested 1 2 3 4 5 Interested

To the SkyTellers module? Uninterested 1 2 3 4 5 Interested

How did the SkyTeller module worked in this program? Not well 1 2 3 4 5 Well

Comments:

Stage 2 Teacher Attitude Survey

SkyTellers
Teacher Survey

Hello! We are studying how teachers feel about stories, science, and science classes. Please mark the box which best fits your feeling about each statement.

1	I like to tell stories when I teach.	I strongly agree	I agree	I disagree	I strongly disagree
2	Science concepts are very difficult for my students.	I strongly agree	I agree	I disagree	I strongly disagree
3	Stories are a good way to teach science.	I strongly agree	I agree	I disagree	I strongly disagree
4	It is hard to fit science lessons into my classroom plans.	I strongly agree	I agree	I disagree	I strongly disagree
5	I don't feel I can tell stories very well.	I strongly agree	I agree	I disagree	I strongly disagree
6	My students enjoy science lessons.	I strongly agree	I agree	I disagree	I strongly disagree
7	I like using science programs others have prepared.	I strongly agree	I agree	I disagree	I strongly disagree
8	I don't have time for stories in my classroom.	I strongly agree	I agree	I disagree	I strongly disagree
9	Teaching science requires covering a lot of detailed facts.	I strongly agree	I agree	I disagree	I strongly disagree
10	I feel comfortable teaching science.	I strongly agree	I agree	I disagree	I strongly disagree

[*Note*: This survey was originally printed in landscape view. It has been reformatted to fit this page for easier reading.]

SkyTellers Teacher Program Evaluation

We would like to know how you felt about the SkyTellers planetarium show. Thank you for your time! If possible, please try one of the activities in the resource guide, then return this questionnaire to the planetarium.

A	My students reacted positively to the program.	I strongly agree	I agree	I disagree	I strongly disagree
B	I found the program interesting.	I strongly agree	I agree	I disagree	I strongly disagree
C	My students enjoyed the animal stories.	I strongly agree	I agree	I disagree	I strongly disagree
D	The science stories were well-done.	I strongly agree	I agree	I disagree	I strongly disagree
E	I would like to use more programs like this one.	I strongly agree	I agree	I disagree	I strongly disagree
F	I would like to have the audio cd's in my classroom.	I strongly agree	I agree	I disagree	I strongly disagree
G	The suggested activities are good activities for my students.	I strongly agree	I agree	I disagree	I strongly disagree
H	I would like to use the books and websites listed in the resource guide.	I strongly agree	I agree	I disagree	I strongly disagree

[*Note*: This chart was originally printed in landscape view. It has been reformatted to fit this page for easier reading.]

I. What did you like best about the program?

J. What did you like least about the program?

K. Were there any technical problems with the program?

L. Which activity did you use? Did you find it effective?

M. Is there anything else you would like us to know? Feel free to use the back of the page if you have more comments.

Stage 3 Presenter Response Form

SkyTellers Project

Presenter's Response Form

Name____

Location____

Dates used____

Audiences school_________ after-school program_______ other_________

grade levels_________________

SkyTeller modules used:

Day & Night_______ The Sun_______ The Seasons_______

Lunar Phases_______ Meteors_______ Polaris_______

How did the audience respond to the program? Uninterested 1 2 3 4 5 Interested

Would you like to use these programs again?

Were there any technical difficulties?

Comments:

Stage 3 Teacher Response Form

SkyTellers Teacher Program Evaluation

Thank you for your time! We would like to know how you felt about the SkyTellers planetarium show.

		Agree	Disagree
A	My students reacted positively to the program.	1 2 3 4 5	
B	I found the program interesting.	1 2 3 4 5	
C	My students enjoyed the animal stories.	1 2 3 4 5	
D	The science stories were well-done.	1 2 3 4 5	
E	I would like to use more programs like this one.	1 2 3 4 5	
F	The resource guide is helpful.	1 2 3 4 5	
G	The suggested activities are good activities for my students.	1 2 3 4 5	
H	I would like to use the books and websites listed in the resource guide.	1 2 3 4 5	

I. What did you like best about the program?

J. What did you like least about the program?

K. Did you try any of the activities? If so, which did you use? How did it work?

L. Have you visited the SkyTellers website (http://www.lpi.usra.edu/education/skytellers/)?

M. Is there anything else you would like us to know? Feel free to use the back of the page for additional comments.

Appendix D

Presenter and Teacher Response Summaries

Table D1
Stage 2 Frequencies and Means of Presenter Responses

Room	*n*	5	4	3	2	1	Mean
			Audience response to program				
Fixed Planetarium	11	8	3	0	0	0	4.7
Portable Planetarium	14	13	1	0	0	0	4.9
Classroom	7	0	4	1	2	0	3.3
All Rooms	32	21	8	1	2	0	4.5
			Audience response to module				
Fixed Planetarium	11	7	3	1	0	0	4.5
Portable Planetarium	14	13	1	0	0	0	4.9
Classroom	7	0	3	3	1	0	3.3
All Rooms	32	20	7	4	1	0	4.4
			How module worked within program				
Fixed Planetarium	11	8	1	3	0	0	4.5
Portable Planetarium	14	13	1	0	0	0	4.9
Classroom	7	0	2	3	2	0	3.0
All Rooms	32	21	4	6	2	0	4.4

Note. On this scale, 5 represents “Interested” and 1 “Uninterested” for the two audience response questions. For the question about how well the module fit the program, 5 represents “Well” and 1 “Not well.” The intermediate values were not given names.

Table D2

Stage 2 Summary of Presenter Comments on Open Response Questions

	n	Well received	Sound problems	More visuals	Not attentive	Very attentive	No science	Replaced science
Fixed Planetarium	11	8	-	2	1	2	1	7
Portable Planetarium	14	5	7	-	1	2	6	-
Classroom	7	-	3	3	-	-	-	-

Note. *N* = 32 programs.

Other comments

Fixed Planetarium

Even 6th graders looked for more visuals, but they seemed very attentive to the storyline. Long pauses in the "science" story were a distraction!

Probably best interaction among all the groups. It was a very relaxed and happy group of kids, however, no school "stress" on them at this time of year.

Story good for this age, but science explanation too long and slow for kindergarten.

Story well received, audience very quiet and listening for whole show, more verbal during show with on topic comment than were the younger students. Teachers were very favorable of program. Adults enjoyed both parts of show as well. (This set of comments were repeated 5 times.)

Story well received, audience very quiet and listening for whole show. Teachers very favorable of program. Students made many lovely pictures illustrating story in their own way.

Story well received, audience made comments on topic and were very happy with the show. Teachers were very favorable of program. Second grade is more on target for this program than kindergarten. I must take the groups that sign up.

Portable Planetarium

A child cried in this Pre-K group inside skylab and all the children ran for teachers' laps!

This highly sensory, intimate experience was wonderful for the children.

Children were very interested in the constellations. Wanted to do "research" "when we get back to the room."

This particular class was a research group for our Storytelling & Literacy work in the winter. They were so ready for the experience and slipped easily into deep listening behavior. That behavior transferred to the science story.

This was the best of the day. 4+ children camp in the summer and helped along our discussion. The class was stimulated and attentive. The Skylab is so wonderful for these classes.

This class was also very interested in how the dome stayed up with just a fan. He [kindergartener] said, "It's just like Frank Lloyd Wright" (we had studied him in January). "How?" I said. "Because it's so large on the inside. It's the universe! But you get outside and it's little."

By Friday the whole school was talking about us. Some teachers were upset they had not signed up and no slots were left!

The children were so eager to 'repeat' yesterday's experience. We did not have to repeat the "rules" as kids remembered those. We got right into the content. Oh, joy! The bliss of people coming together easily because they know/sense something wonder filled will happen.

? Is Skytellers about Native people or science, that is, as a teacher I tend toward knowing many peoples have stories about the constellations/the sky, not just native tellers. Is the science 'retelling' just that? What is true about the stars?

Peggy & I have so much confidence about our ability to do this program! "Well-oiled machine!" Except for the difficulty hearing, this has been fun. 16 presentations in 2 days, that is, two very warm days…a native sweat lodge. A spiritual experience: hearing the stories over and over in that hot, close space increased my capacity to listen. Occasionally, we all were silent when the stories ended. And peaceful.

Classroom

Need more pictures & less folklore!

Table D3

Stage 2 Frequencies and Means of Teacher Pretest

	I strongly agree 4	I agree 3	I disagree 2	I strongly disagree 1	Mean
1. I like to tell stories when I teach.	15	6	1	1	3.5
2. Science concepts are very difficult for my students.	0	8	11	3	(2.2) 2.8
3. Stories are a good way to teach science.	10	12	1	0	3.4
4. It is hard to fit science lessons into my classroom plans.	1	6	5	9	(2.0) 3.0
5. I don't feel I can tell stories very well.	3	2	13	5	(2.1) 2.9
6. My students enjoy science lessons.	11	11	0	0	3.5
7. I like using science programs others have prepared.	3	14	3	2	2.8
8. I don't have time for stories in my classroom.	1	0	15	7	(1.8) 3.2
9. Teaching science requires covering a lot of detailed facts.	4	8	4	4	(2.6) 3.4
10. I feel comfortable teaching science.	11	10	2	0	3.4
Overall					3.2

Note: $N = 23$.

For each negative question, the mean shown in parentheses is on a reversed scale, with 1 the highest and 4 the lowest. For consistency of scale, the number below the actual mean is the corresponding value in a positive direction, with 4 highest and 1 lowest. The overall mean was calculated using the positive scale means.

Table D4

Stage 2 Teacher Evaluation Summary

		I strongly agree 4	I agree 3	I disagree 2	I strongly disagree 1	Mean
A	My students reacted positively to the program.	10	11	0	0	3.5
B	I found the program interesting.	11	10	0	0	3.5
C	My students enjoyed the animal stories.	9	11	1	0	3.4
D	The science stories were well-done.	8	12	1	0	3.3
E	I would like to use more programs like this one.	13	7	1	0	3.6
F	I would like to have the audio cd's in my classroom.	10	9	2	0	3.4
G	The suggested activities are good activities for my students.	4	11	1	0	3.2
H	I would like to use the books and websites listed in the resource guide.	8	9	1	0	3.4

Note. N = 21

I. What did you like best about the program?

the novelty
visual/audio combo
The storytelling
Gazing at the stars on a rainy morning [portable dome]
That it was taught for the whole classroom at one time. [portable dome]
The tent captured kids attention. [portable dome]
Combination story/skylab [portable dome]
The experience of crawling through the stars and moon and stories [portable dome]
I liked the environment…realistic…the stories were good too [portable dome]
Compatibility with curriculum
The storytelling
The presentation was great.
The websites
Stories were interesting.
Storytelling before introducing the main concept of the lesson.
The pictures
Everything was well prepared.
The use of imagination and the visuals

J. What did you like least about the program?

It's hard for old ladies to sit on the floor with no backrest, middle schoolers, too. [portable dome]
mostly audio only when explaining science concept
It was hot in the skylab [portable dome].
Some of the speakers were hard to hear from.
The stars were a little difficult to see.
Nothing
The story we could not hear [module 1]
It was difficult to hear the last story…it seemed to get in depth as well. [module 2]
N/A
The music used w/stories
More pictures need to be add to each story
Least graphic or picture while stories are told
too little of pictures
The sound was too low. Not enough pictures.

K. Were there any technical problems with the program?

difficult to hear	[Portable dome]
no	[Portable dome]
no	[Portable dome]
The story was a bit difficult to hear—the volume was not loud enough.	[Portable dome]
Some of the speakers were hard to hear from.	[Portable dome]
No	[Portable dome]
No	[Portable dome]
Just the tape by Dovey [module 1]	[Portable dome]
The volume on the speakers	[Portable dome]
none	[Fixed planetarium]
No	[Fixed planetarium]
no	[classroom 1]
no	[classroom 1]
no	[classroom 1]
Volume	[classroom 2]
Audio wasn't loud enough	[classroom 2]

L. Which activity did you use? Did you find it effective?

N/A
just stories
Nothing, yet...
N/A
Looked at stars + heard coyote tale of the origin of the sun.
Day & Night [module 1]. Yes, it was good.
N/A
Day/Night Cycles [module 1]- yes
Sun [module 2]
"Sun" [module 2] & "Day & Night" [module 1] = somewhat

Day & Night Cycles [module 1], yes the "light bulb" came on

M. Is there anything else you would like us to know? Feel free to use the back of the page if you have more comments.

Great fun!
Lovely!
I would like to have access to other lessons and programs
Just more pictures/diagrams while describing the concept. The more interactive, the better it would be.
NAH!
The program would be most effective in a VHS form or interactive DVD [classroom]

Table D5

Stage 3 Presenter Response Summary

Audiences: 32 school, 3 public

SkyTeller modules used:

Day & Night The Sun x The Seasons x

Lunar Phases x Meteors x Polaris x

How did the audience respond to the program? Uninterested 1 2 3 4 5 Interested
Mean: 4.5

Would you like to use these programs again?

yes [7]
Definitely [2]
Only on DVD. Better graphs or animation.
I would like to use these shows in the future – they were well received and appeal to children who like stories as well as children who like science. Adult audiences also responded favorably to the presentation.

Were there any technical difficulties?

Fixed Planetariums
There were major technological problems with this show (Seasons, 9/15/04) due to the incompatibility with later versions of PowerPoint. I believe the students still enjoyed both stories although may have been distracted by the lack of consistency between the images and the story.
There were only minor technological problems (Sun, 5/04/04). Due to the incompatibility with later versions of PP, the images skipped and were not exactly in synch with the audio part of the show. However, this was not a major problem and did not detract from the impact of the show.
Technical suggestions (Polaris DVD):
-If the borders of the slides were less bright – grey or a deep color, students could have seen stars during the science part of the story.
-Sometimes an arrow appears and disappears during the DVD show, it is slightly distracting.

Portable Planetarium
Yes, should be on a CD or DVD compatible to both PC and Mac
Initially, but it was worked out. (Couldn't play on our laptops)
We only had problems trying to connect the software w/ our own computers. With SkyLab's [LPI] computer, everything ran perfectly. I loved it! :)
Yes. Volume. Set up of all the different tech devices.
No

Only with the volume. The stories need to be a little louder.

Comments:

Great!
I'd love to see & use the planets & how the stars were formed.
I look forward to doing this again. :)
[Both fixed planetariums reported that the school audiences were quiet and attentive. Adults also enjoyed the programs.]
The children very often said that the Polaris story was their favorite part of the planetarium visit.
The PowerPoint would benefit from slide transitions – "fade smoothly – slow" would give a dimension of smooth motion and animation to the slides.
The lines that outline the Big dipper could be animated using custom animation – wipe, which can be made directional. The bowl could be outlined first and then the handle.
The end of the bowl pointer stars could be animated with a wipe colored line and then the line out to Polaris could be animated in the same way.
All of these are minor suggestions as you have a very excellent professional product.

Table D6

Stage 3 Teacher Evaluation Summary

	Agree 1	2	3	4	5 *Disagree*	Mean
A. My students reacted positively to the program.	29	6	-	3	-	1.39
B. I found the program interesting.	26	7	3	2	-	1.5
C. My students enjoyed the animal stories.	28	6	1	3	-	1.45
D. The science stories were well-done.	26	8	1	3	-	1.5
E. I would like to use more programs like this one.	26	5	6	-	-	1.46
F. The resource guide is helpful.[a]	14	6	6	-	-	1.69
G. The suggested activities are good activities for my students.[a]	11	9	7	-	-	1.85
H. I would like to use the books and websites listed in the resource guide.[a]	8	8	7	1	1	2.16

Note. *N* = 38

a. Some teachers reported that they did not get resource guides.

I. *What did you like best about the program?*

Fixed Planetarium

organized and interesting

The entire program. This is excellent for the students.

well organized

The stars.

Planets and star stories

The story

[Five other comments referred to parts of the planetarium show outside the SkyTeller module.]

Portable Planetarium

the constellations

very interesting + informative

different format - kept student's interest

Stories, visual display

The view of the stars

Very different and exciting environment is always good for grabbing attention

I loved the connections between Native American mythology + science.

It was very different. I liked the fact that it was a realistic atmosphere.

Information about the stars.
seeing the stars
realism of star constellations
New + different, engaging
the excitement of the students--excitement about learning!
Unique
It was something completely new to the students.
I liked the Native American stories. Very interesting - kept the kids attention - something the kids haven't heard before
Everything
Animal stories, learning about stars and constellations.
The star lab
New, different approach
everything was so nice
Science story
Showing stars in sky--planet's location
Polaris story
Native Am. Story

J. *What did you like least about the program?*

Fixed Planetarium
I liked the entire program
All was good
We need more time.
I like everything!
[Four comments about elements of other parts of planetarium show,
one request for presenter's usual discussion period]

Portable Planetarium
need another story [re: Sun]
confined quarters + darkness (My students got a little restless)
more intro about Native American storytelling vs. scientific knowledge prior to beg. of prog.
The "orange-moon" explanation [re: Lunar Phases]
Not enough visuals
I thought it could have been a little longer
Hard to hear
No complaints.
Students entering the dark.
it was fine.
difficult to hear. Too dark when entering/exit.
There never seems enough time to integrate the activities
limited information about the constaletions
It was great overall.
The sound was too low.
volume was too low
wait time
Science stories a little too young

K. *Did you try any of the activities? If so, which did you use? How did it work?*
Time is an issue!
Not yet [3]
Not yet, but I will [3]
No [7]
No--haven't had time
N/A [2] (did not get resource guides)
I have not had time to try the activities out. Curriculum is very crowded.
[Two comments about Planetarium activity not related to SkyTellers.]

L. *Have you visited the SkyTellers website (http://www.lpi.usra.edu/education/skytellers/)?*
No [12]
Not yet [3]
No, but I hope to though. I would like to do some creative writing with this.
No, but I will
Not yet, but I will!
N/A [2] (although they were given resource guides)
I have not had time to try the activities out. Curriculum is very crowded.
Briefly
Yes

M. *Is there anything else you would like us to know? Feel free to use the back of the page for additional comments.*

No [3]
Thanks for coming to our school. :)
Maybe have the students find the constellations after the stories.
No, thank you for making this possible for our students.
Any helpful websites
[Student on survey: Thank you!! It was a lesson I'll never forget!! :)]

Appendix E

Student Attitude Surveys

Student Pretest for Stages 1 and 2

SkyTellers Survey for Students

Is this a test??? No! We're studying how students learn science.

We just want to know how you feel science and about stories.

Please don't put your name on this paper, just mark the box that best expresses how you feel.

1	Stories are fun to hear.	I strongly agree	I agree	I disagree	I strongly disagree
2	Science is too hard for me to understand.	I strongly agree	I agree	I disagree	I strongly disagree
3	I would like to look at a book about the stars.	I strongly agree	I agree	I disagree	I strongly disagree
4	I would enjoy a science lesson about the sun.	I strongly agree	I agree	I disagree	I strongly disagree
5	Sometimes I like to hear the same story again.	I strongly agree	I agree	I disagree	I strongly disagree
6	I wish we talked more about science in school.	I strongly agree	I agree	I disagree	I strongly disagree
7	I get bored listening to stories.	I strongly agree	I agree	I disagree	I strongly disagree
8	I would like to hear a story about planets and others things in the sky.	I strongly agree	I agree	I disagree	I strongly disagree
9	A TV show about the stars and planets would be neat.	I strongly agree	I agree	I disagree	I strongly disagree
10	I like to picture stories in my head.	I strongly agree	I agree	I disagree	I strongly disagree

Note. The surveys were originally printed in landscape layout. They have been reformatted for easier reading.

SkyTellers Second Survey for Students

Gee, this looks familiar! Yes, it's the same survey you took a while ago.

Sometimes people's feelings change from day to day. We want to know how you feel about science and story today.

It's still not a test, so don't put your name on it! Just mark the box that fits how you feel.

1	Stories are fun to hear.	I strongly agree	I agree	I disagree	I strongly disagree
2	Science is too hard for me to understand.	I strongly agree	I agree	I disagree	I strongly disagree
3	I would like to look at a book about the stars.	I strongly agree	I agree	I disagree	I strongly disagree
4	I would enjoy a science lesson about the sun.	I strongly agree	I agree	I disagree	I strongly disagree
5	Sometimes I like to hear the same story again.	I strongly agree	I agree	I disagree	I strongly disagree
6	I wish we talked more about science in school.	I strongly agree	I agree	I disagree	I strongly disagree
7	I get bored listening to stories.	I strongly agree	I agree	I disagree	I strongly disagree
8	I would like to hear a story about planets and others things in the sky.	I strongly agree	I agree	I disagree	I strongly disagree
9	A TV show about the stars and planets would be neat.	I strongly agree	I agree	I disagree	I strongly disagree
10	I like to picture stories in my head.	I strongly agree	I agree	I disagree	I strongly disagree

Note. The surveys were originally printed in landscape layout. They have been reformatted for easier reading.

Name____

- -

SkyTellers Survey for Students

Is this a test??? No! We're studying how students learn science.

We just want to know how you feel science and about stories.

Mark the box you that fits how you feel. Thank you for your help.

1	Stories are fun to hear.	I strongly agree	I agree	I disagree	I strongly disagree
2	I don't like science.	I strongly agree	I agree	I disagree	I strongly disagree
3	I would like to look at a book about the stars.	I strongly agree	I agree	I disagree	I strongly disagree
4	I would enjoy a science lesson about the sun.	I strongly agree	I agree	I disagree	I strongly disagree
5	Sometimes I like to hear the same story again.	I strongly agree	I agree	I disagree	I strongly disagree
6	I wish we talked more about science in school.	I strongly agree	I agree	I disagree	I strongly disagree
7	I get bored listening to stories.	I strongly agree	I agree	I disagree	I strongly disagree
8	I would like to hear a story about planets and others things in the sky.	I strongly agree	I agree	I disagree	I strongly disagree
9	A TV show about the stars and planets would be neat.	I strongly agree	I agree	I disagree	I strongly disagree
10	I like to picture stories in my head.	I strongly agree	I agree	I disagree	I strongly disagree

Note. The surveys were originally printed in landscape layout. They have been reformatted for easier reading.

Student Posttest for Stage 3

Name____

- -

SkyTellers Second Survey for Students

Gee, this looks familiar! Yes, it's the same survey you took a while ago.

Sometimes people's feelings change from day to day. We want to know how you feel about science and story today.

Mark the box that fits how you feel. Thank you for your help.

1	Stories are fun to hear.	I strongly agree	I agree	I disagree	I strongly disagree
2	I don't like science.	I strongly agree	I agree	I disagree	I strongly disagree
3	I would like to look at a book about the stars.	I strongly agree	I agree	I disagree	I strongly disagree
4	I would enjoy a science lesson about the sun.	I strongly agree	I agree	I disagree	I strongly disagree
5	Sometimes I like to hear the same story again.	I strongly agree	I agree	I disagree	I strongly disagree
6	I wish we talked more about science in school.	I strongly agree	I agree	I disagree	I strongly disagree
7	I get bored listening to stories.	I strongly agree	I agree	I disagree	I strongly disagree
8	I would like to hear a story about planets and others things in the sky.	I strongly agree	I agree	I disagree	I strongly disagree
9	A TV show about the stars and planets would be neat.	I strongly agree	I agree	I disagree	I strongly disagree
10	I like to picture stories in my head.	I strongly agree	I agree	I disagree	I strongly disagree

Note. The surveys were originally printed in landscape layout. They have been reformatted for easier reading.

Appendix F

Student Survey Responses

Table F1

Stage 2 Frequencies and Means of Student Answers on Pretest and Posttest

			I strongly agree 4	I agree 3	I disagree 2	I strongly disagree 1	Mean
1	Stories are fun to hear.	pre	79	140	19	5	3.21 ± .04
		post	84	119	23	12	3.16 ± .05
2	Science is too hard for me to understand.	pre	21	38	98	86	3.02 ± .06[a]
		post	20	40	99	79	3.00 ± .06[a]
3	I would like to look at a book about the stars.	pre	47	109	61	26	2.73 ± .06
		post	62	103	53	20	2.87 ± .06
4	I would enjoy a science lesson about the sun.	pre	60	110	57	16	2.88 ± .06
		post	57	98	70	13	2.83 ± .06
5	Sometimes I like to hear the same story again.	pre	47	115	57	24	2.76 ± .06
		post	51	111	49	27	2.78 ± .06
6	I wish we talked more about science in school.	pre	53	73	73	44	2.56 ± .07
		post	94	93	36	15	2.65 ± .06
7	I get bored listening to stories.	pre	19	39	93	92	3.06 ± .06[a]
		post	15	36	93	94	3.12 ± .06[a]
8	I would like to hear a story about planets and others things in the sky.	pre	70	112	46	15	2.98 ± .06
		post	72	97	43	26	2.90 ± .06
9	A TV show about the stars and planets would be neat.	pre	68	89	68	18	2.85 ± .06
		post	66	91	57	24	2.84 ± .06
10	I like to picture stories in my head.	pre	89	98	35	21	3.05 ± .06
		post	90	84	37	27	3.00 ± .06

Note. Pretest $N = 243$, Posttest $N = 238$.

a. For consistency of scale, means for Statements 2 and 7 have been reversed to reflect positive attitude.

Table F2

Stage 3 Frequencies and Means of Student Answers on Pretest and Posttest

			I strongly agree 4	I agree 3	I disagree 2	I strongly disagree 1	Mean
1	Stories are fun to hear.	pre	332	477	48	27	3.26 ± .02
		post	409	385	58	32	3.32 ± .02
2	I don't like science.	pre	61	86	300	437	3.26 ± .03[a]
		post	54	84	270	476	3.32 ± .03[a]
3	I would like to look at a book about the stars.	pre	212	399	192	81	2.84 ± .03
		post	303	357	162	62	3.02 ± .03
4	I would enjoy a science lesson about the sun.	pre	299	386	141	58	3.05 ± .03
		post	347	349	138	50	3.12 ± .03
5	Sometimes I like to hear the same story again.	pre	167	383	200	134	2.66 ± .03
		post	202	390	178	114	2.77 ± .03
6	I wish we talked more about science in school.	pre	288	290	210	96	2.87 ± .03
		post	314	296	180	94	2.94 ± .03
7	I get bored listening to stories.	pre	65	109	349	361	3.14 ± .03[a]
		post	81	101	325	377	3.13 ± .03[a]
8	I would like to hear a story about planets and others things in the sky.	pre	375	368	81	60	3.20 ± .03
		post	408	339	93	44	3.26 ± .03
9	A TV show about the stars and planets would be neat.	pre	311	364	136	73	3.03 ± .03
		post	353	325	133	73	3.08 ± .03
10	I like to picture stories in my head.	pre	350	340	109	85	3.08 ± .03
		post	371	300	123	90	3.08 ± .03

Note. N = 884

a. For consistency of scale, means for Statements 2 and 7 have been reversed to reflect positive attitude.

VITA

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