

Early Childhood Learning in Preschool Planetarium Programs

Kaylan Brae Petrie

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Committee:

Jessica Luke

Angelina Ong

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Abstract

Family groups comprise a significant percentage of the museum visitor population, and many programs are created specifically for young learners (Borun, 2008). One such learning environment is that of planetaria, where both live and pre-recorded programs are presented to introduce concepts in Earth and Space Science to young children. Pacific Science Center's *Preschool Trip to the Moon* live, interactive planetarium program was used as a context for exploring families' motivations for attending a planetarium show, their reactions to the show, and in particular what children learned from the show. Methods included adult questionnaires and child interviews. Adult motivation for attending the program was largely due to their own interest in astronomy or their desire for their child to be interested in astronomy, not because the child was already interested in the subject. Children expressed an interest in returning to the planetarium in the future, and many identified several features of the program that they enjoyed. Results pertaining to what children learned suggested a range of outcomes that were behavioral, observational, and conceptual. Future planetarium programming should incorporate support for adults in rooting this interest through informal education led by the adult.

Chapter I

Introduction

Many museums today have special programs that support preschool education. There are entire museums devoted to play, separate toddler areas in many museums, and special programming aimed at young learners and their caretakers. One example of such opportunities is age-appropriate planetarium programs created for children ages 7 and younger.

Pacific Science Center, Seattle, WA, has offered a live, interactive preschool planetarium program titled *A Preschool Trip to the Moon* since 2012. This program is a 20-minute live presentation guided by a planetarium presenter or “planetarian”, and follows a general outline of daytime sky observation, nighttime sky observation, the telling of a folktale with astronomical themes, traveling to the Moon, comparing and contrasting the Earth and the Moon, a dance party on the Moon, then returning to Earth. *A Preschool Trip to the Moon* has been presented 566 times to 17,419 individuals to date (J. Purnell, personal communication, March 15, 2013). While outputs are well documented, little is known about the impacts of programs such as this. How do early learners respond to preschool planetarium programs? What do they get out of these programs? How do these programs advance children’s thinking about the world around them?

The goal of this study is to explore the nature of early childhood learning in planetaria by discovering what families value most about planetarium shows, what children remember and enjoy about these shows, what educators and curriculum developers believe are the main aspects of successful astronomy programming for young children, and what steps should be taken for future astronomy programming for the 3-5 age group. Specifically, the study is designed to answer the following research question: *How do planetarium programs contribute to science learning in children ages 3-5?* Sub-questions included the following:

- What motivates family groups to attend a planetarium show?
- What are adult expectations coming into the planetarium show?
- What is the most enjoyable thing for young children about a planetarium?
- What is the nature of young children's (3-5 years) learning experiences in a planetarium show?
- What do families value most about astronomy programs for young children?
- What are professionals in the field of informal astronomy education doing to create successful planetarium and museum programs for young children?

The results from this study will be of foundational importance for other informal learning institutions that wish to create, improve, or explore their offerings for young learners. Planetaria heretofore have inconsistently supported their youngest learners in Earth and Space Science, and perhaps the best way to prepare them for future science learning is through exposure to planetarium programs designed especially for them. Additionally, due to the lack of sufficient literature on young learners in astronomy, this study will strengthen the ties between early childhood learning and Earth and Space Science education, especially in informal settings.

About Pacific Science Center

Pacific Science Center (PSC) is located in Seattle, Washington and is the first U.S. museum to be founded as a science and technology center. PSC reports that their programs reach nearly 1.5 million people annually, both on-site and through their outreach programs.

Mission

Pacific Science Center inspires a lifelong interest in science, math and technology by engaging diverse communities through interactive and innovative exhibits and programs (Pacific Science Center, 2013).

Willard Smith Planetarium

The Willard Smith Planetarium was installed in 1977, 15 years after the opening of PSC. The planetarium was renovated in late 2010, upgrading to a new system created by Zeiss Optics. The acquisition of the new digital projectors was made possible by a NASA grant, and has allowed Pacific Science Center to present up-to-date data and images as soon as they are made available to the public.

Figure 1: Exterior of Willard Smith Planetarium and adjacent exhibits.
Photo credit: Jason Gift Enevoldsen



The Willard Smith Planetarium is a full-dome style digital theatre that seats 40 visitors. All programs are researched and created on-site by PSC staff, and no pre-recorded films are shown.

Figure 2: Interior of the Willard Smith Planetarium.
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Chapter II

Literature Review

American planetariums have inspired the minds of the general public since the 1930s (Rudolph, 2006). Since the popularization of digital full-dome theatres, planetariums have increased visitors' satisfaction with their museum experience and enhanced their understanding of Earth and Space Science (Heimlich et al., 2010; Yu, 2005). Planetariums have the ability to immerse their audience and thereby alter their sense of reality (Lombard, 2008). By using this aspect of planetaria, museums can create a rich storytelling environment that captivates even the youngest visitors (Lantz, 2011).

Most museum planetariums are round theatre-like structures with slightly reclined seats that encourage the visitor to look towards the ceiling where media is projected. Some museums use portable inflatable planetariums where participants sit on the floor. While in these dark environments, visitors are often shown vibrant images and stunning animations about the cosmos. Depending on the planetarium, either a pre-recorded narration or a live educator will guide the visitor's attention through a variety of astronomical topics, often in a theatrical manner. Because of this imaginative storytelling environment in planetariums, an increasing amount of attention is being given to the role of planetaria in educating early learners about astronomy. As proof, in 2012 the National Science Foundation awarded \$2.5 M to the Astronomical Society of the Pacific to research young children's astronomy learning and to create successful age-appropriate materials for preschoolers who visit museums and planetaria (NSF award number 1217441). The goal of this grant is to support both young children as well as the informal

educators who present this astronomy content to them. Little is currently known about what children are learning in planetariums and what methods educators and researchers can use to measure this learning. Inquiry-based experiences increase learning (Allen, 1997), but being immersed in a program where children have little opportunity to speak and act may not yield the same results.

Many museum exhibits and programs already exist to promote family learning, and planetarium shows are no exception. To provide two examples, both Pacific Science Center (PSC) in Seattle, WA and the Lawrence Hall of Science (LHS) in Berkeley, CA have offered live, interactive planetarium shows for young children for many years (Willard Smith Planetarium, 2012; Lawrence Hall of Science Planetarium, 2013). These institutions are not alone in their focus on early childhood education, but are unique in that they offer live, interactive programs rather than a prerecorded film. Loch Ness Productions (LNP), an international database of commercially available planetarium resources, indicates in their Full-Dome planetarium show compendium that there are 48 shows for children from preschool to second grade and their families (Loch Ness Productions, 2013). While LNP is a comprehensive source citing programs from a number of different countries, many more planetarium programs may exist for young children that are not included in this database because they are live-performance shows (like at PSC and LHS) or were not made to be distributed outside of the planetarium it was created in.

The existence of dozens of programs on this genre of immersive informal learning experiences in addition to the apparent international audience of interested children suggests a need to understand the role planetarium programs can play in contributing to astronomy learning. However, there appears to be a disconnect between museum's knowledge about how young

children learn in planetariums, how and if young children learn astronomy, and whether it is necessary for museum staff to create programming on this branch of Science, Technology, Engineering, and Mathematics (STEM) education. This literature review will synthesize what is known and not known relative to five main areas of literature: 1) How and what do people learn from Planetarium experiences? 2) What do young children know about astronomy, and how is that measured? 3) What do we know about how and what young children learn in museums? 4) What is the role of storytelling in science learning? and 5) What is being done now to explore the intersection of 3-5 year olds and their learning of astronomy in museums?

How and what do people learn from Planetarium experiences?

Planetariums have the ability to psychologically affect visitor's sense of reality because they fully immerse their visitors in an audio-visual experience (Lantz, 2011). As more digital planetariums start to arise, many science centers may decide to use them for non-astronomical educational programming simply because they are so effective at fostering learning (Yu et al., 2009). The advantage of a digital planetarium is that media can be easily manipulated and updated as necessary, as opposed to analog slide projector styles of the past. Lantz designates this experience as "sensory immersion," and suggests that the resulting educational value can be both cognitive and affective. For example, a visitor may feel more introspective or relaxed during and after a large screen or dome show (affective response), and the visitor simply may be able to absorb more factual information from the show due to this immersion (cognitive response). Other research shows that full-dome planetarium shows increase interest in the show topic and are a stimulating mode of presenting information whether it is astronomical in nature or not (Heimlich et al., 2010). This same paper indicates that the size of the presentation screen is correlated to the visitor's interest in the topic and perhaps consequently their engagement and

understanding. For example, an individual will be more interested in the same movie if it is presented to them on a large screen such as a full- or half-dome planetarium screen or IMAX theater as opposed to watching the movie on a television or computer screen.

Another way that planetarium learning has been described is via the notion of “telepresence,” or “the psychological state or perception in which a media consumer has the sensation of being with and connecting to people, objects and events” (Lombard, 2008). In other words, planetarium visitors are given the sensation of being outdoors, flying through space, or observing astronomical phenomena without physically experiencing these events. Several studies have looked at planetaria in contrast to movie theater screens, including IMAX movies and television screens (Lombard, Reich, Grabe, Bracken & Ditton, 2000). Heimlich et al. (2010) also indicate that the sense of immersion visitors experience when they are inside a planetarium is the main ingredient in creating an impactful and enjoyable experience. In their study, planetarium visitors were asked to comment on their level of sensory immersion and to what extent they felt that they were in another place. Visitors who reported having felt immersed were also likely to score higher on a post-show survey assessing their knowledge of the science content presented during the show. Using telepresence as a basis for enjoyment, other planetariums use their domes not only to teach about astronomy, but for laser programs, live and pre-recorded musical performances, and presentations on scientific topics outside the realm of Space Science (Yu, 2009).

These data suggest that planetaria can serve as valuable learning resources; placing learners in a sensory immersive environment can enhance their enjoyment, understanding, knowledge, and engagement.

What do young children (3-5 years) know about astronomy?

How is that knowledge measured?

State preschool learning standards emphasize the introduction of science into preschool curriculum so that students will be better prepared with the skills they need for future learning (Washington State Preschool Education Standards). Research shows that cognitive growth is at its highest between ages 3 and 5 (Shonkoff & Philips, 2000). Developmental research shows that even before children attend kindergarten, they have basic knowledge of physics, chemistry, psychology, and biology (Duschl, Schweingruber & Shouse, 2007). To name a few examples, young children can describe and predict phenomena regarding light, shadows, seasons, speed, weight, and classification.

Many of the strategies for measuring learning in preschool-aged children are focused on classroom, home, and/or daycare settings and may not be appropriate to apply to a museum setting where children have brief, often one time interactions with educators. However, when measuring responses from children under age 5, there are two choices for generally assessing early childhood programs such as planetarium programs. Through direct assessment and observation-based measurements, the researcher may glean relevant information (Snow & Van Hemel, 2008). Respectively, these methods assess the way in which children physically or verbally respond to a series of questions (like in an interview), and observing a child's behavior when they are participating in an activity (interacting with a museum exhibit, for example). One way this learning can be measured is on the preschool learning scale utilized by the California Department of Education (Gelman et al., 2010). This scale ranks children's learning by aligning the educator's lesson objectives with the student's ability to apply concepts over time. The

results from using this scale offer insight regarding the quality of educational programs as well as the level of efficacy in fostering learning.

Another way to measure learning is when a child changes their behavior based on verbal/non-verbal information that another person provides. For example, a child who is struggling to complete a task at an exhibit station may observe another person complete it successfully and then copy the action themselves. Describing this learning takes a lot of inference for the researcher, as there is no direct evidence of an initial incorrect behavior (Puchner, Rapoport & Gaskins, 2011). This research indicates that a lot of learning can happen in a short amount of time, around 60 seconds at an exhibit. Since some preschool planetarium shows last approximately 20 minutes, one can assume that children have more opportunities to learn. Planetarium educators do not know unequivocally that audience members are learning, and often make assumptions about the engagement of their audiences.

Crowley and Callanan (1998) say that the way children learn depends on their current ideas about the way things work. When a new piece of information is presented, children either alter what they already know to make it make sense, or they ignore it all together. Parents can help link theory with evidence, but without them sometimes meaning is lost. This research also shows that children will often learn a new fact or skill, use it, and then almost immediately forget it. However, when children share their knowledge with another person, they are more likely to remember what they learned. Therefore, social learning can be more effective than isolated learning, especially for young children.

Children have daily experiences and interactions with Earth and Space Science, sometimes simply by noticing the Sun and Moon travel across the sky (Worth & Grollman, 2003). Researchers can use these experiences as a platform for bringing Earth and Space Science

into the informal science learning environment of planetaria. Worth and Grollman indicate that children know that the Moon and Sun are not always in the same place, that the Moon changes shape, and that you cannot see the Sun at nighttime.

There are many tools that have been developed to assess whether overall preschool programs are effective, but few have been created to measure if science learning is happening (Gelman et al., 2010). Gelman et al. indicate that well-designed science experiences support the ways in which children learn about scientific processes. Preschool planetarium shows should be included in this framework because they address very specific scientific concepts utilizing a unique technological system. Museum staff assume that their “well-designed science experience” is effective, but without data to indicate whether astronomy learning is actually happening, such assumptions remain unfounded.

While young children are naturally scientifically curious, Murphy and Beggs (2003) indicate that children’s interest in science and math tends to taper off once they reach ages 8-11. Perhaps if museums and planetaria actively fostered a love of science and math when they were very young, children would be more apt to pursue future careers in STEM fields.

What do we know about how and what young children learn in museums?

Young children will be more interested in a topic if it has special significance to their caretaker or close family members. For example, if a parent has an interest in astronomy, they are likely to bring their child to a planetarium show not only for the child’s benefit, but also to satisfy their own personal curiosity and wonder. This correlates to the child wanting to repeatedly revisit the planetarium because they know it has special meaning to their parent (Dockett, Main & Kelly, 2011).

Family learning can occur and be measured through several indicators such as: asking or answering a question, commenting on or explaining an exhibit (or show in this instance), and reading text either silently or aloud (Borun et. al., 1997). There are three levels of that learning – identifying, describing, and interpreting/applying. This is something that planetarium educators try to do in preschool programs. Although most of the literature references how to measure learning in museum exhibits, the findings can be applied to how children learn inside of planetariums when they are asked a question or to comment on a phenomenon. Many museums assume that children are learning, but few have explored what type of learning actually occurs and how frequently learning does occur (Puchner, Rapoport, & Gaskins, 2011)

Munley (2012) suggests that children show an interest in scientific subjects before these subjects are introduced to them in school. Of the non-children's museum programming that is offered to young children, nearly all of it is offered in science centers and science museums. In fact, most of the emphasis is strictly on science.

Research shows that 3 and 4-year-olds have the ability to give correct answers about biology, machines, natural, and inanimate objects, and that this information help in problem solving, remembering, and understanding (Bransford, 2000).

What is the role of storytelling in science learning?

Munley (2012) notes that children are accustomed to hearing stories and it is a great opportunity for museums to capitalize on the attention they give to storytelling and make it an educational opportunity. Museums use story times, hands-on activities, and artifacts to engage preschool aged children, and it is believed that the museum's use of dramatic narrative helps children learn but it also engages their imaginations, emotions, and memories (Bowers, 2012). Children's imaginations are already wandering when they listen to a story and imagine it in their

heads, and “slipping in science” is being opportunistic. Planetaria can be and are used as a vehicle for storytelling (Lantz, 2011). Telling stories through a planetarium program helps particular individuals connect with scientific content without fully acknowledging that it is an educational lesson. To provide an example, Heimlich et al. (2010) indicated that incorporating cultural aspects through storytelling into a planetarium show (what the research refers to as a “cultural wrapper”) had a positive effect on some visitor’s learning of non-cultural scientific content also provided in the program.

Because visitors and family groups have multiple motivations for visiting, learning and entertainment often coexist (Monaco & Moussouri, 2009). Planetariums are appropriate environments for this type of informal science learning to occur. Lombard (2008) says that storytelling is a “critical factor” in enhancing learning in immersive experiences like planetarium shows and IMAX movies.

What is being done now to explore the intersection of 3-5 year olds and their learning of astronomy in museums?

Because few astronomy programs currently exist for 3-5 year olds, so too is there little published research on the topic. One such program that has been evaluated is *One World One Sky*, a pre-recorded planetarium program for young children featuring characters from *Sesame Street* (Sesame Street, 2008). This pre-recorded planetarium program was created by the Sesame Workshop, Liberty Science Center, and the Beijing and Adler Planetariums targeting an audience of 4-6 year olds and their families. Children are introduced to Big Bird, Elmo, and their friend Hu Hu Zhu from China. The show launches into an observational experience pointing out that the night sky looks the same on Sesame Street as it does in China. The audience travels to the Moon and observes phenomena relating to the physical characteristics of it. This program was

translated into Spanish and Mandarin and is currently being played in planetariums both in the U.S. and China. An evaluation of two audiences in the U.S. and China indicates that most children learned new information after seeing the planetarium show, interviewing children both before and after viewing the program. Many children scored higher on the post-show interview than they did on the pre-show interview, suggesting that the program is successful in its mission to provide age appropriate science content to young children (Miller, 2011).

State preschool learning standards suggest that the earlier children engage in STEM concepts, the more comfortable they will be with these subjects as they grow older (Washington State Education Standards). There is not currently any material to support educators who want to improve methods of science teaching and learning in early science education (Brenneman, 2011). Most of the studies that are relevant to assessing young children in science are focused on the nature of informal learning experiences rather than the measurable outcomes either based on education standards or on stated exhibit or program goals (Munley, 2012). Children have a natural desire to be curious and educators can take advantage of this curiosity in museums and planetaria.

Facilitated discussions with staff at three informal astronomy education institutions provide further context for this study. Several small planetariums incorporate a live, hands-on aspect into their planetarium shows and believe the addition of these kinesthetic activities enhance children's learning while in the planetarium (Lawrence Hall of Science, personal communication, March 22, 2013), as well as making it a more memorable experience (Museum of Flight, personal communication, April 18th, 2013). Some of these institutions also suggest that a technique for increasing the probability of information retention would be for the adult to continue the informal education experience after the planetarium visit (Astronomical Society of

the Pacific, personal communication, March 26, 2013). If museums and planetaria are able to provide adults with useful tools for helping their child extend their learning, some institutions believe the chances of children retaining information will be higher.

How this study contributes to the literature

The amount of literature that exists on early childhood development and education is overwhelming and exhaustive. It is clear that researchers place great value on 3-5 year old children in our educational culture, and we know that young children can learn a breadth of information in a short amount of time (Puchner, Rapoport & Gaskins, 2011). Similarly, as technological advances continue to improve digital planetarium experiences, more and more programming is bound to emerge. However, to date, very little published research has been done to intersect these two important fields of education. As more program evaluations are done, the subject of educating young children in astronomy becomes progressively popularized in museums and audience research.

This study aims to uncover what experiences young children and their families have while attending live, age-appropriate programs in small planetariums. By gathering information from adults and young children who attend these programs a clear platform can be created from which to continue this study in the future. These findings may be of use to institutions that already deliver live astronomy programming for young children, museums that wish to create such programs, or educators who wish to engage their students and audiences in astronomy but are unsure how to successfully do so. Furthermore, this data will contribute to the small pool of available literature on learning in planetarium programs, and will provide evidence supporting the value of planetarium programming in early astronomy learning.

Chapter III

Methods

This study was designed to answer the following research question: *How do planetarium programs contribute to science learning in children ages 3-5?* Sub-questions included the following:

- What motivates family groups to attend a planetarium show?
- What is the most enjoyable thing for young children about a planetarium?
- What is the nature of young children's (3-5 years) learning experiences in a planetarium show?

This chapter describes a) the research context; b) the methods used for collecting and analyzing data; c) the study samples and sampling procedures; and d) the study's limitations.

Research Context

The *Preschool Trip to the Moon* program at Pacific Science Center is a live, 20-minute interactive presentation that takes place in a 40-seat circular theatre. This is Pacific Science Center's only free planetarium show, and it is aimed at preschool-aged children. The program begins by observing an afternoon sky with clouds, the Sun, and a first quarter Moon. After the Sun sets and the stars come out, the presenter launches into an ancient Chinese folktale about a day when 10 Suns rose. An archer, the hero of the story, shoots down 9 of the Suns and is rewarded with a magic potion that is accidentally consumed by his wife, who consequently floats to the Moon. At the end of the story, the audience is "flown" to the Moon and a short video clip of astronauts walking and singing is shown. Children are then given noisemakers and are invited to "dance on the Moon" like astronauts. After this activity the children are seated and they are

returned back to Earth and the show ends. As children exit the planetarium they are given a hand stamp and an activity worksheet to take home.

This program was chosen as the research context for this study because it is one of few live planetarium programs that exist for the 3-5 age group. Furthermore, the program was written to address three basic concepts that can be explored through an interview with the children.

These concepts are:

- The Moon is visible during the day
- The sky contains the Sun, Moon, and stars, which many people understand by telling stories
- Astronauts move differently because there is less gravity on the Moon

Methods

To answer the research questions, two methods were used. First, pencil-and-paper surveys were administered to adults who attended Pacific Science Center's *Preschool Trip to the Moon* program. Second, short interviews were conducted with children (ages 3-5) in family groups, after they participated in the planetarium program. Both of these methods are described below.

These methods were selected for the convenience of the parent, child, and researcher. Because young children can sometimes be restless, the questionnaire was designed to be brief so adults could attend to their child shortly after completing it. Additionally, a number of the questions asked both in the questionnaire and the interview directly address several of the research questions, particularly those in reference to motivation and enjoyment. Finally, the rationale for conducting interviews with the 3-5 year olds was to glean information from their responses to understand the impact planetarium programs have on their science learning. This is

similar to the “direct assessment” philosophy outlined by Snow & Van Hemel (2008). Most children and museum visitors are unable to directly comment on what they learned during their visit or how a program impacted them, so the conversational nature of the interview was designed to promote discussion of the entire experience from which the researcher could extrapolate relevant data.

Adult Questionnaires

A total of 57 questionnaires were collected at Pacific Science Center during the months of February and March 2013, on weekdays and weekends, targeting the participants of the 11:00am, 11:30am, 1:30pm and/or 2:00pm *Preschool Trip to the Moon* planetarium shows. These were time slots that public shows were available and the researcher was able to attend and collect data. As family groups waited in line for the planetarium program to begin, the researcher addressed the group and informed them that research would be taking place both before and after the show. All individuals were told that participation in this research was voluntary.

Pens and clipboards were placed on planetarium seats prior to the admittance of audience members. The clipboards contained the questionnaire (see Appendix A), as well as two identical copies of a consent form, one for the researcher and one for the participant (see Appendix B for consent form). Adults were asked to sign the consent form before completing the questionnaire. The one-page questionnaire asked mainly closed-ended questions about adults’ motivations for participating in the program, and their previous experiences with planetarium programs. Numerical values were assigned to closed ended questions and all questionnaires were coded and entered into a Microsoft Excel spreadsheet. Write-in answers were grouped by similar responses.

Child Interviews

Family groups with a 3, 4, or 5-year-old were given the option of participating in a post-show interview; those who accepted were assigned an interview time in 10-minute staggered increments. Twelve interviews were conducted outside the planetarium in the adjacent space-themed exhibit. At the start of each interview, the researcher gave the adult(s) in the group a copy of the Interview Guide (see Appendix C) with the questions the child would be asked, and requested that he/she refrain from assisting their child in answering the questions. Once the child assented to being audio recorded by nodding or saying yes, the researcher proceeded to conduct the interview using an iPad to record responses. Interview questions were designed to assess the child's memory of the show, their astronomy content knowledge that was intended by the show's script, and to explore their enjoyment while in the planetarium.

After completion of the interview, participating children were given a thank you gift (a foam space shuttle or a sticker sheet). At that time, the researcher matched the questionnaire completed by an adult in the group with the child's interview. Interviews were later transcribed and coded by the researcher using the coding scheme described in Appendix E.

Limitations

Planetarium Presenters

Pacific Science Center has seven different presenters who perform the *Preschool Trip to the Moon* show. Naturally, each presenter has a different theatrical presentation style. While each individual is expected to deliver the same content provided in the show script, there is room for inconsistencies or omission of important information on which the instrument questions were based. For example, some presenters start their program looking for shapes in the clouds. This may lead some children to believe the story they heard in the show was not the Chinese folktale

but instead was one about a cloud shape they observed and discussed right at the start of the show. Some presenters make a point to ask the children in the show what shape the room is, while others do not. Because this is one of the child interview questions (see Appendix C), some audiences may be given an inadvertent advantage over others because they were asked during the presentation to comment on the room itself. Lastly, presenters have different ways of indicating that the Moon can be seen in the daytime as well as in the nighttime. For example, one presenter indicated that the Sun and Moon can “share the sky”, while another said more factually that during certain times of the month, one can see the Moon in the daytime sky. This difference in semantics may influence the responses of the children.

Measurement Issues

When completing the questionnaire, some adults interpreted the question “What is one thing you think your child learned in today’s show” as a discussion prompt for their child, so instead of writing in their personal opinions, they asked their child, “What did you learn?” and wrote in their response. There is no way of distinguishing between those questionnaire responses where adults reflected on their child’s learning and those where adults facilitated conversation with their child and recorded those responses. Some young children may have felt uncomfortable speaking with the researcher, an unfamiliar adult, and this could have contributed to some inconsistent data across the interviews.

Group Composition

Another limitation is the sample size of the study. Because museum visitors with young children often feel rushed or overcommitted, many families were unable to devote even a few minutes to the interview aspect of this research. Additionally, many children over the age of 5 were interested in participating in the interview, but were excluded due to the scope of the

research. Because this research only focused on public audiences, the findings may not apply to visitors who attend the program in school groups. Because many preschools cover units on astronomy or “pre-astronomy”, the children’s exposure to astronomy topics before attending the program may influence the results. Furthermore, the time of year that this data was collected (late winter) may influence the results due to when preschool teachers decide to introduce astronomy topics in their classrooms.

Type of Planetarium

An initial limitation to generalizing these findings is the setting in which this planetarium program takes place. There are essentially three types of planetariums; small portable/inflatable planetariums, small theatre planetariums such as those at Pacific Science Center and Lawrence Hall of Science, and large-scale theatre planetariums with nearly 300 seats. With such a spread of planetarium styles, these findings may not be applicable to large-scale or small inflatable planetaria. These findings also may not be applicable to planetaria that neither provides programs for young children nor have staff to create programs like this.

**Chapter IV
Results & Discussion**

This chapter describes the results from the study. First, the characteristics of the samples are described. Next, findings are presented for each of the 3 research questions: 1) What motivates family groups to attend a planetarium show? 2) What is the most enjoyable thing for young children about a planetarium? 3) What is the nature of young children’s (3-5 years) learning experiences in a planetarium show?

Description of the Samples

Adults

All adults who participated in the study attended *A Preschool Trip to the Moon* with at least one child of any age. Adults were not asked their relation to the child(ren) they attended the program with, so they could have included non-family members. All adult participants attended a public program during a weekday or weekend, and every individual was given the same questionnaire.

Table 1: Adult Characteristics (N= 57)

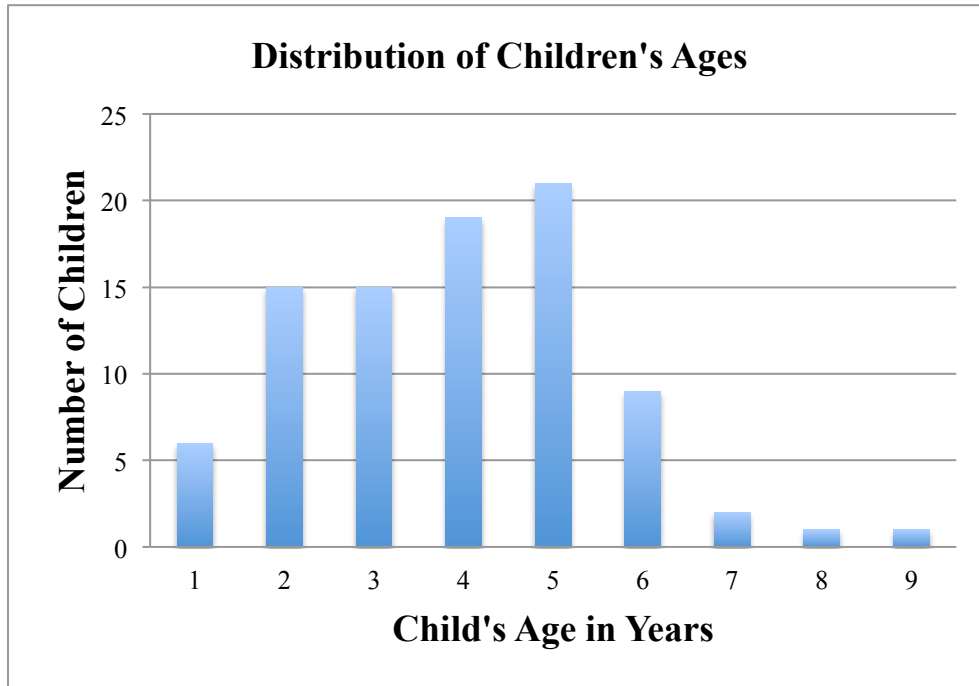
Group Composition	
Average Number of Children in Group	1.6
PSC Member	
Yes	43.6%
First Time Seeing <i>Preschool Trip to the Moon</i>	
Yes	84%
No	14%
→ Average number of times seen in the last 12 months	1.5 times
Average interest in astronomy	
1 = not interested, 7= very interested	5.04

Children

For the purpose of this study, children included any person attending the show who was under the age of 18. All children who attended *A Preschool Trip to the Moon* were part of a non-

school group. Children’s ages were reported on the questionnaire by the adults in their group, and verbally by the child during the interview. Children invited to participate in the interview were between the ages of 3 and 5 years old, and understood and spoke English.

Figure 3. Ages of children in the audience (n=90)



Although the gender of the children was not asked in the questionnaire, many adults provided that information when answering why they attended the show. Of the 48 individuals who answered the question, 12 responses indicated the gender of their child, and 75% (n=9) of these children were male.

Table 2. Ages of Interviewed Children

	3 year olds	4 year olds	5 year olds
Number of Children Interviewed	4	3	5

What motivates family groups to attend a planetarium show?

Adults who completed questionnaires were asked why they had attended the Planetarium’s preschool program. Specifically, adults were given a list of 7 possible motivations for attending the show, and asked to indicate which were true for them. Table 1.4 below shows the range of responses to this “check all that apply” question, and illustrates that the majority of adults reportedly attended the show because they wanted their child to learn about astronomy and/or because they were interested in astronomy themselves.

Table 3 Reasons for attending *A Preschool Trip to the Moon*

Response	N	Total % of Surveys that included this response
I wanted my child to learn about astronomy	45	80%
I was personally interested in the program and/or astronomy	43	75%
My child is interested in astronomy	28	49%
This show was happening at a convenient time	27	47%
This show is free	21	37%
Other (Write-in)	6	11%
I wanted to rest while my child does an activity	5	9%
I wanted my child to feel more comfortable in the dark	3	5%

Although participants were able to check all responses that applied, some adults wrote in additional responses regarding their motivations for attending the program such as:

Wanted to introduce friend to planetarium

Wanted [the child] to see that learning is fun

Only show my son can see

Great way to introduce a new hobby/learn

Reinforce ideas/concepts my kids have studied

To be inspired by the wonder of their world

Eighty-four percent of adults who completed the questionnaire (n=46) indicated that this was their first time seeing *A Preschool Trip to the Moon*. Those adults who had been before were asked to indicate how many times they had, and why they returned. On average, they had been 1.5 times in the last 12 months. Table 4 below shows their reasons for repeated participation. This finding is inconsistent with Pacific Science Center’s planetarium staff assumption about this characteristic of their visitors, which is that the majority of the audience has attended the program at least once before (J. Hutchings, A. Plemmons, D. Hooper, C. Jacobson, S. Taylor, S. Culp, and J. Purnell, personal communication, February 27, 2013).

Table 4: Responses given for returning to see *A Preschool Trip to the Moon* (n= 8)

Thematic category	Key terms	Responses
Child’s choice (N=4)	Love, wants/wanted	To bring a 4-year-old friend who loves space; Son loved it and wants us to see it; Child really wanted to come back; Kai loves it!
PSC Characteristic (N=3)	Enjoy, great	Great presenters; Timing was right; youngest child recently studied a unit on space at preschool; Wasn't actually sure of we'd been to this one, but figured he'd enjoy it either way
Parent’s choice (N=1)	Enjoy	We have children in the group who have not seen it and I enjoy the show

What is the most enjoyable thing for young children about a Planetarium?

During interviews, children were asked what they liked about the Planetarium show and what they did not like about the show. Responses were mixed. For example, Table 5 below shows the aspect that some children indicated they enjoyed was the exact same thing that another child remarked they disliked.

Table 5: Children’s Likes and Dislikes

What did you like?	What didn’t you like?
The darkness (n=2)	The darkness (n=1)
“Everything” (n=2)	“Nothing” (n=5)
Traveling between the Earth and the Moon (n=6)	Traveling between the Earth and the Moon (n=1)
The beginning of the show (n=1)	Miscellaneous (“The puzzle”) (n=1)

Ten out of 12 children indicated that they would like to come back to the planetarium in the future. Two children were shy and were not asked whether they would be interested in returning, because they declined to answer most questions asked earlier in the interview.

What is the nature of young children’s learning experiences in a Planetarium show?

Adults were asked in the questionnaire, “What do you think your child learned from the show?” Responses to this question are shown in Table 6, and indicate that the majority of adults felt their children learned something about the Moon/stars/sky.

Table 6: What do you think your child learned from the show? N= 39

Category	Key terms	Responses	N
Something about the Moon/stars/sky	Facts	There is one Moon and one Sun; About the Moon and stars; Facts about the Moon; Stars, Moon; Moon	12
Observational	Perspective, relationship, interesting	The sky is an amazing huge space; The sky/Moon is interesting; The distance relationship between Earth and Moon; Perspective. Seeing the Earth from the Moon; Relationship of Earth, Moon, and Sun; The Sun and Moon can be in the sky at the same time	8
Behavioral	Movement, participation	How to participate in an interactive presentation; Dancing; How to sit still for the entire time; Fun in exploration; On the Moon, one should jump	5
Something from the story		The story of the Jade rabbit; That it is not good to drink water fast; The Chinese tale about the Moon; The story of Suns getting shot	4
General Information		Cool new facts Terminology The astronaut was new for us Solar system	4
“Nothing”	--	--	4
Gravity		The Moon is bouncy; about gravity	2

Recollection of Program Content

A Chinese folktale that involves 10 Suns, an archer, a princess, and the Moon is told during *A Preschool Trip to the Moon*. Some presenters add a section about the “Jade Rabbit”, a character who belongs to the princess. Immediately after the story, a discussion about astronauts comprises the rest of the show. During the interview, children were asked to recall what the story was about. Four children were able to correctly recall major details of the story; 2 children indicated something about a person removing 9 Suns from the sky, one child simply said the story was about the Moon, and the fourth child replied that the story was about a rabbit. Incorrect responses included;

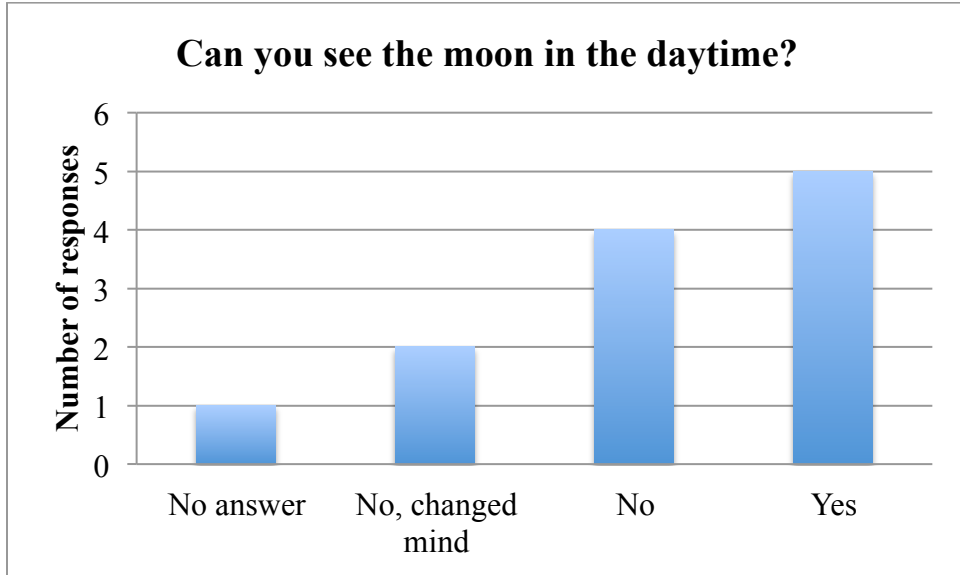
Umm, the planetarium gets dark. When you put Earth right by the Sun, then it burns up the water. Then it makes a series of noises and a water twister spins around you get all the water out. Then they put a drain plug.

Astronauts (many responses)

Earth and rockets

Two major content points of *A Preschool Trip to the Moon* are for children to recognize that the Moon can be in the sky during the day, and that astronauts are able to move differently because there is less gravity on the Moon. Of the 12 children asked about being able to see the Moon in the daytime sky, five replied yes (the correct response), four replied no, two initially said no, then immediately changed their answers to “sometimes” and “maybe”, and one child did not reply at all. A larger sample size should be used to indicate whether or not these results are indicative of children’s learning of this concept.

Fig. 4 Child responses to “Can you see the Moon in the daytime?”



When shown an image of an astronaut on an iPad and asked, “why can he float like that?” 6 children responded it was due to a difference in gravity. One child responded that the astronaut can float because “there is not as much weight in space”, and this answer was coded as being correct. The other 5 children used the word “gravity” in their responses. Incorrect responses to this question included;

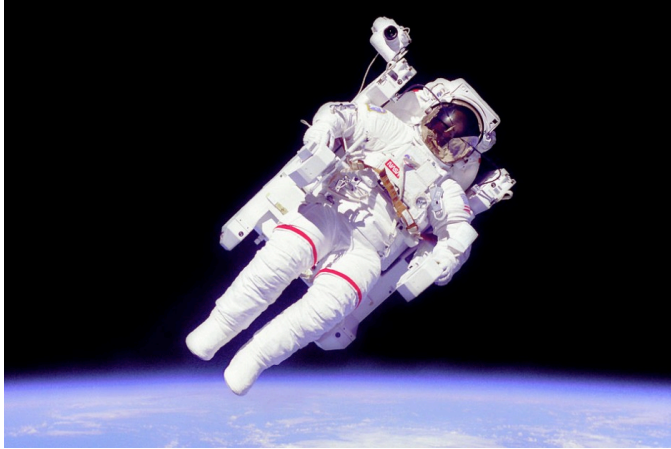
Because he has to

He’s an astronaut.

Because he has machines.

I dunno [why] he can fly like that

Fig 5: Image shown to children on iPad



Finally, to assess the children's memory of the planetarium environment, they were asked what shape the room was. Two children did not reply, two gave an incorrect response ("square", and "square...maybe a circle"), and eight children provided the correct answer, indicating that the room was round, oval, or a circle. One child was coded as giving a correct response to the question by saying, "the ceiling was kinda like the top of the Earth".

Chapter V

Conclusion

Findings suggest that most children attending the preschool planetarium program are first-time *Preschool Trip to the Moon* visitors. As such, the nature of their experience is primarily introductory; they come into the program with little expectations about the content of the show or the experiences they will have while inside. This claim is supported by the data showing the main motivation for attending the planetarium shows is because the parent is interested or because the parent wants their child to learn about astronomy; *not* because the child has a prior interest. Adults do not seem to bring their children to planetarium programs to rid them of their fear of the dark, nor because the show is happening at a convenient time, two hypotheses put forth by PSC planetarium staff. Attending for someone's educational benefit, be it the child or the adult, was the most common response.

However, for returning visitors, the data show that the main motivation is due to the child's interest. Although this is a small sample size, this result suggests that children who have prior exposure to astronomical concepts, be it from the *Preschool Trip to the Moon* show or another source, may be more likely to want to return. It is worth noting that other research suggests many young children know about astronomy concepts before attending the planetarium program (Duschl, Schweingruber & Shouse, 2007), but the findings from this study demonstrate the impact of repeat visits on interest and enjoyment. This finding paired with the corresponding adult's interest in the topic support the Dockett, Main & Kelly (2011) research that indicates the parent's interest in a subject influences their child's interest as well.

Children commonly reported that they enjoyed the sense of traveling while in the planetarium, and almost all indicated that they would like to return to another show in the future.

This shows that children enjoy their time in the planetarium, and that a positive association is being made between the environment and the child's desire to participate in future learning.

Furthermore, it provides evidence that telepresence or sensory immersion is at play and, according to the literature, children who indicate experiencing and enjoying this phenomenon are more likely to also have a learning experience during the show (Lantz, 2011).

Children were not able to consistently indicate their understanding of several content points of the show. The small sample size of interviewed children may not be indicative of the average experience 3, 4, and 5 year olds have after seeing *A Preschool Trip to the Moon*, but nearly equal proportions of correct and incorrect responses were given regarding the presence of the Moon in the daytime sky, and a reasonable explanation for why astronauts can move differently in space than on Earth. Furthermore, children were also not able to consistently recall a folktale that was told to them during the show. Being able to repeat details about a story may not be indicative of a child's ability to learn astronomy in this study, but it is a meaningful comparison to consider when assessing the successes of such programming. One possibility for this variability is that children have not had time to process the potentially new information that was provided to them in the program. Crowley and Callanan (1998) express that when presented with information that contradict their current ideas, children are most likely to either alter their philosophy or to completely reject the new information given, particularly when they have not had the chance to discuss these ideas with another person.

Group composition data shows a wide range of ages attending the show, during a time when daily attendance at the Willard Smith Planetarium was inconsistent – some planetarium shows had average attendance numbers, while others had numbers much lower than average. Because a portion of the data collection occurred during a school break period as well as normal visiting

hours, the group composition could have changed depending on if the adult bringing the child was a family member or not. The majority of child visitors to this show, however, do fall into the target range of 3-5 year olds. Because cognitive growth is highest in this range (Shonkoff & Philips, 2000), it is possible that although attendance numbers were not as abundant as normal, the audiences that do attend are gaining the most information cognitively.

Suggestions for Future Research

Because adult visitors to the planetarium show seemed interested in exposing their children to astronomy, it might be worth Pacific Science Center's effort to focus on helping adult caretakers instill their personal astronomy interest in the children they attend the program with. *A Preschool Trip to the Moon* is attended by three separate groups of children; those who come during the school year with a scheduled school group, those who come during the school year with a parent or caretaker, and those who come during the summer either with a camp or family. For this reason, future studies should be focused on the following three areas of impact. 1) The impact of teacher-student relationships on learning. Because teachers and parents have a long-term relationship with their individual students (while the planetarium presenter has a one-time, 20-minute interaction with the entire group), a stronger foundation for accurately assessing the child's academic progression can be established by the adult. 2) The impact of pre-visit classroom activities on out-of-school learning. Many preschool classrooms may teach Earth and Space Science concepts before attending a planetarium show, and this may alter the results targeted at assessing the knowledge of the children. 3) The impact of social learning. Interviewing children who participate in school shows may result in more complex responses since they are experiencing the program with a group of their peers rather than a group of strangers.

Astronomy is a dynamic, interesting, but often overlooked subject in early childhood education. Children of all ages have observational experiences in astronomy on a daily basis (Worth & Grollman, 2003), but those observations are not always discussed. Findings from this study should be used to support both formal and informal educators in creating foundational support for young learners. Earth and Space Science deserve the same level of inclusion in early childhood curriculum as the other sciences, and the sooner children are introduced to concepts like those presented in planetarium programs, the stronger their life-long interest in science will be.

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Appendix A: Adult Questionnaire

Why did you decide to come to *A Preschool Trip to the Moon* today?

Is this your first time seeing this show?

Yes No I'm not sure

If no, how many times have you been in the last 12 months? _____

If you have been to this show before, what made you decide to come again?

Are you a member at Pacific Science Center? Yes No

How many children did you bring to today's show? _____

What are the ages of the children in your group? _____

What is one thing you think the children in your group learned from this program?

Please rate your personal interest in astronomy:

1 2 3 4 5 6 7

I'm not interested

I'm very interested

What were your motivations for attending today's show? Check all that apply

- I wanted my child to learn about astronomy
- This show was happening at a convenient time
- I wanted my child to feel more comfortable in the dark
- My child is interested in astronomy
- I wanted to rest while my child does an activity
- This show is free
- I was personally interested in the program and/or astronomy
- Other: _____

Appendix B: Consent Form

Researchers' statement

I am asking you and your child to be in a research study. The purpose of this consent form is to give you the information you will need to help you decide whether to be in the study or not.

Please read the form carefully. You may ask questions about the purpose of the research, what I would ask you and your child to do, the possible risks and benefits, your rights as a volunteer, and anything else about the research or this form that is not clear. When I have answered all your questions, you can decide if you want to be in the study or not. This process is called “informed consent.” I will give you a copy of this form for your records.

PURPOSE OF THE STUDY

My research will explore early childhood learning in children ages 3-5 who attend interactive planetarium presentations. While much work has been done on astronomy learning in planetariums grades 3 and up, little research exists that evaluates the pre-k to grade 2 age group. Pacific Science Center has never evaluated their “Preschool Trip to the Moon” program, but recognizes it is a successful program based on attendance numbers and self-identified repeat visitors.

STUDY PROCEDURES

After your visit to the *Preschool Trip to the Moon* planetarium program, I ask that you take a moment to fill out a short survey. If you decide to participate in a follow-up interview, I will sit with you and your child and ask a series of questions pertaining to the planetarium show. You will be given a copy of these questions immediately before the interview. I am interested in how your child responds without any prompting, so please do not share the questions with your child before the interview starts, and please allow your child to answer the questions without help.

This interview is expected to take approximately 3 minutes.

Your child may refuse to answer any questions and may leave the interview before all questions have been asked. The most sensitive question asked on the interview is in reference to your child's age.

This interview will be audio recorded digitally, and all files will be stored in a locked file on the researcher's computer. All audio files will be destroyed after June 14th 2013.

RISKS, STRESS, OR DISCOMFORT

Digital audio recordings of subjects may be shared with the researcher's thesis advisory committee, and written transcripts may be excerpted in the final research paper. Children may feel uncomfortable speaking with a stranger or being audio recorded.

BENEFITS OF THE STUDY

This research will contribute to astronomical societies, science museums, and planetariums that want to cater to their youngest visitors but haven't ventured into program presentations or evaluation of their own programs. There might not be a direct benefit to you and your child for participating in this research.

CONFIDENTIALITY OF RESEARCH INFORMATION

All data collected in this interview will be confidential, and will be stored in a locked file on the researcher's computer. All audio recordings will be destroyed on June 14th, 2013.

All of the information you and your child provide will be confidential.

Government or university staff sometimes review studies such as this one to make sure they are being done safely and legally. If a review of this study takes place, your records may be

examined. The reviewers will protect your privacy. The study records will not be used to put you at legal risk of harm.

OTHER INFORMATION

You may refuse to participate and you are free to withdraw from this study at any time without penalty or loss of benefits to which you are otherwise entitled.

Kaylan B. Petrie

Printed name of study staff obtaining consent	Signature	Date
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Subject's statement

This study has been explained to me. I volunteer to take part in this research. I have had a chance to ask questions. If I have questions later about the research, I can ask one of the researchers listed above. If I have questions about my rights as a research subject, I can call the Human Subjects Division at (206) 543-0098. I will receive a copy of this consent form.

Printed name of parent/Guardian	Signature of parent/Guardian	Date
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Copies to: Researcher

 Subject

Appendix C: Child Interview Guide

Hello, my name is Kaylan. Can I ask you some questions?

- How old are you?
- I have a picture of an astronaut. Will you tell me something about it?
 - Why is he wearing special clothes?
 - **Why can he float like that? *****
 - Did you learn that today?
- I heard that you went to the planetarium. What did you like most about the planetarium?
 - Did you hear a story?
 - What was the story about?
- What didn't you like about the planetarium?
 - Why didn't you like that?
- What did it look like in the planetarium?
 - What shape was the room?
 - Did you see pictures on the ceiling?
 - **What did you see in the sky? *****
 - You saw the Sun and the Moon?
 - **Can you see the Moon in the daytime? *****
- Could you tell me one new thing you learned from the show today?
- Would you like to come back to the planetarium some day?
 - I'm glad you had fun! Thanks for helping me! Here is a prize (the child will be given a sticker, pencil, or other non-food item incentive)

Appendix D: Employee Focus Group Guide

Researcher: Thank you for participating in this research study. The purpose of this focus group is to contextualize my research in the larger field of early childhood learning in informal astronomy settings. Knowing the opinions and beliefs of other professionals such as you will add a level of credibility to the data I collect in a different aspect of my research. Information gathered from this focus group will help me generalize my findings to the research community.

You were selected to be part of this focus group because of your involvement in the creation and/or implementation of informal astronomy programs here at [name of institution]. Your experience at [name of institution] will help my research be more applicable to other institutions interested in creating their own astronomy programs for young children.

I will be recording your responses digitally and taking notes. All data will be stored in a locked file on my computer and will be destroyed no later than June 14, 2013. Your responses will not be linked with your name or position at [name of institution], but direct quotes may be used in my final research study. Any questions so far?

I will be asking you 5 questions regarding your job here at [name of institution]. Please feel free to ask me to repeat the question or to explain anything that you don't understand. I may ask you to expand on your idea or statement, or to clarify a point that you've made. You may decline my request for clarification by saying "pass" or another verbal indication that you are finished speaking on that point.

This focus group is expected to last one hour. I will be keeping time during the discussion.

Q1) I would like to begin by asking you to each state your name, job title, how long you've been at this institution, and your educational background.

Q2) Please describe what, in your opinion, [name of institution]'s most effective astronomy program is (for any age group) and what makes this program effective.

Q2a) When creating such effective programs for young children in astronomy, is it more important to focus on engagement, interest, knowledge, skills, or behavior? Please rationalize your response.

Q3) Why do you *personally* believe it is important for young children to be knowledgeable in astronomy? What makes you say that?

Q3a) From a *research standpoint*, how does knowing more about a young child's experience with astronomy contribute to the larger field of informal science education?

Q4) Very little research currently exists on 3, 4, and 5 year olds and their engagement with astronomy. As you're aware, an increasing amount of attention is now being placed on this age group in this subject. Why do you think researchers have waited until now to explore astronomy learning in this age group?

Q4a) In your experience, what factors have contributed to [name of institution]'s decision to focus on this age group now?

Q5) What impact, if any, do you *personally* believe planetariums have on early childhood learning? What makes you say that?

Q5a) What methods should be used to ensure that astronomy learning does occur during planetarium presentations?

This concludes the discussion section of this focus group. Does anyone have any final remarks they would like to make? If not, thank you all for your time and contributions to this discussion. Please take a copy of the consent form with you – you will find my contact information on that sheet should you want to get in touch. Thank you!

Appendix E: Coding Scheme for Child Interviews

After transcription, quantitative interview responses were coded using this document:

Question	No Answer	Correct Answer	Incorrect Answer	Unrelated Answer
Astronaut picture – why is he wearing special clothes?		<i>Examples: there is no air in space, it's cold in space, for protection</i>		
Astronaut picture – why can he float like that?		<i>Examples: there is less/no gravity in space</i>		
Astronaut picture – did you learn that today?		<i>'Yes' will be coded as correct</i>	<i>'No' will be coded as incorrect</i>	<i>Note: there is not a right or wrong answer here</i>
What was the story about?		<i>Examples: the Moon, China, many Suns</i>		
What shape was the room?		<i>Examples: round, circle, bubble, dome, oval</i>		
Can you see the Moon in the daytime?		<i>Examples: yes, sometimes, not always, they can share the sky</i>		