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Informal Science Educators' Pedagogical Choices and Goals for Learners: The Case of Planetarium Professionals

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Abstract

This study extends our understanding of the goals, beliefs, and pedagogical choices made by planetarium professionals. Interviews were conducted with planetarium professionals (N = 36) to assess their goals for audiences and beliefs about the design of the learning environment. Classification of participants, according to a six-facet framework on effective learning environment design, suggests a range of perspectives on the design of the learning environment that primarily include learner-centered, motivationally-oriented, socioculturally-centered, and physically-oriented perspectives. Results also point to the importance of considering increased opportunities for professionalism in the field of planetarium education.

1. INTRODUCTION

Science learning in informal (see Note-1) environments has been the subject of research for decades. Much of this literature focuses on how people learn, including the design of learning environments, such as museums and science centers (e.g., Allen 2004; Falk and Dierking 1992; Falk, Donovan, and Woods 2001; Hein 1998; National Research Council [NRC] 2009; Rennie and McClafferty 1996). Short interventions, such as in the planetarium (e.g., Plummer 2009) or museum visits (e.g., Falk and Storksdieck 2005), have been found to improve understanding of science concepts. Connecting school field trips with classroom instruction can promote increased learning opportunities beyond disconnected museum visits (e.g., Bitgood 1991; Davidson, Passmore, and Anderson 2010; DeWitt and Storksdieck 2008; Tal and Morag 2007).

And yet, limited research has focused on the informal science education (ISE) professionals themselves (Falk and Dierking 2002; Bailey 2006; Bevan and Xanthoudaki 2008). Using a learning science framework on frontline ISE practitioners may help us understand their role as agents in the learning environment. A research-based perspective on ISE professionals will allow the field to provide appropriate professional development and promote a strategic design of products to support the creation of these learning environments (Bevan and Xanthoudiki 2008; Tran and King 2007). This paper explores ISE practitioners' goals and beliefs about the learning environment by focusing on one particular sub-set of informal science educators: planetarium professionals.

Recent changes to the planetarium field suggest that now is a critical time to understand planetarium professionals' beliefs and attitudes towards their practice. The planetarium field is in a state of evolution with fulldome technology replacing traditional optical-mechanical projection systems. As of 2011, there are 492 fixed (not portable) fulldome theaters in the United States with a majority being mid-size domes and theaters (Petersen 2012). In recent years, the number of fulldome theaters worldwide has increased dramatically; the number of fulldome projector systems increased to 1064 worldwide (see Note-2), an

increase of more than 300 compared to the previous year (Petersen 2012). The majority of planetariums in the United States are associated with an educational or cultural institution, such as a university or college (35%), school district (28%), or museum/science center (27%) (Petersen 2012). At the same time, commercially available programs that are being produced for fulldome theaters often have a passive, movie-like quality rather that engaging in the type of live-interaction that planetarium professionals value in education (see Note-3) (Small and Plummer 2010). By examining planetarium professionals, as a unique group of educators with specific pedagogical philosophies and goals for their learning environment, we may better understand how to improve the planetarium's role in astronomy and space science education. This may also help address gaps in the research literature on how ISE professionals develop and deliver educational programming (Tran 2008).

However, we raise an issue in our exploration of planetarium professionals as a case of *informal* science educators. Members of the planetarium community are drawn from across both the informal and formal education world (Small and Plummer 2010; Petersen 2012). Both school-based and museum-based planetarium professions, as with other ISE professionals, are likely to be responsive to the needs of classroom teachers bringing students on fieldtrips (e.g., Bailey 2006). Thus, it may be important to consider the lines between formal and informal science education blurred in our analysis of this professional community.

2. INFORMAL SCIENCE EDUCATORS: GOALS AND PROFESSIONAL PRACTICE

While the literature exploring the beliefs and practices of ISE practitioners is limited, recent studies have begun to explore both their beliefs and observed actions. Museum educators often draw on the pedagogical practices of classroom teachers, at least partly because they are often hired from people who are certified as teachers (Tal and Morag 2007; Tran 2007). Observations suggest they often use didactic, educator-directed instruction (Tran and King 2007). This may be because, "in lieu of any other model of practice, educators may be transferring the organization and management practices of the school system straight into the museum environment" (Tran and King 2007, p. 134). Learning to teach in a way that differs from your own experience as a learner is challenging (e.g., Hammerness *et al*. 2005; Lortie 1975), which may explain why a traditional, transition model of teaching has been observed in ISE professionals (Bevan and Xanthoudaki 2008; Tal and Morag 2007). These similarities between classroom teachers' practices and informal science educators' practices may suggest that we will observe less diversity among the formal and informal planetarium educator communities. However, ISE professionals also display characteristics of reform-based teaching, such as adapting instruction to visitors' prior knowledge by making changes to planned activities (Tran 2007). ISE professionals often indentify with having a curiosity about the world, an interest in learning, and a desire to share their own passion about science with their audience (Bailey 2006; Tran and King 2007).

Informal educators' beliefs and attitudes towards designing learning environments may also reflect their goals for the learners. Tran (2007) investigated ISE professionals' goals through observations and interviews at two museums. Similar goals were found across professionals, including: increasing interest in returning to the museum, increasing motivation to pursue further science learning, helping them learn some content (though this was less important), creating a positive experience, and connecting to school curriculum/standards. Affective goals were the most prominent. Croft (2008) found similar goals among seven planetarium professionals, selected to represent leaders in the planetarium field: "[The] primary goal of planetarium shows, according to the participants in this study, is not to convey specific astronomical concepts. Instead shows are considered a success if they inspire audience members with a desire to find out more, and imbue them with a greater reverence for the cosmos and the scientific process in general" (p. 16). These studies suggest that ISE professionals' goals for their audiences reflect two of the recommended goals suggested by *Learning Science in Informal Environments* (NRC 2009): developing interest in science and understanding science knowledge. It is unclear whether ISE professionals' goals and beliefs reflect the remaining goals: engaging audiences in scientific reasoning, supporting their understanding of science as a way of knowing, appreciating how scientists communicate in the context of their work, and promoting audience interest in identifying as scientists. However, Bevan and Xanthoudaki (2008) report that science museums are shifting from developing visitors' *understanding of* science towards a focus on supporting visitors' *engagement with* science, which moves towards helping audiences identify with the scientific enterprise.

Enacting one's goals as an educator requires a certain level of control over one's work as well as a sense that these goals will be valued in the community in which they are enacted. This highlights the importance of understanding how ISE practitioners view themselves as *professionals* and what elements of professionalism exist in the planetarium community. ISE professionals are often specialized and object-oriented, in that they are concerned with "using authentic objects to represent both a body of knowledge and the cultural artefacts or specimens (both living and non-living) that are valued by society)" (Tran 2008, p. 143). ISE professionals share a technical language around their practice that enables them to effectively converse about their work and develop a shared identity. As part of this, museum educators often prefer terms such as "presenting," "facilitating," or "delivering," over a more formal use of the word "teaching" (Tran 2008). Tran (2008) suggests that the prevalence of the use of the term "deliver" over "teach" may reflect their beliefs in a knowledge-transfer model over a constructivist model of learning. ISE practitioners often develop pedagogical skills through practice because they came to their jobs without specific education training (Bailey 2006).

> For many, developing this knowledge has been a gradual process of fine-tuning their teaching skills. They attributed gaining their expertise to accumulating a backlog of experience in which they've gathered practical know-how and an intuitive ability to effectively engage learners. (Bailey 2006, p. 186)

This constructivist attitude in how ISE professionals described their beliefs about how audiences learn is at odds with the more didactic language use found in Tran's study, which may suggest diversity among ISE practitioners or a mismatch between professional language and beliefs about how audiences learn. Tran's investigation of ISE professionals' work and how it is organized led us to wonder about planetarium professionals' opportunities for engagement in a professional community and how these opportunities may have shaped their goals and beliefs.

Limited research has been conducted on the specific characteristics, needs, and interests of planetarium professionals. In addition to Croft's (2008) study, we previously described planetarium professionals' use of live interaction as a contrast to the recent movement towards "fulldome movies" in planetariums (Small and Plummer 2010). We found that planetarium professionals believe that both improving content knowledge and attitude towards science are important aspects of their work. All planetarium professionals in the study held strong beliefs about the importance of using of live interaction for meeting their educational and attitudinal goals. At the same time, the nature of that live interaction differed greatly between individuals. These findings, and the limited literature on informal educators, led us to wonder how planetarium professionals' goals, beliefs, and pedagogical choices reflect modern learning theories, across both formal and informal learning environments.

3. THEORETICAL FRAMEWORK: IMPLICATIONS OF LEARNING THEORY FOR INTERPRETING THE INFORMAL EDUCATORS' BELIEFS ABOUT INSTRUCTIONAL DESIGN

The seminal publications *How People Learn* (NRC 2000) and *How Students Learn* (NRC 2004) synthesized decades of cognitive and developmental science research to uncover the foundational principles of learning. These findings "can be used as lenses to evaluate the effectiveness of teaching and learning environments. These lenses are not themselves research findings; rather, they are implications drawn from the research base" (NRC 2004, p. 12). We have adopted this perspective to describe potential lenses on instructional design and the learning environment as a theoretical framework for interpreting the pedagogical beliefs and choices made by planetarium professionals. Here, learning is broadly defined to include gains in content knowledge, science inquiry skills, as well as in interest or motivation. We identified additional elements for evaluating learning environment design from three additional research syntheses that focus on informal learning environments: the *Contextual Model of Learning* (Falk and Dierking 2000), the *Ecological Model of Learning* (NRC 2009), and the *Constructivist Museum* (Hein 1998). We drew upon literature relating to learning both in the classroom and the museum to interpret our sample because planetariums and planetarium professionals often serve both formal and informal audiences.

We have organized perspectives on learning and instructional design from each of these publications into the following six lenses as a theoretical framework to guide our analysis in this study. In our analysis, we looked for ways in which practitioners' interview responses reflected each of these lenses as well as the ways in which their

responses may have reflected limited attention to facets of each lens. With this analysis, we hope to begin to unpack how planetarium professionals view their role in the learning environment and how their facilitation of audiences' participation helps them reach their goals.

3.1 Lens #1—Learner-Centered

The learner-centered lens is centered on what the learner brings to the learning environment, including knowledge, culture, and interest, and that these are likely to differ between learners (NRC 2000, 2004, 2009). Educators in a learner-centered environment "are aware that learners construct their own meanings, beginning with the beliefs, understandings, and cultural practices they bring" to the educational setting and design their instruction with this in mind (NRC 2000, p. 136). This includes making connections between everyday talk and scientific discourse, finding ways to make bridges between prior experiences and the scientific goals (NRC 2000, 2004). Falk and Dierking suggest that, in order to maximize the learning environment, educators should "provide opportunities for people to construct connections between museum experiences and their lives, both before and after" the experience (2000, p. 188). ISE practitioners can facilitate learners' entrance into the learning environment as they provide opportunities to relate new ideas and observations to prior experiences (Falk and Dierking 2000).

A learner-centered, or constructivist, educator is one that refers to learners' naïve or personal conceptions, rather than misconceptions, because the conclusions a learner reaches must make sense within the learner's "constructed reality" rather than an authority's standard of truth (Hein 1998). A constructivist-oriented museum environment uses exhibitions and experiences that present multiple points of view, "enable visitors to connect with objects (and ideas) through a range of activities and experiences that utilize their life experiences," provide opportunities for experimentation, analysis, and constructing personal conclusions (Hein 1998, p. 35). Constructivist pedagogy considers whether the learning environment will provide possible connections with the learner, allowing them to engage with a familiar object, idea, or activity (Hein 1998). Visitors are guided to consider their own prior knowledge, to express their personal ideas, and then to challenge those ideas through a "stimulating cognitive dissonance" that may lead towards the scientific perspective (NRC 2009, p. 35).

3.2 Lens #2—Knowledge-Centered

The knowledge-centered educator recognizes the importance of helping learners develop well-organized understanding of concepts in ways that will facilitate increased depth of understanding and future knowledge transfer (NRC 2000, 2004). Knowledge-centered educators consider how prior knowledge will impact learning new concepts (an overlap with the constructivist perspective of the learner-centered environment) but also recognize which aspects of the discipline will be important for developing rich understanding of science. Educators working towards improving content knowledge focus on depth into big ideas over coverage of disconnected facts (NRC 2000, 2004). They focus on helping their students make sense of the world by considering incremental ways of moving them towards increased levels of sophistication. In doing so, they intentionally organize instruction in ways that will support students in building knowledge over time (NRC 2004).

3.3 Lens #3—Assessment-Centered

Findings from research on learning suggest that providing feedback increases opportunities for learners to meet educators' goals (NRC 2000). *How People Learn* suggests "opportunities for feedback should occur continuously, but not intrusively, as part of instruction. Effective teachers continually attempt to learn about their students' thinking and understanding" (NRC, 2000, p. 140). Assessments should allow learners the opportunity to revise their thinking and for teachers to revise their practice (NRC, 2000). Assessment in informal environments can focus on aspects of knowledge, skills, attitudes, and behaviors (NRC 2009).

3.4 Lens #4—Motivationally-Oriented

A successful learning environment will allow learners to feel supported, be free from anxiety, and have a level of personal choice in the engagement (Falk and Dierking 2000). Challenges presented should also be appropriate to

the skill level of the learner (Falk and Dierking 2000). Those personal connections discussed as part of the learner-oriented lens are also important to consider here; learners who form personal connections to experiences are motivated to engage in an emotionally rewarding learning experience (Falk and Dierking 2000). "[Capitalizing] on emotion is an important key to successful educational programming… education and entertainment are not opposite ends of a continuum, they are separate and complementary, and in the museum context they combine to become the museum experience" (Falk and Dierking 2000, p. 185). Given that learning is an emotion-laden experience, educators can build on this knowledge by providing the opportunity for human interactions (Falk and Dierking 2000, p. 188). Educators with a motivationally oriented lens consider ways that the learning environment can accommodate the learner's interests. An individual's interests shape the choices made in learning environments: what to attend to, the level of engagement, and the magnitude of recollection. Interest is shaped by prior knowledge; in studies of museum recollections, visitors often bring up ways that museum visits built on what they already knew (Falk and Dierking 2000). Further, interest is more than just what a person likes; rather, it describes "attention, persistence in a task, and continued curiosity" (Falk and Dierking 2000, p. 22). Museums that consider motivational factors encourage audiences to explore and find ways to make the experience their own (Falk and Dierking 2000).

3.5 Lens #5—Socioculturally-Centered

The sociocultural perspective goes beyond the learner-centered, cognitive approach to explain learning through a focus on the cultural experiences that influence learning and the ways that an individual acquires cultural practices (NRC, 2009). It reflects learning that occurs through visitors' conversations, interactions between educators and visitors, and the cultural perspectives that shape a visitor's experience and learning (Davidson, Passmore, and Anderson 2010; DeWitt and Hohenstein 2010; Bamberger and Tal 2008a, 2008b; Tal and Morag 2007). Past presentations of constructivist views focus more on the individual, while the sociocultural perspective orients the educator to focus on modes of participation for learners that are comfortable and culturally appropriate (Callanan and Valle 2008; NRC 2000, 2009). Falk and Dierking explain:

> "It is fair to surmise that the sociocultural facilitation of learning is a typical component of most museum learning. In the real world, unlike in the classroom or laboratory, if you do not know the answer to something you want to know about, you ask for help, read about it, or in some way seek out ways to maximize your zone of proximal development. Free-choice learning in general and museum learning in particular are commonly marked by some sort of socially facilitated learning. (2000, p. 46)

Facilitators can also help inter-group dialog go beyond the museum visit by bringing topics of conversation with them to their home or school environments (Falk and Dierking 2000). This requires that museum staff become "facilitators of experiences rather than disseminators of information" (Falk and Dierking 2000, p. 194). Learning is also facilitated by the educator's use of modeling behaviors and intentions to communicate actions and ideas (Falk and Dierking 2000).

3.6 Lens #6—Physical-Centered

Learning is intimately tied to the situation in which the concepts were learned resulting in the relative difficulty in transferring understanding to new contexts (Brown, Collins, and Duguid 1989). Making sense of our environment is fundamental to the human condition. Our memories are linked conceptually and emotionally to our past experiences. Falk and Dierking (2000) sum up the importance of the physical context to memory: "When people are asked to recall their museum experiences, whether a day or two later or after 20 or 30 years, the most frequently recalled and persistent aspects relate to the physical context" (p. 53). The physical-centered educator builds on the contextual research findings by helping learners engage across multiple modalities of learning in an "all-encompassing" experience (Falk and Dierking 2000). Such an experience hones the learners' focus to the engagement at hand. Learning environments that consider the importance of the physical also recognize the use of artifacts in mediating learning (NRC 2009). These artifacts can include visual representations, the use of tools, material objects associated with scientific phenomena, and various forms of media (television, video games, print, etc.).

4. RESEARCH QUESTIONS

This study extends our previous research on planetarium professionals (Small and Plummer 2010). In that study, we analyzed interviews with planetarium educators to answer questions about how their beliefs compared to trends in the planetarium industry; in this study, we analyze additional aspects of those interviews to further our understanding of planetarium professionals' beliefs about learning environments. We were guided by the following research questions:

1. How do planetarium professionals' goals compare to goals set by policy documents for science education, models of learning, and other ISE professionals?
2. What professional opportunities do planetarians draw on that may influence their beliefs about the design of learning environments?
3. How can we characterize planetarium professionals' beliefs about the design of learning environments using a theoretical framework of theories of learning?

Findings may be useful for those interested in providing professional development for ISE practitioners and for researchers interested in understanding how informal experiences shape what students learn about astronomy.

5. METHODOLOGY

5.1 Participants

Participants were invited into the study at two annual meetings of regional planetarium associations. Thirty-six planetarium professionals (11 female, 25 male) volunteered to be interviewed (onsite or by phone). Participants included planetarium directors, operators, and vendors who had previously worked in planetariums. Interviews, conducted by the first author, were audio recorded for later analysis. The open-ended interview protocol can be found in the Appendix of our previous paper (Small and Plummer 2010). This interview protocol asked participants general questions about their goals for audiences and beliefs about engaging audiences with live interaction. We also asked participants to specifically comment on their beliefs about learning and show design for elementary-age children, a goal of our previous study.

Most of participants (56%) have been in the planetarium field more than 15 years (average time in field was 20.4 years, SD = 12.4 years). Participants worked in universities (28%), school districts (19%), museums and science centers (19%), planetarium companies (11%), and other types of jobs, such as consultants (17%). Participants included: planetarium directors/supervisors (42%), current and former planetarium operators (includes self-employed) (22%), vendors, consultants, and other management positions (28%), planetarium technicians (6%), and an education specialist (3%). Participants included both professionals working with full-dome digital and optical-mechanical projectors. Slightly over half of the asked participants (53%; N = 30) reported that they currently work with fulldome technology (six participants were not currently working in a planetarium dome).

5.2 Analysis

We developed a series of categories based on the interview question topics and our research questions (Small and Plummer 2010). Initially, codes were developed, representing concepts we expected to see in the interview data, based on the literature, and our own experiences in the planetarium field. Next, both authors analyzed a subset of interviews to generate additional codes grounded in ideas held by the participants (Marshall and Rossman 1999). The remaining interviews were split between the authors to be coded; the authors periodically met to compare coding and determine whether new codes should be added or existing codes should be improved. Each author then reviewed previously coded interviews to match any changes produced in discussions. Once a relatively stable set of categories and codes was reached, both authors coded eight interviews to establish the inter-rater reliability. An agreement of 96% was reached in this comparison. A sub-set of these initial codes was analyzed for our previous paper (Small and Plummer 2010); additional analysis of the full data set was performed for this manuscript. We analyzed these codes to answer Research Questions 1 (comparison of goals to external policy documents) and Research Question 2 (professional development opportunities shaping the experiences of planetarium professionals).

Answering Research Question 3 required using the six lenses as broad analytical categories. First, the initial codes were aligned with the six analytical lenses; a first pass through the initial codes by the first author was used to start sorting participants' responses into the six lenses. A few responses appeared to be "alternative ideas" or oppositional to the ways in which research syntheses describe supportive learning environments. Second, each of the original interviews was re-examined, looking for additional evidence of ways that the subject may reflect one or more lens. Finally, themes were identified within and across lenses allowing us to further represent the ways in which planetarium professionals view the design of learning environments.

6. FINDINGS

6.1 Planetarium Professionals' Goals

The planetarium professionals' goals are listed in Table 1. The second column lists the percentage of professionals who hold that goal for all audiences; the third column lists the percentage of professionals who hold that goal for elementary-aged children; and the last column lists the percentage of professionals who mentioned that goal for *either* general audiences or children (it was not counted double if they mentioned the goal for both general audiences and children).

In this paper, we go beyond the analysis presented in our previous paper (Small and Plummer 2010) to compared planetarium professionals' goals for audiences to policy documents. *Learning Science in Informal Environments,* suggests six goals, three of which are well reflected in the planetarium professional data (though these are spread across the participants): Developing Interest in Science, Understanding Science Knowledge, and Engaging in Scientific Reasoning. Similar to science museum professionals (Tran 2007; Tran and King 2007) and another study of planetarium professionals (Croft 2008), these planetarium professionals felt that inspiring interest or engagement to be one of the two most important goals for the planetarium.

However, unlike the ISE professionals in Tran's study, developing content knowledge was equally important across the sample, for children and for general audiences. Why are planetarium professionals disproportionately interested in increasing content knowledge? One reason may be demographics: nine participants (25%) came from K-12 school-based planetariums and six (17%) were from university planetariums. Many of the museum-based planetariums are also likely to serve school-based audiences. This is reflected in the large percentage of respondents who mentioned the importance of district, state, or national standards in their goals for children (39%). Most participants (53%) mentioned having formal education coursework (including taking a few education courses, undergraduate and/or master's degrees in education, and state teaching certifications). This may not explain all of the variation; many ISE professionals outside of the planetarium are also drawn from those trained as classroom teachers, and yet studies of their goals have not found this focus on content (Tran 2007). However, our study did not specifically ask participants to rank their goals and many suggested more than one goal in their interview. Observations of ISE practitioners may potentially reveal a stronger

Table 1. Planetarium professionals' goals for audiences

General goals	General n = 28	Children n = 30	Combined[a] n = 30
Interest/engage	19 (68%)	18 (60%)	23 (77%)
Education about content[b]	20 (71%)	17 (57%)	22 (73%)
Provide an educational experience	8 (29%)	5 (17%)	8 (27%)
Not just facts	6 (21%)	4 (13%)	8 (27%)
Entertainment	6 (21%)	0 (0%)	6 (20%)
Education about scientific reasoning	5 (18%)	6 (20%)	8 (27%)
Knowledge of the sky	4 (14%)	7 (23%)	10 (33%)
Teach State or National standards	2 (7%)	13(43%)	12 (40%)

Note: Individual participants may have been coded in more than one possible goal. A portion of this table appeared originally in Small and Plummer (2010).

[a]Combined looks at how many people listed this type of goal when asked about *either* goals in general or goals specific to elementary-aged children.

[b]This includes participants who discussed helping improve visitors' alternative conceptions and build on prior knowledge of visitors.

emphasis on increasing content knowledge. Tal and Morag (2007) found that the guides in four natural history museums "were very concerned with covering a great deal of content" (p. 763). This was reflected in the ISE practitioners used of lecture delivery and use of a significant amount of new science vocabulary. Further research that compares ISE practitioners' goals to observations of their engagement with audiences may help clarify these differences.

As with Croft's (2008) study of seven leaders in the planetarium field, entertainment was not frequently mentioned for general audiences and was never mentioned as a goal for children. Participants in Tran's study of ISE professionals did not include entertainment as a potential goal or element of their work with audiences. On the other hand, Davidson, Passmore, and Anderson report that the zoo educators in their study "believed that many students (and teachers) would still take more of an entertainment view of their experience, and that learning would be in the background" (2010, p. 132). This suggests that though entertainment may not be a major goal of ISE professionals, they may anticipate that this is a goal of their audiences—to be "entertained"—and use this in their planning.

6.2 Planetarians as Professionals: Opportunities and Influences

We examined factors relating to planetarium professionals engagement in a professional community, including opportunities for professional development and influences on their pedagogical approach. Most participants (83%) (see Note-4) engage in professional development opportunities beyond the conference where they were interviewed. Many professionals attend the conferences for other planetarium societies and a few attend astronomy-oriented conferences. University courses were also mentioned, such as the Ball State planetarium program and the cosmology short course at University of Chicago. Several workshops were described, though few were specifically designed for planetarium professionals; rather they were designed for classroom and/or informal astronomy educators. A few participants mentioned that they had acted as the facilitator of professional development opportunities.

When asked to describe what has *influenced how they interact with audiences* in the planetarium, many described experiences they have *on the job* (42%) and *working with audiences* (38%). Some describe drawing on the existing norms of their current facilities or past experience working with interactive exhibits as a museum educator. Others described how their interactions are influenced through "trial and error" or experimentation with audiences. They pay attention to how the audience reacts to their facilitation. Many (38%) were also categorized as drawing upon personal interest or educational philosophy as an influence, such as interest in engaging their audiences in active (versus passive) experiences. Other influences included reading journals, asking for feedback from teachers after a program, and mentors in college.

The most frequently mentioned methods of finding *new ways of interacting with audiences* included engaging with other planetarium professionals (54%) and attending conferences (42%) (see Note-5). This includes frequent mentions of observing other planetarium professionals facilitating programs and talking to colleagues. A few (17%) also obtain information from journals. The following were also mentioned as potential sources of new ways of interacting with audiences, though not more than once or twice: internet resources, list-servs, live theatre, TV, and live science shows.

Examining these opportunities and influences lead us to suggest that, while many planetarium professionals mention a variety of professional development opportunities, they do not view these as the primarily experiences that influenced their beliefs about how they design their learning environments and engage their audiences. It is their personal experiences on the job and working with the audience that they believe has made the most difference. Bailey (2006) also found that ISE professionals attribute on-the-job experience as a major source of their knowledge of how to effectively engage audiences. The importance of interacting with peers as an influence on practice reflects similar opportunities professional learning observed in classroom teachers; practicing teachers continue to learn, beyond their teacher education programs, through interactions with other teachers in and out their own schools (NRC 2000).

Tran and King (2007) suggest that professional preparation for ISE professionals should be built on a theoretically grounded body of knowledge and skills; they further draw attention to the disparity of training opportunities provided for new professionals across ISE venues. We found that the planetarium professionals in this study come from a wide range of backgrounds including classroom teacher training, science training, and other forms of formal education. On the one hand, these professionals share common elements professional

practice such as their attendance in annual meetings with other planetarium professionals, a shared language about their work in planetariums, and similar goals for their audiences. However, their responses about how they grow in their profession suggest that they do not see external organizations, such as conferences or publications, as the major source for learning and improvement in their professional practice. Tran and King (2007) describe a growing movement towards professionalism in the museum education community, including training programs and certifications. We wonder whether planetarium professions are traveling within the same circles as other ISE practitioners; movement within that community towards formalization of skills and professional knowledge may not be translating into the planetarium community, or may only be resonating with planetarium professionals situated in museums and science centers.

6.3 Characterizing Planetarium Professional's Beliefs about Learning Environments

We looked for evidence of whether or not their beliefs reflected the six lenses across the breadth of the interview; many of these questions asked participants to specifically consider elementary-aged audiences in their answers, though other questions were open to responses about audiences in general. First, we will discuss the ways in which these lenses appeared in the participants' goals and beliefs. Few participants provided evidence that that reflected all six lenses but most reflected at least two of these views on learning. Second, we will further illustrate our findings using case studies; four subjects were purposefully selected to represent the range of facility demographics and educational backgrounds of the overall sample. Case-based research is important for developing concrete, context-dependent knowledge that researchers can use to develop "a more nuanced view of reality" (Flyvbjerg 2006, p. 223).

6.3.1 The Six Lenses on Learning

6.3.1.1 Learner-Centered Lens Planetarium professionals expressed ideas that fit within three general categories of the learner-centered lens: *building on prior knowledge*, *enabling visitors to connect through a range of experiences*, and *providing tools for future learning*. The methods for visitors to *build on prior knowledge* were somewhat limited. A few suggested a constructivist perspective of learning: "That is how students learn best. [If they are] sitting back watching they fall asleep. They build their own knowledge" (Paula, Planetarium Director). Others described ways that they asked their audiences to "point out things before I show them" (Lou, Planetarium Director). Far more participants described ways in which they attempted to *connect their audiences to the learning experience*. Audience interaction often included more than just verbal response, such as asking and answering questions, through the use of props and kinesthetic engagement. Their interactive approach is a central element of the learner-centered environment. A few participants expressed a third perspective on the learner-centered lens through their desire for audiences to *gain tools for future learning* beyond the planetarium. Paula (Planetarium Director) expressed this view by describing the importance of teaching observational techniques because science is based on observations.

6.3.1.2 Knowledge-Centered Lens Improving the audience's understanding of science content was the most frequently mentioned goal, along with increasing interest and motivation, for planetarium professionals. Many participants described either specific concepts they wish their audiences to learn from their programming ("for them to understand that they live on a planet and when they look up in the sky, those stars, way more of them than they can see with naked-eye" Linda, Education Specialist) or to help teachers meet state standards. Some of these comments related to professionals' beliefs about their purpose in the planetarium: to communicate about science. "It's our responsibility to get this information out there to the public, the whole thing with dark matter, dark energy. To convey that science is a dynamic process, not something just figured out 100 years ago, adding to body of knowledge. [For example, the] Kepler mission, even if it finds nothing… even that result, that means something! [It's] not just a collection of facts" (Vince, Planetarium Director).

However, one of the key elements of the knowledge-centered perspective is recognizing the importance of helping learners develop well-organized knowledge of the target discipline in ways that will facilitate increased depth of understanding and future knowledge transfer (NRC, 2000). Thus a knowledge-centered approach goes beyond specific content they wish audiences to learn or helping teachers meet state standards. A few participants were moving towards this knowledge-centered perspective by suggesting ways that one should develop content from an organized perspective or as a foundation for future learning. Paula (Planetarium Director) suggests: "Take them one step further than they came in with for their understanding of the universe around them." Brenda (Planetarium Director) described a more organizational approach regarding the age level of the children coming

in, while also drawing on the importance of working with the state standards. “Depends on the age group. Young age group, we want to give them experience… something to build on. We have a different show for each grade that comes in. We look at the school’s curriculum and essential content they are looking for and we try to support that. We look at pedagogy for what research says children can do at certain ages. At the kindergarten level, we want them to make observations and be exposed to new environments and new ideas; at the upper elementary level, we get into real astronomy content.” A few participants mentioned the importance of focusing on only a few concepts, rather than many, during their planetarium programs.

6.3.1.3 Assessment-Centered Lens Assessment of learning outcomes in informal science settings is a challenge (NRC, 2009). Thus, we did not anticipate that many professionals would discuss the design of a learning environment from an assessment-centered lens given the transitory nature of the audiences that visit planetariums. “Visits to museums and other designed informal settings are typically short and isolated, making it problematic to separate the effects of a single visit from the confluence of factors contributing to positive science learning outcomes. The very premise of engaging learners in activities largely for the purpose of promoting future learning experiences beyond the immediate environment runs counter to the prevalent model of assessing learning on the basis of a well-defined educational treatment” (NRC 2009, p. 56). However, we did find three themes relating to this lens from a portion of the professionals interviewed.

The first theme describes *general ways* in which planetarium professionals see assessment as part of their practice. Practitioners described the ways in which they “watch” their audiences to gauge their reactions and their understanding in the planetarium. Vince suggested “Having a live actual person who can present but also take questions, engage through seeing audience’s blank looks” (Vince, Planetarium Director) as well as, “We use Bloom’s taxonomy in questioning; go up the levels and see where the kids drop off. Then we can make some changes to next section we do” (Steve, Planetarium Director). Other professionals described more *formalized ways of using assessment*. “Using [an] audience response system is fine if you are not grading the audience but rather seeing how they approach a concept and then re-measure to see if there is progress throughout the lesson. Measure the progress and usually by the end, the participants are now asking the answer to the questions” (Joe, Planetarium Director). Finally, we found a few participants that expressed *interest in further assessment* on learning in the planetarium. “We need to know what audiences are getting out of this. Some stuff is not well understood, like dark energy, but audience can get excited [about that. But we also] don’t want to propagate misconceptions. Does it fit their needs? Hopefully we are changing minds and inspiring. Improving our programs and doing that better. That comes with research and investigation. We want them to come back and learn more” (Vince, Planetarium Director). Thus, some planetarium professions recognize assessment as a way to evaluate whether or not they are meeting their goals, but some believe more work needs to be done.

6.3.1.4 Motivationally Oriented Lens As expected, the planetarium professionals’ beliefs and goals reflected an orientation towards engendering and increasing interest among their audiences. Responses fell into three main categories: a *general desire to increase the enthusiasm or interest of their audiences* (without a clear motivation for why this is important), a *desire to increase interest and engagement to foster learning*, and building on that theme, a *desire to increase interest so that learning will extend beyond the planetarium experience*. The *general desire to increase interest* in astronomy, or science in general, may reflect a desire to increase science literacy or improve the pathway towards entering scientific fields, as reflected in Linda’s response (Education Specialist): “[I’m] always enthusiastic about involving kids that young… The more I hear is earlier, earlier, earlier. Middle school is way too late. [You have to] have seeds planted that will stick. Need to be excited about science in general, earlier.” Other participants specified that interest or emotional responses were their goals in order to increase learning outcomes. For example, “[That is the] power of fulldome [productions]; [they produce a] much more emotional response. [It] opens up an emotional bridge to sneak in real learning” (Sean, Planetarium Consultant). Similarly, “Kids are enthralled with the planetarium. The environment is so gripping their excitement level is already there. Excitement is there from their first visit and they retain” (Lou, Planetarium Director). A number of participants described their role as one of motivating future learning or participation in other science events. “To excite people about the realm of [astronomy]. Kindle their interest so they want to find out more. Present topics that intrigue the public such as the solar system, [topics that are] not too esoteric. Make them want to come back and want to know more” (Sam, Planetarium Director).

Previous research has found that long after a museum trip, visitors recall the visit as being memorable, enjoyable, and engaging (e.g., DeWitt and Osborne 2009). Davidson and colleagues (2010) report that the zoo educators in their study hoped to make their presentations interesting to the students and engaging so that they would learn. However, the study also found that the students, who participated in presentations from these educators on a fieldtrip, found the lectures from the zoo educators to be the least enjoyable part of their experience. The students

found the social context of the experience to be the most memorable and enjoyable portion of their visit. This leads to our discussion of how planetarium professionals' beliefs reflect sociocultural theories of learning.

6.3.1.5 Socioculturally Centered Lens Sociocultural theories on learning help us understand how social interactions and context influences the learning process in museums and science centers. We were curious to see whether planetarium professions would express interest in facilitating social interactions, both between audience members and between themselves and their audiences given the prevalence of passive "movie-like" planetarium programming as well as the literature suggesting that ISE professionals often engage in transmission-mode instruction (e.g., Davidson, Passmore, and Anderson 2010; Tal and Morag, 2007). A number of participants discussed *general engagement* ("human contact essential," Sean, Planetarium Consultant) as well as *dialog between visitors* ("Students talk with a neighbor," Lou, Planetarium Director). The *planetarium operator engagement* was also an essential component of their professional outlooks for many of ISE participants. For example, "Active discussion, not a lecture, I hate lectures, I prefer - never say it is a lecture, the way you listen changes. When you say it is a discussion, it changes the interaction" (Tom, Planetarium Director). Other participants reflected a traditionally used planetarium strategy of *asking the audience questions* while also *allowing the audience to ask questions of the operator*. Informal science educators often use factual recall questions and simple yes/no response questions that do not require depth or complexity of thought (Tal and Morag 2007; Cox-Petersen *et al*. 2003). Thus, more investigation may be needed to understand the extent to which questions used by planetarium professionals support a sociocultural model of learning.

This lens overlaps with the motivationally-oriented lens through the planetarium professionals' interest in facilitating visitors' interest in astronomy (and science, in general) and in extending their audiences' opportunity to learn. Thus, the social interaction, for them, was a method of increasing interest in a topic—not just in improving content knowledge. For example, some saw their role as *responding to their audience and providing opportunity for student choice*, a belief reinforced by recommendations made by researchers on learning in informal environments (e.g., Davidson, Passmore, and Anderson 2010; Griffin and Symington 1997): "Go with students, rather than other way around. Students [should] have a sense of control. They have the questions" (Tom, Planetarium Director). Others saw facilitated interaction as a way to *get everyone to want to be involved in the experience*. "One starts to interact then everyone wants to be a part of it. It's fun - this is where the learning takes place, seeing them open up" (Kyle, Planetarium Director). This facilitation of the audience's experience is also reflected in a few participants' orientation towards *modeling behaviors*. "Be impressive with yourself and your life so they experience what you have. That's the only way to teach them. That comes down to storytelling. Tell how it relates to your life, more meaning for them" (Erik, Planetarium Operator). This perspective draws on the personal connection that an ISE practitioner can make with their audience by facilitating interest and understanding through their own modeling behaviors.

While many of the participants reflected elements of a sociocultural view of learning and learning environment design, this may be an area to study in more depth among the planetarium community; opportunities for professional development around supporting sociocultural perspectives of learning environment design could build capacity within the planetarium community. The audience's interest in engaging in social interactions should be built into learning activities as this may help to enhance engagement in the learning goals (Davidson, Passmore, and Anderson 2010). Building on the importance of the social and cultural aspects of a museum visit may help connect school-based science experiences with students' everyday experiences (Tal and Morag 2007).

6.3.1.6 Physically Oriented Lens Much has been written on the importance of objects in the museum profession (Tran and King 2007). A planetarium is structured more like a theatre or movie presentation in that the experience is tied to a simulated projection on an artificial sky. This led us to wonder; in what ways might planetarium professionals reflect an orientation towards the physical connection that other informal educators may experience with the physical exhibits and important objects of science museums and centers? Another way to examine this lens is to look for ways in which professionals recognize that recall and understanding is tied to the context in which we first had the experience or learned the concept. This perspective suggests that planetarium professionals may need to consider how audiences may either transfer knowledge into the planetarium environment.

Many of the participants described the use of visual, kinesthetic, and tactile strategies to engage their audiences. Kyle (Planetarium Director) described how he saw the importance of the *visual* aspect of the environment: "Visualization is also import. Some people learn visually. Either with models—like moon globes, physical things to see, lit up by a light bulb, part of it lit up and part of it in shadow. They will remember that." Some suggested that planetarium programs should be "Visually appealing" (Andrea, Planetarium Director). Several participants

described ways in which physical objects are used either as *demonstrations or hands-on props* within the dome, including balls to model the phases of the moon and using the laser pointer to indicate constellations. Several participants also suggested the use of *kinesthetic interactions* as a way they engaged with audiences. Gerry (Planetarium vendor) was particularly vocal in his indication of the importance of kinesthetic engagement as part of a planetarium program: "At the minimum, the audience has to move their head to look around the room; if your head is on the back of your seat then it is just a movie. You have to physically move to see. Much better is to get them to stand up, turn around, do measuring, pointing, etc. Whole body, gross motor function." Finally, we found some professionals who expressed an interest in extending the experience of the planetarium towards *making connections with the world beyond*. This was reflected in responses that suggested audiences should make a connection with the nighttime sky, "something we are losing in this culture" (Brenda, Planetarium Director).

6.3.2 Case Studies of Planetarium Professionals

Paula, a school district planetarium director with 20 years of experience in the field and degrees in education, is representative of professionals who draw highly on aspects of a constructivist, learner-centered perspective. When asked about her use of live versus automated programs, she stated that she moved back to live format to make the planetarium more of an educational tool. Paula wants to involve her audience, as she is a "big believer" in the use of scientific inquiry as an instructional method. She believes visual, kinesthetic, and haptic experiences support her own learning and that this influences her design of the planetarium as a learning environment. She believes that an audience learns best when they are engaged in building their own knowledge. Her belief in using the planetarium to build a foundation for future learning is indicative of using the knowledge-centered lens in learning environment design. Finally, she draws on aspects of the motivationally oriented lens, as she hopes to use the planetarium to inspire audiences to want to learn more about what is out there, and the physically oriented lens, by using the planetarium to facilitate the audience's *experience* of the nighttime sky as well as through the use of a range of hands-on props with the audiences.

Lou is also a school district planetarium director though he has experience facilitating programs at science museums, as well. He has been in the field for 18 years, holds a masters degree in education, and is certified in general science. Lou's beliefs and practices also reflect an educator drawing upon the learner-centered lens in designing his learning environment. His goals include taking the audience "one step further than they came in" for their understanding of the universe around them and changing children's alternative conceptions. The design of his learning environment has the potential to support these goals: he strives to support scientific reasoning skills, such as making predictions and observations, and he engages audiences through data collection or kinesthetic interactions. His beliefs about designing the learning environment also reveal aspects of the motivationally-oriented lens, as he suggests a link between the engagement and excitement exhibited by children and their retention level from the program, the sociocultural-centered lens, as he includes children talking to one another and to the operator as part of the interaction, and to the physically-oriented perspectives, as he describes the importance of visuals and use of props.

Sam, 35 years in the field, manages the planetarium and observatory at a science museum, and has degrees in astronomy but has no formal coursework in education. His goal and pedagogical choices primarily reflect a motivationally oriented perspective; he believes that programs should present topics that excite and interest the public and "kindle their interest so they want to find out more." He also feels that it is important to connect people to the sky through the planetarium and to not load them up with facts. He stresses that the standards must dictate the content of the programs or the teachers will not come; this guides how he chooses the content for his young audiences. Live interaction is part of his philosophy for the planetarium, though most shows run at his facility are automated with brief live "star talks" at the end. This is reflective of the tension we previously investigated: how planetarium professionals' views compared to the reality of prerecorded, automated planetarium programming (Small and Plummer, 2010). However, beyond expressing a belief that live interaction is important, Sam did not explain how he believes that this may relate to learning or how it influences the design of his learning environment.

Andrew, director of a University planetarium, has about 6 years of experience in the planetarium field and a PhD in Astronomy. As a graduate student, he took one course in education and has no relevant professional development experiences prior to the conference at which he was interviewed. Andrew's strongest beliefs and design strategies tend towards inspiring audiences and exposing children to astronomy in ways that are otherwise inaccessible. He believes that the planetarium should be used to communicate astronomical research findings to

the public because the public pays for this research and as a means to inspire further support for science. Children should be exposed to an appreciation of the night sky. Thus, rather than drawing on motivationally-oriented perspective to build on existing interests, he aspires to generate or extend existing interest through the content and context of his show design. Further, he is concerned that the planetarium community (based on his observations at the conference he was interviewed at) spends too much time focused on "gadgets and gizmos," on technology, than on how to design programming that helps people learn. He draws on aspects of a constructivist, learner-centered, perspective through his beliefs about how programs should be designed to meet these goals: use of interaction, short segments, building, exploring, hands-on, and through inquiry-based experiences, which he believes is the way that we learn. He discussed how he was surprised that long—35–45 min—planetarium programs exist, as he believes that audiences are not learning through these passive experiences.

In summary, many planetarium professionals draw on aspects of a learner-centered, constructivist, educator in their goals and beliefs about planetarium design. This primarily arises as planetarium professionals attempt to engage audiences through active strategies going as far as to suggest that the learners need to do so to construct their own meaning. However, participants are less likely to discuss making specific connections to prior knowledge. They merge aspects of the learner-centered and motivationally oriented perspectives through choices that emphasize inspiring the audience to go out and learn more about astronomy on their own, which further extends to some professionals who describe their role in facilitating that desire and ability. Rather than capitalizing on learners' current interests and prior knowledge, planetarium professionals appear to lean more towards generating new interests in their audiences. While assessment-centered views are not commonly expressed by planetarium professionals, those that do often focus on how they can gauge their audience during a program and only occasionally mention more extensive pre/post or automated-response strategies. Many participants focused on specific content-related goals or the desire to help their audiences better connect to the night sky; however, the more in-depth knowledge-centered perspective—supporting learners in developing in-depth, connected understanding of science— was observed in the responses of only few planetarium professionals. This may relate to the short time these educators have to work with their audiences. Sociocultural perspectives primarily arose in descriptions of how the planetarium professional could engage his or her audience personally, with less focus on interaudience interactions or modeling behaviors. Finally, physically oriented perspectives were frequently observed in the planetarium professionals through their integration of kinesthetic, tactile, and visually appealing experiences in the planetarium and to a lesser extent, through their desire to help audiences make a connection with the world beyond the planetarium. The frequent mention of kinesthetic, tactile, and visual aspects of planetarium programming may be influenced by the fact that some of our interview questions focused on elementary students. More work should be done to explore these trends in ways that distinguish between different types of audiences.

7. CONCLUSION

This study extends our understanding of informal science educators by describing the knowledge, beliefs, and interests of planetarium professionals towards the planetarium as an educational venue, building on previous research in informal science educators (Bailey 2006; Bevan and Xanthoudaki 2008; Croft 2008; Tran 2007; Small and Plummer 2010). Croft's (2008) study of seven leaders in the planetarium field concluded that planetarium professionals are far more interested in educating their public than entertaining them. This study goes further by sampling a larger and more diverse sample of planetarium professionals to examine the ways in which their beliefs and goals reflect research-based orientations towards learning. Planetarium professionals, as a community, straddle the formal and informal worlds. The findings of this investigation of the goals, beliefs, and professional opportunities reflect this reality, as do the demographics of participants. Their goals for their audiences, including elementary-aged students, often reflect this connection through a focus on increasing both content knowledge and motivation to continue learning more about astronomy, more so than other studies of informal science educators (Croft 2008; Tran 2007). A few planetarium professionals also suggested goals that reflected participating productively in the practices of science or seeing themselves as science learners or those who identify with science—goals set by a policy document put forward by the National Research Council (NRC 2009).

We also began the process of examining the ways in which planetarium professionals may exhibit a common understanding of best practice that is characteristic of a professional community. Tran and King (2007) found that three key elements of professionalism were missing from informal science educators: a lack of a theoretically grounded body of knowledge and skills, no process of certification to ensure the educator's quality, and various levels of training opportunities at work. We found that while planetarium professions describe some opportunities for professional growth, it was their interaction with audiences that they felt was most important

for influencing their practice, a sentiment also reflected in how other informal science educators describe the major source of their pedagogical knowledge (Bailey 2006). Interactions with colleagues, at work and at conferences, were often described as a major source of new ideas about engaging audiences. The planetarium community may wish to further investigate whether the conferences are creating opportunities for the type of support members need to influence their professional practices as it relates to their work in creating learning environments and whether opportunities are available for "professional preparation grounded in a recognized knowledge base" (Tran and King 2007, p. 131).

Our analysis of participants' beliefs regarding the design of learning environments suggests that planetarium professionals often view the learning environment through a learner-centered perspective, through their methods of engaging their audiences and consideration of building knowledge, and motivationally oriented perspectives, by a focus on increasing interest to increase learning in the planetarium and beyond. The sociocultural-centered perspective shaped many others' views of their practice, through their engagement of audiences through dialogue and modeling of practices and the physically oriented perspective was evident in their use of visual, kinesthetic, and tactile experiences and beliefs about using the planetarium to help audiences connect to night sky. Other perspectives on learning were expressed less frequently, though they do suggest directions of future exploration in the planetarium professional population. This included professionals who viewed assessment as a goal of their practice and those who described the importance of designing a learning environment in a way that focused on purposefully building audience-members' science knowledge.

Limitations of the present study lead us to pose additional directions for research. First, we drew upon the six lenses as a theoretical framework to interpret planetarium professionals' responses to questions about their beliefs and goals in their learning environment. The open-ended, exploratory nature of our questions suggests that we may have missed features of the subjects' practices and beliefs. Additional research that targets each of the themes uncovered in this study would provide a more in depth view of these practitioners' beliefs on designing the learning environment as well as revealing areas that may be useful to support through professional development. Second, some of our interview questions included a focus on elementary-aged audiences. Thus, we may not be able to generalize our findings to how planetarium professionals view a broader audience base. Third, our sample of planetarium professionals may be not be representative of the entire planetarium community because they were selected at planetarium conferences. Other planetarium professionals, such as those who do not attend conferences, those who attend different conferences, and those who work in less stable capacities (such as part-time docents) may exhibit different trends than those in this study.

Finally, our findings are based on the practitioners' self-report. Research that couples interview data with observational data would extend our understanding of both the professed beliefs and the actual practices of this community. Future research on planetarium professionals should investigate how these ISE professionals enact their programs to meet their goals for their audiences. These results could be used to better tailor planetarium productions and conference professional development to support planetarium professionals. Further, future professional development that builds on these findings may be able to support planetarium professionals in using assessment strategies that would allow them to productively reflect on whether or not they are meeting their goals for their audiences and make informed choices in their practices. In this way, we may be able to help ISE practitioners in improving their own pedagogical choices as reflective practitioners.

NOTES

Note 1: Multiple terms are used for "out-of-school" learning and learning environments, including informal and free-choice (NRC 2009). We have chosen to use the term "informal" over "free-choice" as the planetarium is often visited by school groups with limits the "free" nature of the audience's choice in attending the experience.

Note 2: This number includes portable planetariums.

Note 3: Current fulldome productions designed to include opportunities to engage audiences include "The Moon" from AudioVisual Imagineering.

Note 4: The questions about professional opportunities and influences were added after the first conference interviews so only 24 participants were asked these questions.

Note 5: Our results may be biased here, given that the subjects were invited to participate in the study at a planetarium conference.

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