RUNNING HEAD: Informal Science Educators' Pedagogical Choices

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

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Abstract

The purpose of this study was to extend our understanding of the goals, beliefs, and pedagogical choices made by informal science educators by specifically focusing on the planetarium learning environment. Interviews were conducted with planetarium professionals (N=36) on their goals for audiences and beliefs about the design of the learning environment. Analysis suggests that planetarium professionals may place a greater emphasis on increasing content knowledge than other informal educators though they also emphasize the motivational and inspirational beliefs found in previous studies. Classification of participants according to a six-facet framework on learning environments' influences suggests a range of perspectives on the design of the learning environment including learner-centered and motivationally-oriented. Results also point to an opportunity for increased opportunities for professionalism in the field of planetarium education.

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Introduction

Questions of informal science learning have been the subject of research for decades. Much of this literature focuses on what and how people learn from free-choice learning (e.g. Falk, Donovan, & Woods, 2001; Hein, 1998). Other literature examines the design of learning environments in museums and science centers (e.g. Falk & Deirking, 1992; Allen, 2004). The literature describes the importance of connecting school field trips to the classroom (e.g. Bitgood, 1991; DeWitt & Storksdieck, 2008; Tal & Morag, 2007). Short interventions such as in the planetarium (Bishop, 1980; Plummer, 2009; Sarrazine, 2005) or in museum visits (Falk & Storksdieck, 2005; see Rennie & McClafferty, 1996 for a review) have been found to result in audience learning. As a result, extensive research illustrates the nature of the free-choice learning environment.

And yet, limited research has focused on the informal science educators themselves (Falk & Dierking, 2002; Bevan & Xanthoudaki, 2008; Bailey, 2006). Understanding frontline practitioners as agents in the learning environment needs to be addressed from the framework of research in the learning sciences. A research-based view of frontline professionals will help us move forward with improving the field through professional development and the strategic design of learning environments (Bevan & Xanthoudiki, 2008; Tran & King, 2007). This paper will focus on the particular sub-set of informal educators: planetarium professionals, in an attempt to shed light on their goals and beliefs about the learning environment.

Recent changes to the planetarium field suggest that now is a critical time to understand the beliefs and attitudes of planetarians towards their practice, in particular, and to science education, in general. The planetarium field is in a state of evolution with more and more fulldome theaters being constructed and fulldome technology continuously replacing traditional theaters which utilize optical-mechanical projection systems. According to the 2009 State of the Dome Address, which includes a compendium of fulldome theaters throughout the world, there are 301 fixed (not portable) fulldome theaters in the United States with a majority being mid-size domes and theaters (Petersen, 2009). In recent years, the number of fulldome theaters worldwide has doubled (Petersen, 2009). While utilizing the latest modern technologies is progressive and an appropriate direction for the field, the types of programs that are being created to show in fulldome theaters are all similar in their presentation approach. These programs, which are now being referred to in the planetarium field as "fulldome movies", are all push-button initiated with no built in interaction with a live presenter. Therefore, the only "for sale" program options for fulldome planetarium facilities are those that provide audiences with a completely passive experience. This raises a question. Are planetarium facilities becoming places where only passive presentations are taking place, limiting the experiences that planetariums are offering their audiences? Does this movement reflect the beliefs and goals of the professional planetarium community? By examining informal educators, in this case – planetarium professionals, as a unique group of educators with specific pedagogical philosophies and views

on the goals of their learning environment, we gain improved access to the kinds of reform efforts that may improve the planetarium's role in astronomy and space education as well as advocates for increased interest in science in general.

Goals and beliefs of informal science educators

While the literature exploring the specific characteristics and practices of informal science educators are limited, a few recent studies have begun to explore both the observed actions and personal perspectives of informal science educators. Tran and King (2007) report that the "observable actions of [museum] educators… were consistent with the didactic, educator-directed instruction within museum education reported by others" (p. 134). Tran (2007) suggests that museums educators are also able to pay attention to and adapt to visitors' prior knowledge by making changes to their planned engagement activities. Tran and King (2007) found that "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" (p. 134). Museum educators often draw in the pedagogical practices of classroom teachers, at least partly because these professionals are often hired from people who are certified as teachers (Tran, 2007). One of the roles that educators often indentify with is "using their own passion for natural history to inspire a similar interest among the visitors" (Tran & King, 2007, p. 134).

Wrapped up in informal educators beliefs and attitudes towards designing learning environments are their goals for the learners. *Learning Science in Informal Environments* (National Research Council [NRC], 2009) suggests that the goals for science educators in informal settings should include:

- Developing Interest in Science,
- Understanding Science Knowledge,
- Engaging in Scientific Reasoning,
- Reflecting on Science,
- Engaging in Scientific Enterprise, and
- Identifying with the Scientific Enterprise.

Tran (2007)'s investigation of museum professionals used observational data as well as interviews to describe their goals. Similar goals were found across all professionals at two different museums. These goals included:

- Increasing interest in returning to the museum
- Increasing motivation to pursue further science learning
- Learn some content (though this was less important)
- Create a positive experience
- Connect to school curriculum/standards

Affective goals were the most prominent. In terms of learning outcomes, professionals focused on developing experiences that would be part of life-long learning in science (Tran, 2007).

These results are supported by Croft (2008) who found that, among the seven planetarium professionals he interviewed, "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. 31).

Historical development of the planetarium as a learning environment

To begin to understand the role of planetarium professionals in informal science education, it is important to situate our discussion in the historical development of pedagogical practices within the planetarium community. In the 1970s, the planetarium community began to discuss how to actively engage the audience in 'participatory oriented programs' rather than the traditional lecture model (Friedman, Schatz, & Sneider, 1976):

> A very exciting alternative to a passive-audience program that relies on elaborate special effects is the "participatory oriented planetarium" (POP) programs now being used at more than a dozen smaller planetariums. In these audience participation programs the visitors are actively involved in: 1) discovery-approach activities; and 2) extensive verbal interactions with other audience members and the planetarium instructor… The most important distinguishing feature of a participatory oriented program is that the audience is actively involved in thinking about the subject matter, not passively absorbing audio-visual information. (p 4)

The participatory approach reflected a growing recognition within the educational community of the constructivist nature of learning

Despite the fact that over three decades have passed since POP was introduced, limited research has investigated this, or any, theories of learning in the planetarium. In 1982, Mallon and Bruce investigated the use of participatory planetarium programs in small educational planetariums. Through a paper-and-pencil content test and a Likert-style science opinionnaire, they found that the participatory oriented program was more effective than a traditional "canned" program in teaching constellations, and possibly for improving students' attitude towards astronomy. Bishop (1980) found that model manipulation and drawing in the planetarium can help students learn projective astronomy concepts (such as the day-night cycle and the phases of the moon). Little research on students learning in the planetarium occurred until recently. Sarrazine (2005) used participatory oriented programming with a strong emphasis on multiple intelligences in a study of middle school students learning about the phases of the moon. Plummer (2009) published a study of a participatory planetarium program in which first and second grade students showed significant improvement in understanding of apparent celestial motion concepts. This improvement can be explained through the use of kinesthetically and visually interactive live techniques in the program. Beyond these studies, there has been little published research investigating the use and educational value of participatory planetarium programs nor the community's beliefs and interest in these types of programs. There is some

indication that planetariums can increase interest in astronomical topics (Mallon & Bruce, 1982; Mergler, 1975) though at this time we lack a detailed understanding of what particular characteristics of the audience and the programming produce specific types of interest (see Falk & Storksdieck, 2003, for characteristics influencing learning).

Limited research has been conducted on the specific characteristics, needs, and interests of planetarium professionals. Planetariums exist in museums, science centers, in schools and universities, and as standalone facilities. Some planetarians have strong ties to formal or school-based educators as many planetariums exist within school districts (Petersen, 2009). And the learning environment invokes the challenges of the school-based, non-"free choice" settings suggesting that interpretation of learning may be a complex from a motivational stand point. Yet they undeniably share commonalities with other informal educators in traditional museum, science center, zoo, and nature park settings.

We have previously described planetarium professionals' use of live interaction as a contrast to the recent movement towards "fulldome movies" in planetariums (Small & Plummer, 2010). The study answered the following questions: 1) What are planetarium professionals' goals for audiences, in general and for K-4 students in particular, and beliefs about designing planetarium programs?, 2) Does the new fulldome passive programming support planetarium professionals' goals and beliefs about planetarium education, and 3) Are planetarium professionals currently integrating live content with pre-recorded content? The study found that planetarium professionals believe that both content and attitude towards science are important aspects of their work. We also found that planetarium professionals' strong beliefs about the use of live interaction for meeting their educational and attitudinal goals are at odds with the move towards passive planetarium productions. These findings and the limited literature on informal educators, including planetarium professionals, led us to wonder how planetarium professionals' beliefs may reflect modern learning theories.

Theoretical framework: Implications of learning theory for interpreting the informal educators' beliefs about instructional design

The seminal publication *How People Learn* (NRC, 1999) synthesized decades of research to uncover the foundations for principals of learning based on work in the cognitive and developmental sciences. From this synthesis, they suggest ways that these research 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, 1999, 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 choices made by planetarium professionals. Here, learning is broadly defined and could include gains in content knowledge, science inquiry skills, as well as in interest or motivation. In this section, we draw on additional research syntheses describing

potentially beneficial choices and attitudes towards the design of learning environments as well as choices that informal educators may make could limit learning.

Four key publications designed to synthesize overarching themes in the research base were used to identify potential frameworks for informal educators' learning environment: *How People Learn: Brain, Mind, Experience and School* (NRC, 1999), the Contextual Model of Learning (Falk & Dierking, 2000), the Ecological Model of Learning (NRC, 2009), and the Constructivist Museum (Hein, 1998). We have organized both common and unique themes from each of these publications as potentially interpretive lenses for planetarium professionals' beliefs and practices. Later we will discuss how these were used to categorize planetarium professionals' statements of their actual practice and their goals for instructional design. We draw on literature relating to learning both in the classroom and the museum to interpret our sample because planetariums and planetarium professionals often exist in both formal and informal worlds. Planetariums can be found in both museums and in schools. People visit planetariums because they want to learn more about space and teachers bring students to the planetarium to enhance their own curricula. Even the space itself has a dual nature; for the planetarium educator, a group's visit may be the only time he or she interacts with the learners. But planetarium room itself can constrain interaction similarly to a classroom where the students are expected to stay in their seats.

The following six lenses were used to analyze planetarium professional's responses to interview questions about their beliefs and practices in planetarium show design. We looked for ways in which practitioners 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 to begin to unpack how they view their learning environment.

Lens #1 - Learner-centered: The learner-centered lens has a cognitive interpretation of the design of learning environments, though it also uses a sociocultural perspective in its consideration of the impact of culture on learners' prior knowledge (NRC, 1999, 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 (NRC, 1999). This includes making connections between everyday talk and scientific discourse, finding ways to make bridges between prior experiences and the scientific goals (NRC, 1999). 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). This can be done by considering the ways provided to learners to "enter" the experience, providing opportunities to relate to prior experiences (Falk & Dierking, 2000).

Thus a learner-centered lens interprets the experience through a constructivist theory; learner centered or constructivist educators are those that refer 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). In the design, 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. 2-5).

Lens #2 – Knowledge-centered: The knowledge-centered educator recognizes 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, 1999). Knowledge-centered educators consider how prior knowledge will impact the learning of new concepts (as such, this is an overlap with the learner-centered environment) but also recognize which aspects of the discipline will be important for developing rich understanding of science. Educators with a goal of knowledge development should promote a focus on depth into big ideas over coverage of disconnected facts (Corcoran, Moser, & Rogat, 2009; NRC, 1999). A knowledge-centered environment focuses on sense-making through "progressive formalization" (NRC, 1999), building towards in successful levels of sophistication such in current work in learning progressions (NRC, 2007).

Lens #3 – Assessment-centered: Findings from research on learning suggest that providing feedback increases opportunities for those learners to meet one's learning goals (NRC, 1999). *How People Learn* suggests that "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" (Chapter 6). Assessments should allow learners the opportunity to revise their thinking and for teachers to revise their practice (NRC, 1999).

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 & Dierking, 2000). Challenges presented should also be appropriate to the skill level of the learner (Falk & Dierking, 2000). Those personal connections discussed as part of the learner-oriented lens are also important to consider here; learners that form personal connections to experiences are motivated to engage in an emotionally rewarding learning experience (F&D, 2000). Falk and Dierking also state that "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" (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 & 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: the choices of what to attend to, the level of engagement, and the magnitude of recollection. Interest is

shaped by prior knowledge; Falk and Dierking report that, in studies of museum recollections, visitors often bring up ways that museum visits built on what they already knew (2000). Further, interest is more than just what a person likes; rather, it describes "attention, persistence in a task, and continued curiosity" (Falk & Dierking, 2000, p. 22). Museum exhibits that consider motivational factors encourage individual exploration and to find ways to make the experience their own (Falk & Dierking, 2000).

Lens #5 – Socioculturally-centered: The sociocultural-centered lens has been heavily explored in museum-based education research through the examination of visitors' conversations, interactions between educators and visitors, and the cultural perspectives that shape a visitors experience and learning. 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). Other constructivist views focus more on the individual while the sociocultural perspective orients the educator find modes of participation for learners that are comfortable and culturally appropriate (NRC, 1999, 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 and bring topics of conversation with them at home, school, etc. (Falk & Dierking, 2000). This requires that museum staff become "facilitators of experiences rather than disseminators of information" (Falk & Dierking, 2000, p. 194). Learning socioculturally is more than person to person interaction; this can occur even when people appear to be alone because whatever medium they are interacting with (exhibition, video, computer, etc.) was created by another human or group of humans (Falk & Dierking, 2000).

Narrative shapes the transfer sociocultural knowledge. "Children as young as three years seem to remember familiar daily experiences in terms of scripts or stories, organized representations of event sequences that provide a general description of what occurs and when it occurs in a given situation. Scripts that are held in long-term memory can be used to predict what will happen in the future on similar occasions" (Falk & Dierking p. 48). Further, scripts seem to be a fundamental aspect of all human's knowledge structure "a basic means through which they organize, interpret, and predict their world" and store information in long-term memory (Falk & Dierking, 2000, p. 48). Learning is also facilitated by modeling: observation and imitation (Falk & Dierking, 2000). Thus one way of explaining the importance of the sociocultural lens is recognizing the role of the facilitator in communicating actions and ideas through their own modeling behaviors.

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, & Duguid, 1989; Falk & Dierking, 2000). 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 twenty or thirty years, the most frequently recalled and persistent aspects relate to the physical context" (p. 53). This phenomenon has been documented across several museum locations and disciplines (Falk & Dierking, 2000).

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 & 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 that the use of artifacts in mediating learning (NRC, 2009, p. 2-6). 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.). Objects may act as the center of conversation among learners and museum educators may specifically design settings to draw out conversation based on carefully chosen artifacts (NRC, 2009, p. 2-7).

Research Questions

The literature on learning theory has much to say about how and why people learn in informal environments. However, as we have noted, the research is far more limited on the characteristics and beliefs of informal science educators, in general, and planetarium professionals, specifically. By analyzing the beliefs and goals of planetarium educators, we hope to provide information that would be useful for those who may be interested in offering professional development as well as for researchers interested in understanding why students are learning what they are learning through their experiences in planetariums. This led us to pose the following research questions:

1. How do planetarians' goals compare to goals set by policy documents for science education, models of learning, and other museum educators?
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 beliefs about instructional design?

Methodology

Participants

Interviews were conducted at two annual meetings of regional planetarium associations as well as over the phone with conference attendees who did not have time to be interviewed onsite. In total, thirty-six planetarium professionals (25 male and 11 female) were interviewed (31 onsite; 5 by phone). This included vendors who have worked at planetariums in the past as well as current planetarium directors and operators. Participants were informed of the study during a presentation session and by being contact while they were visiting the vendors' hall. A semi-structured interview consisting of 16 questions covering: demographic information and opinions about general show characteristics, modular fulldome programs, and research on the field. These interviews were conducted on a one-on-one basis by the first author. Interviews ranged in length from approximately 8 to 35 minutes. Interviews were audio-recorded for later analysis.

The majority of participants (56%) have been in the planetarium field longer than 15 years. Participants were drawn from school districts (19%), universities (28%), museums and science centers (19%), planetarium vendors (11%) and other work situations (17%), with two un clear. Because of the broad distribution of planetarium professionals, not all participants were asked all questions. For example, vendors and consultants who did not or had not worked as a planetarium demonstrator were not asked specific questions about their experience. Subjects 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 educational 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 asked if they work with fulldome technology because they were not currently working in a planetarium dome).

Analysis

As this study represents an initial exploration into planetarium professionals' goals and beliefs, we believe that a qualitative approach is warranted in order to provide rich and detailed data; participants were free to expound on their beliefs and interests in any direction they chose. A series of categories were developed based on the interview questions and our research questions. Codes were then developed using the constant comparison method (Strauss & Corbin, 1998). An initial set of codes were developed, representing concepts we expected to see in the interview data. Then, both authors listened to a sub-set of four interviews to develop additional codes describing patterns that emerged from the data (Marshall & Rossman, 1999). The remaining interviews were split, with each author coding 16 interviews. Periodically during this coding process, the authors met to compare coding and determine whether new codes should be added or old codes should be clarified. Each author then reviewed previously coded interviews to match any changes produced in discussions. Finally, four interviews were randomly selected from each subset of 16 interviews, to be coded by both authors (for a total of 8 interviews). An inter-rater agreement of 96% was reached in this final comparison. This initial coding was also

used in our previous paper (Small & Plummer, 2010). This initial level of coding formed the basis of the results reported for research questions 1 (comparison of goals to external policy documents) and 2 (professional development opportunities shaping the experiences of planetarium professionals).

Answering research question 3 required revisiting the data using the six lenses as broad analytical categories. First, the initial set of codes was tentatively aligned with the six analytical lenses; a first pass through the initial codes by the first author was used to start "sorting" the subjects' responses into the six lenses. Some responses appeared to be "alternative ideas" or oppositional to the ways in which research syntheses describe supportive learning environments. Second, the first author re-examined each of the original interviews, looking for additional evidence of ways that the subject may reflect alignment with one or more of the lenses but also to look for ways in which their responses may counter the research-based lenses on learning environments. Finally, the authors identified themes within and across the lenses representing the ways in which planetarium professionals view the design of learning environments: their alignment with and limitations within the six lenses of learning theory.

Findings

Comparison of planetarium professionals' goals with policy documents, models of learning, and other museum educators

In this paper, we go beyond the limited analysis presented in our previous paper (Small & Plummer, 2010) to present a further analysis of these goals by drawing on existing literature to compare and contrast this sub-group of informal educators. Further, we look for trends in how these goals appear among professionals. Do most professionals have multiple goals and what patterns appear in groupings of goals? We compared the 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) and another study of planetarium professionals (Croft, 2008), these informal educators felt that inspiring interest or engagement to be one of the two most important goals for the planetarium. Supporting audiences' scientific reasoning was uncovered in a smaller percentage of participants (18%, 20% and 29%, in general, children, and overall from their interviews, respectively). As with Croft's study of seven leaders in the planetarium field (2008), entertainment was not frequently mentioned for general audiences and was never mentioned as a goal for children. However, for participants in his study, "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. 31). This is similar to Tran's (2007) investigation of museum professionals:

- Increasing interest in returning to the museum
- Increasing motivation to pursue further science learning
- Learn some content (though this was less important)
- Create a positive experience
- Connect to school curriculum/standards

King (2006) examined museum educators in a large natural history museum which identified the importance of the hands-on experience. They found that "the educators consistently identified their role to be one of making visitors "feel" comfortable in the museum environment, and that their practice involved using their own passion for natural history to inspire a similar interest among the visitors" (Tran & King, 2007, p. 134). Thus interest and motivation appear to be commonly held goals across the informal science education field, including planetarium professionals.

Table 1. Goals for the Planetarium

General Goals	**General n=28**	**Children n=30**	**Combined[a] n=28**
Interest/Engage	19 (68%)	18 (60%)	23 (82%)
Education about content[b]	20 (71%)	17 (57%)	22 (79%)
Provide an educational experience	8 (29%)	5 (17%)	8 (29%)
Not just facts	6 (21%)	4 (13%)	8 (29%)
Entertainment	6 (21%)	0 (0%)	6 (21%)
Education about scientific reasoning	5 (18%)	6 (20%)	8 (29%)
Knowledge of the sky	4 (14%)	7 (23%)	10 (36%)
Teach State or National standards	2 (7%)	13(43%)	11 (39%)

Note: Individual participants may have been coded in more than one possible goal. Portions of this table appeared originally in Small & 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.

However, unlike professionals in Tran's study, developing content knowledge was equally important across the sample. 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 6 (17%) were from university planetariums. Many of the others are likely to serve school-based programs. This is reflected in the large percentage of respondents who mentioned the importance of district, state, or national standards in their goals for children. Further, 53% of the participants (11% unknown) mentioned having formal education coursework (including taking a few courses, undergraduate degrees,

masters in education, and certifications). This may not explain all of the variation; many informal educators are drawn from those trained as classroom teachers and thus reflect their practices (Tran, 2007); yet studies of other informal professionals (above) have found a greater emphasis on interest and engagement. However, our study did not specifically ask participants to rank their goals and many suggested more than one goal in their interview.

Planetarians as professionals: Opportunities and influences

Most of the participants (20 out of 24 asked; the smaller subset of participants is because this question was asked at only one of the interview sites) 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 specifically were designed for planetarium professionals; rather they focused on both classroom and/or informal astronomy educators. A few mentioned their position as facilitators of professional development opportunities.

Later in the interview, these participants were specifically asked to describe what has influenced how they interact with audiences in the planetarium, many described experiences they have on the job and specifically working with audiences. Many planetarium professionals believe that their interactions are influenced through "trial and error" or experimentation with audiences. They pay attention to how the audience reacts to their facilitation. Some describe drawing on the existing norms of their current facilities or their past experience working with interactive exhibits as a museum educator. Other influences included reading journals, asking for feedback from teachers after a program, and mentors in college. Finally, personal interest or philosophy was described as a reason for the nature of their active (versus passive) interactions with audience.

The most frequently mentioned methods of finding new ways of interacting with audiences included other planetarium professionals and, not surprisingly given the study venue, attending conferences. Many planetarium professionals observe others facilitating programs and talking to colleagues. A few also obtain information from journals. One or two subjects also mentioned the use of one each of the following: of internet resources (websites and blogs), list-servs, plays, TV, and live science shows as potential sources of new information for facilitating audience interaction.

Examining these opportunities and influences led us to conclude that, while many planetarium professionals mention a variety of professional development opportunities, these are not the primarily experiences that influenced their beliefs about facilitating live interaction with their audiences. It is their personal experiences on the job and working with the audience that they believe has made the most difference. And while many do feel they get new ideas from conferences, workshops and university courses were not as frequently mentioned. Nor were

journals or resources specifically designed for planetarium professionals or informal science educators. Rather directly interacting with other planetarium professionals through conversation or observation of program facilitation were the most frequently cited influences on new ideas.

Our findings also support Tran and King's (2007) suggestion that "a process of professional preparation for new museum educators built upon a knowledge base for educational practices in a museum settings, and , as a corollary, as widely shared model of practice based on that body of knowledge and skills" (p. 135). 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 do share a common organization of professional practice as represented by their attendance in an annual meeting of planetarium professionals. However, their responses about how they grow in their profession suggest that they do not see this as the major source for learning and improvement in their professional practice. Tran and King describe a growing movement towards professionalism in the museum education community, including training programs and certifications (2007). The responses of the planetarium professionals suggests that they are not traveling within the same circles as professional science museum educators so that movement towards formalization of skills and professional knowledge may not be translating into this community.

Characterizing Planetarium Professional's Beliefs about Teaching and the Learning Environments

The six lenses on learning

In this section, we discuss the ways in which planetarium professionals beliefs and goals are reflective of the six lenses on learning in formal and informal environments. First, we note that this initial discussion will describe the ways in which these lenses appeared in the participants' interviews while also pointing out that few individuals reflected all of the six lenses. We point out where themes appeared most strongly across many participants and where these themes seemed to reflect a minority focus on the learning lenses.

Learner-centered lens: Planetarium professionals expressed three general categories within the learner-centered lens: building on prior knowledge, enabling visitors to connect through a range of experiences, and providing tools for future learning. The opportunities for visitors to build on prior knowledge were somewhat limited. These included a few suggestions that acknowledge a constructivist perspective ("That is how students learn best, sitting back watching they fall asleep, they build their own knowledge" Interview #201). Others described ways that they asked their audiences to "point out things before I show them" (Interview #205). A far larger portion of the planetarium professionals described ways in which they attempted to connect their audiences to the learning experience. Audience interaction often includes more than just verbal response, such as asking and answering questions. It involves the use of props and kinesthetic engagement as well. Their interactive approach is a feature of the learner-

centered environment. More research is needed to understand the extent to which they are able to support their visitors in constructing new understandings and connections. The third way that we found that planetarium professionals demonstrate their vision through a learner-centered lens included a few professionals who expressed a desire for audiences to gain tools and understandings that extend their own learning beyond the planetarium. Interview #201 expressed this view by describing the importance of teaching observational techniques because science is based on observations. Thus, this would lead the learners to have the opportunity to extend their learning experience beyond the planetarium.

Knowledge-centered lens: As mentioned earlier, we found content to be the top 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" Interview #204) 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 but even that result that means something! [It's] not just a collection of facts" (Interview #312).

However, this is a limited view of what the research suggests is a knowledge-centered lens; a knowledge-centered educator recognizes 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, 1999). It may be that our interviews did not tap into the professionals' beliefs or understandings in this area. A few participants were moving towards this knowledge-centered perspective by suggesting ways that one should develop content from an organized perspective. Participant #205 suggests: "Take them one step further than they came in with for their understanding of the universe around them." Participant #319 describes 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."

Assessment-centered lens: We did not anticipate that many professionals would express beliefs about the design of a learning environment from an assessment-centered lens given the transitory nature of the population these professionals serve. 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. This included: "Having a live actual person who can present but also take questions, engage through seeing audience's blank looks" (Interview #312) as well as, "We look at the audience using dimensions of learning. Are they doing something kinesthetic, orally, auditory, tactile, visual? Are they able to actually take something, process it, put it in their own terms using dimensions? 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" (Interview #318). Other professionals described more formalized ways of using assessment. "Using 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" (Interview #313). 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're 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" (Interview #312).

Motivationally-oriented lens: As expected, the planetarium professionals' beliefs and goals reflected an orientation towards engendering and increasing interest and motivation 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 during the program because of a belief that this fosters 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 Participant # 204's response: "[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 full dome [productions]; [they produce a] much more emotional response. [It] opens up an emotional bridge to sneak in real learning" (Interview #202). 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" (Interview #205). 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" (Interview #301).

Socioculturally-centered lens: Socio-cultural theories on learning are broad, encompassing much of what goes on in an informal learning environment. To investigate how planetarium professionals engage in their practice through this lens, we looked for their interest in facilitating social interactions, both between audience members and between themselves and their audience. We were curious of the extent to which this type of interaction, as well as how they viewed interaction, would appear given the prevalence of passive "movie-like" planetarium programs. A number of participants discussed general engagement ("human contact essential", Interview #202) as well as dialog between visitors ("Students talk with a neighbor", Interview #205). Operator engagement was also an essential component of their professional outlooks for many 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" (Interview #302). Other participants reflected a more traditional view of asking the audience questions while also allowing the audience to ask questions of the operator. This lens overlaps with the motivationally-oriented lens through their interest and facilitation of helping visitors increase their interest and extend their learning experience. For example, some saw their role as responding to their audience: "Go with students, rather than other way around. Students [should] have a sense of control. They have the questions" (Interview #302). Others facilitate 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" (Interview #102). 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" (Interview #304).

Physically-oriented lens: Much has been written on the importance of objects in the museum profession (Tran & King, 2007). A planetarium is structured in the same way as a museum exhibit in terms of the physical association with objects; rather, it is 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? 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 (for in-show connections) or out of the planetarium environment (to extend the learning to other settings).

Many of the participants described (most or all) of three engagement strategies: visual, kinesthetic, and tactile. 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. The use of kinesthetic interaction was also suggested by several participants. This participant in particular was vocal in

their indication of the importance of kinesthetics 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" (Interview, #111). 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" (Interview #319).

Case studies of planetarium professionals

To further illustrate our findings with regards to characterizing planetarium professionals' beliefs about the design of learning environments, four subjects were chosen to present in this proposal. These subjects were chosen to represent some of the range of facility demographics and educational backgrounds represented by the overall sample. These cases help illustrate some of our findings on the extent to which planetarium professionals' beliefs about learning environments reflect the six lenses described in the theoretical framework.

Paula (Interview #201), 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 as well as an array of other learning environment beliefs. When asked about her use of live versus automated programs, she states that she moved back to live format to make the planetarium more of an educational tool. Paula wants to involve her audiences as a "big believer" in the use of scientific inquiry. Her own beliefs in her personal learning style (importance of visual, kinesthetic, the sense of touch) influence her goals in designing her 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 suggests aspects of the knowledge-centered lens. Finally, she draws on aspects of the motivationally-oriented (using the planetarium to inspire audiences to want to learn more about what is out there) and physically-oriented perspectives (using the planetarium to facilitate the audience's *experience* of the nighttime sky and a range of uses of hands-on props with the audiences).

Lou (Interview #205) is also a school district planetarium director though he also has opportunities to facilitate programs at two regional science museums. 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 draw on some of the hallmarks of a learner-centered 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. His description of the design of his learning environment has the potential to support these goals: he strives to support scientific reasoning skills such as predictions and observations and he engages audiences through data collection or kinesthetic interactions. His learning environment beliefs also draw in aspects of the motivationally-oriented (he suggests a link between the engagement and

excitement exhibited by children and their retention level from the program), sociocultural-centered (includes children talking to one another and to the operator as part of the interaction), and physically-oriented perspectives (importance of visuals, use of props).

Sam (Interview #301), 35 years in the field, manages the planetarium and observatory attached to a science museum in the southern U.S., has degrees in astronomy but has no formal coursework in education. His goal and pedagogical choices primarily reflect a motivationally-oriented perspective suggestion 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. For children, he stresses that the standards dictate the content of the programs or the teachers won't come. Live interaction is part of his philosophy though most shows run at his facility are automated with brief live "star talks" at the end. However, beyond expressing a belief that live interaction is important, Sam does not explain how he believes that this may relate to learning.

Andrew (Interview #314), director of a University planetarium, has about 6 years of experience 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 belief 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 (as exhibited by the conference) 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 though his beliefs about how program should be designed to meet these goals: interaction, use of short segments, building, exploring, of hands-on, and through inquiry (stating that this is the way that we learn). He discussed how he is surprised that long (35-45 minute) planetarium programs exist as he believes that audiences aren't learning through these.

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 occasionally mention more extensive pre/post or automated-response type strategies. Knowledge-centered perspectives were limited in this sample of planetarium professionals. Sociocultural perspectives primarily arose in descriptions of how the planetarium professionals could engage his or her audience personally with less focus on inter-audience interactions or modeling behaviors. Finally, physically-oriented professionals were found 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.

Conclusions

This study extends our understanding of planetarium professionals by describing the knowledge, beliefs, and interests of planetarium professionals towards the planetarium as an educational venue. This work builds on Croft's (2008) study of seven leaders in the planetarium field. He concluded that planetarium professionals are far more interested in educating their public than entertaining them. This study goes further by sampling a larger and potentially more representative sample of professionals to examine the ways in which their beliefs and goals reflect research-based orientations towards learning. We also add to the limited body of research on informal science educators' goals and beliefs. 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 often reflect this – a focus on increasing both content knowledge and motivation to continue learning more about astronomy. Our analysis of participants' individual belief framework regarding the design of learning environments appears to suggest that planetarium professionals often view the learning environment through lenses of the learner-centered (through their methods of engaging their audiences and consideration of building knowledge) and motivationally-oriented perspectives (increasing interest, engagement and motivation both to increase learning in the planetarium and to extend learning beyond the program). 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 assessing the audience as a goal of their practice. Other professionals described the importance of designing a learning environment with a structured approach (knowledge-centered), ways to engage audiences through dialog and modeling of practices (sociocultural-centered), and physically-oriented connections using visual, kinesthetic, and tactile experiences.

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. Further interview data that targets each of the themes uncovered in this study would provide a more in depth view of these practitioners. Second, our sample may be biased due to the way we sampled the planetarium field. We are likely to have captured the beliefs and opinions of experienced planetarium professionals who view themselves as members of the planetarium community (and thus attend annual regional conferences). This suggests that future research may find differences if we were to investigate planetarium professionals who do not attend conferences (or these conferences in particular). Third, our findings are based on 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.

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