Factors influencing planetarium educator teaching methods at a science museum

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Abstract
A qualitative study was conducted exploring the ways three planetarium educators at an informal science center teach school programs and the factors that influence the teaching methods they use. Data collection techniques included an initial interview, observations of educators teaching planetarium programming, and a final interview. Results from this study found that teaching methods used by the participants included questioning, explanation, kinesthetics, modeling, observation, identification skills, reinforcement, prediction, and story-telling. The teaching methods of participants were informed by previous astronomy and professional experiences, education, purposes and goals for planetarium education, audience, and technology.

Introduction
A qualitative study was conducted to examine the ways planetarium educators teach program content, and the factors that influence the teaching methods they use. While planetariums can be found in many institutions such as schools, universities, government institutions, and science centers/museums (Small & Plummer, 2010), this study examines planetarium education that occurs within a science museum. The need to address planetarium education at science centers and museums is particularly relevant as many science centers are currently undergoing a paradigm shift from presenting information to promote an understanding of science to developing content that promotes engagement with science (Bevan & Xanthoudaki, 2008).

This paradigm shift in science centers and museums represents a great opportunity to educate the public about astronomy, but it also presents a challenge to planetarium educators to provide quality educational experiences within the planetarium setting. Small & Plummer (2010) found that while many commercially available fulldome movies are largely “push-button” (p. 1) programs that do not include a live-interactive component, “planetarium professionals want educationally oriented programs that offer the opportunity to interact with their audiences” (p. 8). If educators are to use interactive experiences as opposed to passive fulldome movies in planetariums to educate audiences about astronomy, it will be important to understand the current factors that influence planetarium educator teaching methods in order to develop effective professional development tools for educators.

Purpose of the study, research questions
The purpose of this case study is to identify the factors that influence planetarium educator teaching methods at a science museum located in the southwestern United States. The central question this study seeks to answer is:

• What factors inform planetarium educator teaching methods at a science museum?
• To more deeply explore this question, this study use the following sub-questions:
• In what ways do planetarium educators teach program content?
• What types of teaching and education background do planetarium educators have?
• What influences their current teaching methods?
• What do they view as the purpose of planetarium education?
• How does professional development influence planetarium educators?

Theoretical framework approach and researcher positionality
The positionality of this science education researcher is based upon a post-positivist ontology and epistemology, and a science education constructivist pedagogy. A post-positivist ontology and epistemology takes the stance of “critical realism” (Lincoln, Lynham, & Guba, 2011, p. 98), which assumes that while there may be a single reality, it can only be approximated and never fully understood (Creswell, 2013). While Lincoln et al. (2011) argue that post positivist and constructivist views are incommensurable, Gil-Pérez et al. (2002) argue that it is possible to have a constructivist pedagogy without constructivist epistemology, and that “constructivism in science education has little to do with philosophical constructivism” (p. 559).

In science education, constructivism is concerned with the active participation of groups and individuals in the construction of knowledge; however, it rejects notions and ideas that distort the nature of science (Gil-Pérez et al., 2002). Socially constructed ideas must, therefore, be consistent with the nature of science. This idea within science education constructivism is similar to the description of post positivists by Patton (2015) that states: “it is possible, using empirical evidence, to distinguish between more and less plausible claims” (p, 106). In this way, the pedagogy of constructivism in science education can be commensurable with an ontology and epistemology of post-positivism.

Based upon researcher positionality, the researcher used a post-positivist framework approach with a science education constructivist lens. A post-positivist approach is one that takes a “scientific approach to research” (Creswell, 2013, p.23), and accepts and evaluates multiple perspectives to develop an approximation of reality that is constructed by the researcher through data analysis (Creswell, 2013). Additionally, within a post-positivist framework, the researcher analyzes the data and interprets its meaning while attempting to control biases (Creswell, 2013). Using this approach, a case study methodology was used in which the researcher defined the parameters of the study, collected and analyzed the data, and interpreted the meaning. A science education constructivist lens was used to analyze the data and identify themes that emerged about how planetarium educators teach content and view themselves as educators.

Literature review: Educating in science centers and museums
When conducting research within a science center or museum, it is important to understand the educational role the museum plays...
in the community. The types of educational content provided by museums can include exhibits, performances, outreach activities, programs outside the museum, research, partnerships with other organizations, and web-related content (Hein, 2005).

While there are many methods and contexts to provide educational context to museum visitors, Hein (2005) contends that constructivism is “the most powerful and appropriate educational theory and practice for museums” because it “is an active process in which we as learners make meaning” (p. 359). Bell, Lewenstein, Shouse, & Feder (2009) identified six strands that represent the different goals science museums and educators may have when delivering science content: 1) developing an interest in science, 2) understanding science knowledge, 3) engaging in scientific reasoning, 4) reflecting on science, 5) engaging in scientific practice, and 6) identifying with the scientific enterprise.

Many science centers and museums are also beginning to go through a paradigm shift in how they present educational content. Traditionally, museums have presented information to promote an understanding of science content, but there is a growing trend for museums to develop content that promotes engagement with science (Bevan & Xanthoudaki, 2008). In line with this paradigm shift, Bevan & Xanthoudaki (2008) found that constructivist and socio-cultural pedagogical approaches were used by many educators in museums. However, they also found that without continued professional development, museum educators “often revert to conceptualizations of knowledge and pedagogy they themselves experienced in their own learning” (Bevan & Xanthoudaki, 2008, p. 108).

In light of these trends in science center and museum education, in this study the researcher used a scientific constructivist lens to identify the types of pedagogies employed by planetarium educators, examine the rational for utilizing those pedagogies, and determine if or how constructivist pedagogy is being used in planetarium education at a science center.

**Literature review: Planetarium education**

Even though planetariums are often connected with science centers and museums, they offer a unique educational setting that requires specialized research (Plummer, Schmoll, Yu, & Ghent, 2015). The learning environment created by planetarium education operates on a spectrum ranging from formal to informal education (Plummer et al., 2015). The type of learning environment that occurs in the planetarium is dependent upon the specific educational goal of the planetarium, and the delivery method used by planetarium educators (Plummer et al., 2015). Formal learning environments are characterized by teacher led lessons where “students have little control over what they study” (Plummer et al., 2015, p. 9), whereas informal learning environments focus on providing learners with a certain level of choice. Even though planetariums may be connected to an informal learning environment, such as a science center or museum, they may “offer more structured learning activities and time constraints than other parts of a museum or science center” (Plummer et al., 2015, p. 9). Portable planetariums that are brought out to schools may fall into the middle of the learning environment spectrum as they often combine informal learning strategies in connection with school curriculum (Plummer et al., 2015). When researching planetariums, Plummer et al. (2015) contend that research conducted in more formal environments should focus on analyzing how the structured elements of the program improve content knowledge, whereas research conducted in more informal environments should focus on understanding the use of social elements such as choice, interest, and motivation.

Sumners, Reiff, & Weber (2008) describe a study conducted using a portable planetarium that can be taken to schools. Their study examined the impact a 22-minute prerecorded fulldome show had on the earth science conceptual knowledge of students 3-12 years old. The study found that planetariums provide an “immersive environment” (Sumners, Reiff, & Weber, 2008, p. 1848), which can be a useful tool for engaging students in concept exploration. The authors concluded that the immersive experience is particularly useful in helping students understand “concepts that are intrinsically three-dimensional” (Sumners, Reiff, & Weber, 2008, p. 1848) such as earth and space science content. While this study examines the type of environment created by planetariums, the study focuses on use of fulldome movies rather than teaching methodology of the planetarium educator.

Chastenay (2015) conducted a study that examined how a live interactive portable planetarium program was used to teach the concept of the lunar cycle to students 12-14 years old. The study combined a planetarium program with student observations of lunar phases for 1 month prior to the planetarium show to allow them to have a real world context for the content taught in the planetarium. Within the study, the educator used the digital planetarium software to create a “highly realistic simulation” (Chastenay, 2015, p. 6) of a space-based perspective of the Moon. The space-based perspective shown in the planetarium created a discrepant event between what students observed prior to the planetarium and the simulation. The planetarium educator used a live interactive teaching style that included questioning methodology, and students were asked to develop potential explanations for the discrepancies between what they observed outside the planetarium and in the planetarium show. In addition, the educator asked students to make predictions about the position of the Moon, and then compare their predictions to the simulation of the motion of the Moon as seen in the planetarium. Chastenay (2015) concluded that this method of using a live interactive planetarium program in combination with student observations aided students in developing conceptual understanding of lunar models and applying that knowledge to make predictions regarding lunar position and phases.

**Beliefs and practices of planetarium educators**

While there are several studies regarding the educational benefits of planetariums, studies examining the teaching methodology beliefs and practices of planetarium educators are just emerging. Small & Plummer (2010) conducted a small survey of 36 planetarium professionals’ beliefs about what the goals of planetariums should be, and how planetarium programs should be designed. The majority of planetarium professionals believe that the goal of planetariums should be to provide audiences with an “opportunity to learn more science content and to be inspired to continue learning more in the future” (Small & Plummer, 2010, p. 8). Small & Plummer (2010) also found that planetarium educators prefer interactive programming as opposed to fulldome movies, and they prefer to use live interaction methods that include: conversational dialogue, questioning the audience, kinesthetic activities, props, and combining digital movies with live presentation.

In another case study, Plummer & Small (2013) explored the pedagogical choices and goals planetarium professionals have for audiences in the planetarium. The study found that the majority of participants had some level of formal education background, which impacted the pedagogical choices they made (Plummer & Small, 2013). However, the authors found that the two largest factors that impacted how participants interacted with their audiences were “experiences they have on the job, and working with audiences” (Plummer & Small, 2013, p. 8). Participant response also showed that many planetarium professionals draw on a learner-centered, constructivist philosophy to inform their teaching pedagogy (Plummer & Small, 2013).

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While their study provides insight into the ideas and beliefs of planetarium educators, it is limited due to relying solely on self-report and lacking observational data. This study seeks to expand on the current literature by combining interviews and observations to identify the ways planetarium educators teach.

Methods
Research approach

This qualitative study employed a collective case study approach. This approach is consistent with a post-positivist framework it provides an in-depth look at a specific case or cases within well-defined boundaries that are established by the researcher (Creswell, 2013). The rationale for a case study approach for the current study is based upon prior research. One limiting factor of Plummer & Small’s (2013) of planetarium educator beliefs was that it was solely based on self-reporting, and the authors recommended additional research that combines interviews with observational data to further extend our understanding of the beliefs and practices of planetarium educators. This study used a case study approach in order to add to the body of knowledge previously established in the literature by obtaining in-depth data through interviews and observations to identify the factors that influence and inform planetarium educator teaching methods at a specific science museum.

Research site

The research was conducted with a portable planetarium educational program offered by a nature and science museum located in the southwestern United States. This site was selected in particular due to its many unique attributes, which make it suitable for a case study. First, the planetarium programming offered by the museum is mostly based on live, interactive programs using digital dome technology. Additionally, this research site’s planetarium programming uses a portable planetarium that travels to different sites, including schools. Finally, the research site employs a large number of educators with a variety of educational backgrounds that range from no formal education training or experience at all to educators who have no prior education training or experience.

Participants and sample size

The participants for this study were selected from a purposeful sample (Creswell, 2013) of educators at the museum who taught planetarium programs. All planetarium educators at the museum were told about the study and given an opportunity to participate. After being provided with an informational packet, three planetarium educators provided their consent to participate in the study. The three participants in this study are Anne, Brittany, and Celina. All of the participants are female, and have diverse personal and educational experiences. Their experiences as a planetarium educator at the museum ranged from 6 months to 35 years.

Data collection

Qualitative data was collected from observations and individual interviews with participants. Data collection methods included field notes and audio-recording during interviews and observations. The initial interview used an open-ended, semi-structured interview protocol. The initial interviews were 30-45 minutes in length. During the initial interview participants were asked to questions regarding their educational background, experience, teaching methods, views on professional development, and educational philosophies.

After the initial interview, the researcher conducted an observation of the planetarium educators teaching a 45-minute planetarium program. Due to the traveling nature of the portable planetarium, the observations were conducted in different elementary school locations. Observations were conducted in a 5-meter portable planetarium dome that used an omni-directional, fisheye lens projector located in the center. The dome used in this study was capable of accommodating up to 26 students, who would sit in a concentric configuration on the floor. The programs were taught by two planetarium educators at a time, who would walk around the perimeter of the dome while teaching. The programs were taught by two planetarium educators at a time. Observation protocol included the researcher recording descriptive and reflective notes during the program. The descriptive and reflective notes taken by the researcher were focused on the teaching methods used by the planetarium educators during the program. The methods of observation included the researcher sitting in the planetarium program being taught, recording field observations, and obtaining audio recording of the program.

A final interview was conducted with individual participants after the researcher observed the program. The final interview used an open-ended, semi-structured interview protocol, and required approximately 15-20 minutes of the participants’ time. The interviews were audio recorded, and the researcher also kept field notes from the interview. During the final interview, participants were asked questions related to the planetarium program observed by the researcher. Specifically, questions focused on the goals and teaching methods used by the instructor during the observed program.

Data analysis

An initial analysis of the data was conducted to identify relevant themes. After identifying themes, a second analysis was conducted by the researcher to further refine the themes. Themes were first analyzed in terms of each individual participant, and then in relation between participants. A word table was also used to help identify “similarities and differences among the cases” (Creswell, 2013, p. 200). The software program Wordle.net was used in combination with the word table to represent the data visually with a word cloud. Field notes from observations and interview transcripts were also analyzed to identify teaching methods used by the planetarium educators in this study. Teaching methods were coded using descriptive terminology. Additionally, the post-interview transcripts were analyzed to identify participant responses to the teaching methods used in the planetarium, and factors they believed influenced their decisions to use those methods. Participant responses were analyzed through a science education constructivist lens to compare the methods and beliefs of the participants in the study with principles of constructivist practice in science education. Additionally, the data were analyzed for content and trends that appear throughout the data. From the trends in data, this researcher developed naturalistic generalizations about the specific case from examining the data in this study. However, due to the limited scope of the study it will be difficult to form larger generalizations from the data.

Table 1
Observed Planetarium Teaching Methods

<table>
<thead>
<tr>
<th>Participant</th>
<th>Teaching Method</th>
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<tbody>
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<td>Anne</td>
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<td>Brittany</td>
<td>Questioning</td>
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<tr>
<td>Celina</td>
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Findings

After data analysis the findings of this study are presented by first examining the teaching methods used by the participants in the study, followed by the factors that influence their teaching methods.

Teaching methods

There were a number of teaching methods used by each educator. After analyzing field notes, and discussing the teaching methods used with each educator, the teaching methods used during planetarium programs were coded (Table 1). The teaching methods used by the participants included questioning, explanation, kinesthetic, modeling, observation, identification skills, reinforcement, prediction, and story-telling.

Anne and Brittany

Anne and Brittany taught a portable planetarium program together at a local elementary school. During the transportation and set up of the planetarium, both educators discussed and shared content ideas. Brittany made the comment "I've been doing this activity with identify directions, using hand motions to know what direction to look in the sky." During the planetarium set up Anne and Brittany continued to discuss what content they would focus on during the program. Content included focus on rotation versus revolution, and whether or not the term "orbit" is included in the state's science standards. Anne also talked with the teacher at the school to determine the content that should be covered in the program. The teacher asked that the educators review the solar system.

Once the students entered, both Anne and Brittany taught the program together and each used a variety of teaching methods. Anne used a combination of questioning, explanation, kinesthetic, modeling, observation, identification skills, and reinforcement techniques. Anne began the program by using a combination of questioning and observation methods by asking students to use their observation skills and identify what they saw as they entered the planetarium. Using the planetarium software, Anne sped up time to illustrate the motion of objects in the sky. While doing so, Anne employed kinesthetic methodology by asking students to place their hands on the ground to see if they could feel the Earth move. She then modeled the rotation of the Earth by using the projector in the middle of the planetarium as a representation of the sun and her face as a representation of the Earth. She then spun around to model the rotation of the Earth and day/night cycle. She continued the model by walking in a circle around the dome to model the revolution of the Earth.

As the program continued, the planetarium displayed the stars of the night sky. Anne helped students to identify the Big Dipper by creating an illustration of the constellation. She then continued by using kinesthetic methods to show students how to use the Big Dipper to identify Polaris, the North Star. Students used their hands to create a straight line from two stars in the Big Dipper to the next brightest star, which is Polaris. As the program continued, Anne displayed images of planets in the solar system, and provided explanation and details about each planet.

The program concluded by Anne reinforcing what the students had learned and asking students to explain the differences between rotation and revolution. In a follow up interview, Anne stated that her main goal was to review the concepts of rotation, revolution, and planets of the solar system. She felt that the methods she used in the program were effective in achieving her goal.

During the same program, Brittany also used a variety of teaching methods. Brit-

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tany used a combination of questioning, explanation, observation, prediction, kinaesthetic, identification skills, reinforcement, and story-telling teaching methods. Before Anne sped up time in the planetarium, Brittany asked students to make a prediction of where the sun will be later in the afternoon, and to demonstrate their answer by pointing to a spot in the planetarium. As time was sped up, she asked students to evaluate their prediction, and explained that as the Earth rotates the sun appears to move from the east to the west in the sky.

When the planetarium program switched to the night sky, Brittany combined kinaesthetic methodology to teach identification skill methodology. She asked a student to stand up, and pointed the student in a certain direction. Brittany then taught the students the phrase “If I put my left to the west, and my right to the east, then my nose knows where the north is.” Brittany later explained that this method was something she learned as a young girl, and was useful in helping her identify the direction she was facing at night. Later in the program, Brittany helped students identify the constellation Cassiopeia. She then told a story related to queen Cassiopeia, and incorporated other constellations such as the Big Bear and Little Bear.

In a follow up interview, Brittany said that her goal was to help student review rotation and revolution and show them some interesting objects such as planets and galaxies. However, she said that she felt most of her time was spent explaining rather than using more interactive elements because the students in the program were talkative and not receptive to the program. She said that when students are not receptive, that limits the types of teaching methods she can use in the program.

**Celina**

Celina taught a portable planetarium program with another educator who was not a participant in the study. The program was taught at a spring break camp for elementary aged students. After the planetarium was set up, Celina talked with the teacher on site to ask about student ages and content to be covered. The students had been studying planets and nebulae, and the teacher requested that material to be addressed in the program. Prior to the program Celina also practiced using the technology to familiarize herself with the order of content she planned covering with students.

When teaching the program, Celina used a variety of teaching methods: a combination of questioning, explanation, observation, prediction, modeling, and story-telling techniques. As students entered the planetarium, Celina asked them to make observations about what they noticed in the daytime sky being displayed on the dome. As she sped up the time of day within the planetarium, Celina provided explanation to the students that the sun appeared to be moving because the Earth was rotating. She then modeled this phenomena, using the projector to represent the sun and her nose was “Mount Nose.” She began to slowly spin, and explained that her motion represented the day/night cycle we have on Earth.

As the program began to display the night sky, Celina pointed out the moon to the students and described the phases of the moon. She asked students to predict where the moon would be the next day by having them point to a location in the sky. Celina used the planetarium software to move the time to the next day so students could evaluate their predictions. Later in the program, Celina showed students the constellation Orion in the night sky, and told the students a story about Orion the Hunter.

Celina concluded the program by showing students images of Jupiter and explaining that the big red spot on the planet is a storm similar to a hurricane on Earth. However, at this point in the show, students were becoming talkative and Celina ended the show 5 minutes early.

In a follow up interview, Celina described her goal for the program was to get students interested in space. She described her experience as being largely successful, but noted that she had trouble towards the end of the program as the students were becoming increasingly talkative. She attributed the students’ attitudes to their young age and their limited attention span.

**Themes**

After analyzing the interview transcripts, a number of themes emerged as factors that influence planetarium educator teaching methods. The themes include experience, education, purpose and goals, audience, and technology. Using these themes, a word cloud was created using words from participant transcripts that were associated with each theme (Figure 1). The word cloud illustrates words and phrases that appeared most frequently in conversation. It is evident from the word cloud that experience was the most frequently used word in discussion with teachers.

**Experience**

One factor discussed by participants that influenced their decisions as planetarium educators was personal experience. Each participant spoke extensively about their experiences, and the influences those experiences had on them. The experiences discussed (Continues on page 26)
Astronomical experiences

Anne and Brittany both discussed their experiences with astronomy. In contrast, Celina did not discuss having extensive experience with astronomy apart from her education. Anne described her experiences with astronomy as having an influence on her as an educator. During the initial interview, she discussed her experience with astronomy as a young child. She recalled not being aware about many constellations except for the Big Dipper and Orion, but being impressed when a family member took her outside to observe the night sky through a telescope. To Anne, the sky looked different from the pictures of the stars she had seen in books and on screens. She additionally recalled an experience she had when her grandparents took her to Griffith Observatory (in Los Angeles). To Anne, these experiences made astronomy “a lot more interesting.” This experience of using a telescope and visiting an observatory was more impactful for Anne than simply reading about that information from a book.

Anne continued to explain later in the interview that she tries to incorporate real life experiences into planetarium programs. She stated:

I do ask them things like “Have you ever been out to your grandparent's house or had a house out on the lake or something, or up in the mountains? Have you been to somewhere where you can see dark skies?” A lot of them have and they go “Oh yeah, yeah, I’ve seen the Milky Way.” If I ask them questions like that, they remember things that they’ve seen. But if you don’t ask them the questions, then they forget.

Anne explained that creating connections to real world experiences is a part of her strategy as a planetarium educator. She uses questioning strategies to help students make those connections to the real world, which Anne believes helps students remember the content.

Brittany also discussed her experience with astronomy as being influential to her as a planetarium educator. For Brittany, it was her experiences with astronomy that drew her into planetarium education. She recalled always wanting to study planets, saying “planetology is my real love.” She also described a vivid experience with the night sky and with planetariums.

Well, I’ve always been an amateur astronomer. When I was a teenager, we moved to El Paso, and that’s dark sky out there, so I got to see lots of stars and I went to the planetarium in New York on the way to Texas and fell in love with the planetarium.

Brittany's discussion focused on how her experiences moved her into being a planetarium educator due to her passion for studying planets and being exposed to planetariums as a child. Brittany also further elaborated about her experiences with astronomy as an amateur astronomer. She has over twenty years of experience hosting star parties with a statewide astronomical society. Additionally, she talked in detail about hosting a star party in Cancun to observe Halley's Comet. The experiences described by Brittany highlighted her enthusiasm and passion for astronomy, which has impacted her as a planetarium educator.

Professional experiences

Each participant described the importance of their professional experiences, which included specific workplace experiences in the planetarium, collaborations with other educators, and additional professional experiences that have been influential.

Anne has over 15 years of experience as a planetarium educator. She described her professional experience of moving from a fixed dome, which is a planetarium that resides within a permanent structure, to teaching in a portable planetarium. In the fixed dome, Anne was behind the control console, and able to plan out and organize shows with precision. However, she explained she found the transition to the portable dome to be really difficult, because instead of being behind the console with a script in front of her, she was on the floor with the students and was required to interact with them in a way she was not used to. However, after working with another educator and with additional practice, she became confident in teaching programs in the portable planetarium. She explained:

So I worked with [another educator] quite a bit, learned some of his techniques for dealing with kids who don’t want to listen to you and how to make them want to listen and just how to get around that whole “I’m sitting here behind them and they’re all taller than me” mentality. I don’t sit anymore, I walk, so that made a huge difference. He said “You just need to walk around, you just need to not sit, but you need to be up on the periphery all the time” and that made a huge difference. I feel like I had more presence, so I could get their attention a little bit better.

Brittany also discussed the influence on her teaching from professional experiences and collaborations. She has been a member of an international organization of planetarium educators and researchers for the past 35 years. During the interview, she stated “I know that I got a lot out of my interaction with other educators.” Some teaching strategies that Brittany mentioned she used as a result of professional collaborations included “teaching with movement,” using models, and incorporating light bars into the planetarium. She stated that she learned about teaching with movement after reading a paper published by the international organization she was a member of. She began incorporating models of the Earth and moon to represent celestial motion after seeing another educator use the models while teaching a program. Brittany stated that she had conversation with a vendor during a convention about using a light bar to help students see slightly better in the planetarium, and that she planned to purchase one to use in programs.

At the time of the interview, Celina had six months of professional experience as a planetarium educator. When she discussed her professional experience, the focus of her statements involved her transition into becoming a planetarium educator. She had been a software engineer. She stated that she did not like the corporate world, and left to become an educator. Her focus as an educator was in science education because of her engineering background and interest in physics and astronomy. Celina also discussed how what she has learned about the strategies used in planetarium education has come from her experiences with other educators. She has learned how to use the technology to run the planetarium program, and she also learned several teaching strategies such as questioning and story-telling from watching other educators teach.

Education

Education is one factor that has played an influential role for all planetarium educators. Each has diverse educational experiences.

Anne has a master's degree in interdisciplinary studies, combining women's studies and art, and she does have experience with astronomy classes as well. Brittany has a bachelor's degree in geology. Celina has a master's degree in curriculum & instruction with an emphasis in science education. Each of the participants discussed how their educational experiences influenced them as planetarium educators.

While Anne's degree was in women's studies and art, she discussed how that led her into planetarium education. She recalled that as part of her art program she interned at a museum that had a special exhibit, and at the end of her internship someone approached her to volunteer in the planetarium. It was at the same time that she was volunteering (Continues on page 28)
in the planetarium that she began taking an astronomy course. She was impressed by what she learned and enjoyed getting to go out at night and observe the night sky with a telescope. It was her volunteering experience combined with her astronomy course that led her into becoming a planetarium educator.

Brittany’s discussion of her educational background focused on impacts of specific courses and instructors, rather than her degree in geology. She discussed how one instructor in particular, whom she refers to as a “role model,” influenced the teaching methods she uses.

I had an astronomy professor at community college when I was much younger, and I took one of those courses. He was a questioner. He would ask trick questions. He was really good. He’s the one who opened up the job for me to teach ... and then he used the planetarium for reinforcement. And experience, that kind of thing. That’s why I like the idea that a lot of different things instead of just one thing, one way.

According to Brittany, this professor used questioning techniques in combination with the planetarium to provide students with an experience to reinforce learning. These strategies are key strategies Brittany stated that she uses in her teaching, and she can attribute her methodology to an astronomy professor she had in college.

Celina has a master’s degree in curriculum & instruction, and much of her discussion on education focused on how her degree helped inform her methodology. Her educational experience made her aware of curriculum-based approaches, and also made her aware of student-centered teaching methodology. During her program, Celina also took two astronomy courses that provided her with specific teaching lessons. She explained:

Hands on methods was something that we learned and I took two astronomy courses. We had different techniques that we learned, different experiments that we learned to try to help students understand and help them get more interested in the topic.

Celina elaborated that one specific method she learned from her educational experience included using Play-Doh to create models of the Earth and moon, and use those to represent scale distances in the solar system. Celina was able to identify how her formal education training through her master’s program has influenced her approaches as a planetarium educator.

Purpose and Goals

The interviews with educators also highlighted similar views among them regarding the purpose for planetarium education. The common theme was to inspire audiences. While their views on the purpose of planetarium education were similar, there were some differences between them on specific goals the educators had for planetarium programs.

For Anne, the purpose of planetarium is to “get [students] interested in what’s up there.” She continued:

There’s no one class, except an astronomy class, that really talks about space. We really need to know more about it and they don’t really talk much about it in classes. They have a very, very small section of it in the third grade and then they don’t really do it much in the other grade levels, except seasons and that kind of thing ... it’s not like the Apollo days, when everyone’s just so excited about space, but there’s so many more interesting things going on.

Anne described that one purpose for planetarium education is to make up for a lack of space education in the formal classroom. Additionally, she believes there has been a change in interests of students, and there is a lack of interest in space. In order to address this deficiency in education and lack of interest from students, she explained that the goals for planetarium education should be to “help the teachers, push the ideas, in a real environment or way they can actually see what they’re talking about in class.” She believes the goal of planetarium education should be to provide students with additional experiences that supplement what they are learning in the classroom. This influences her decisions as a planetarium educator because she stated that she tries to find ways to introduce real-world experiences into her planetarium programs.

Brittany also views the purpose of planetarium education as inspiring students. However, she continued “but at the same time inspire people to enjoy the sky and related sciences.” For Brittany, the planetarium is a tool that can be used to inspire students to pursue many fields of science, rather than just astronomy. The goal she has for planetarium education is that students recognize that “the universe is a beautiful place.” She explained that to accomplish this goal she uses the planetarium to show students “the pretty pictures” to allow them to experience the beauty of the universe.

Celina views the purpose of planetarium education as making education appealing for students. She explained:

Planetarium education is one of those things that I feel is really innovative and helpful because if you’re just sitting in a classroom with lecturing based topics, students might not [be engaged] ... I think the planetarium is a little bit better of a way to help kids understand and it’s just pretty interesting.

Celina views the planetarium as a way to make education interesting to students as opposed to lecture. She further elaborated that with students interested in learning, her goals for planetarium education are for students to leave with an “understanding of how vast the universe is.” She views the planetarium as a useful tool in engaging students, and then using that interest and engagement to teach them specific content.

Audience

Another factor that influenced how participants taught planetarium programs was the specific audiences being taught. Each participant identified using different teaching methods with younger students than they would use with older students. However, some methods were used regardless of age of the participants.

For younger students, participants discussed finding methods to keep their attention focused on the program. Anne explained that she used the planetarium software to direct the attention of younger students to what she wants them to look at. Brittany also discusses using multiple methods with younger students. She said that one cue for her to change her teaching method was when she would “see them start wiggling around and talking to each other.” When Brittany sees students losing attention, she explained that she would switch between questioning, kinesthetic, and modeling techniques. Celina also discussed keeping content age appropriate. She explained:

With the younger kids, I think you just kind of overwhelm them with too much detail, then they kind of get lost. I think if you just show them a lot of different basic things, that might be a little bit better.

While Anne and Brittany discussed changing methodologies based on age, Celina focused on the type of content. However, each participant discussed the importance of changing how planetarium education programs are taught to accommodate the age of the audience.

Setting/technology

Another factor that was influential to how Anne and Brittany taught in the planetarium is technology. Both educators had experience in multiple planetarium settings, and discussed the differences between the types of planetariums they taught in. Celina only had six months of experience in portable planetariums, and did not discuss technology as a factor that influenced her teaching.
Anne discussed the trouble she faced moving from a fixed dome to a portable planetarium. In the fixed dome, Anne described how she was able to use the computer to “make a program that was pretty organized.” The program was automated, and followed a tight schedule. However, with the portable planetarium, she discussed how she had to control the show throughout the program while also discussing the content. While she sees benefits in the flexibility of changing the program in a portable planetarium to meet audience needs, she Anne identified the different types of planetarium technology as a factor that influenced her teaching style.

Brittany also discussed the differences between teaching in different types of planetariums. One difference she mentioned had to deal with space. She explained:

In the [fixed]...we had a place that was sort of like a diagonal stage area where we could do things. But at the Museum, it was a small dome, and they could fit 30 people in seats and a big machine in the middle of the floor. So we didn’t have room to do very much.

This limited space depending on the type of planetarium used is one factor that influences Brittany’s teaching style.

**Conclusion: Discussion**

The purpose of this study was to identify the factors that influence teaching methods for planetarium educators at a science museum located in the southwestern United States. It is evident from the findings that there are many factors that inform planetarium educator teaching methodology. Results from this study found that teaching methods used by the participants included questioning, explanation, kinesthetic, modeling, observation, identification skills, reinforcement, prediction, and story-telling. The teaching methods of participants were informed by previous astronomical and professional experiences, education, purposes and goals for planetarium education, audience, and technology.

Findings showed a variety of factors that influenced the teaching methods used by planetarium educators; however, as highlighted by the word cloud, experience was the most discussed factor as being influential to educator teaching methodology. Experiences discussed by participants included both real-life experiences with astronomy and professional experiences. Both Anne and Brittany shared stories about how connections with astronomy and real-life experiences of looking at the night sky were influential to them. Anne described the influence her experiences with astronomy had on her, and she wanted to use the planetarium to give students similar experiences. Her teaching methodology included attempting to connect the content with real-world experiences of students. Brittany shared stories of hosting star parties around the world, including viewing Halley’s comet in Cancun. Her experiences highlighted her passion for astronomy, and were in line with her goal of showing people that the Universe is a beautiful place.

The desire of the educators in this study wanting to connect content with real-life experiences is consistent with a Deweyan philosophy of education. Dewey (1916) believed that “an ounce of experience is better than a ton of theory” (p.75) because only experience can verify theory. Additionally, according to Dewey (1907), “the only way to unite the parts of the system is to unite each to life” (p. 89). This concept of uniting content and experiences based on everyday life is a recurring theme throughout Dewey’s writings on the need for experience in education, and it is consistent with the approach taken by Anne and Brittany in planetarium education.

Another interesting finding involved the teaching methods used by planetarium educators, and how they were used. There were a number of methods used to encourage student interest, such as kinesthetic, modeling, making predictions, and story-telling, which are in line with science education constructivist teaching methodologies. These methods allowed students to construct ideas that were consistent with scientific discovery and the nature of science, such as with using the technique of “Mount Nose” to teach the concept of rotation and revolution. Interestingly, while the educators did not describe familiarity with constructivist philosophy during their interviews, to varying degrees each participant used methodology consistent with that philosophy.

The differences in planetarium settings also had an impactful effect on planetarium educators. Anne discussed the difficulty of transitioning from a fixed-dome planetarium to portable planetarium. While confident in a fixed-dome setting, she was less comfortable with her abilities to teach to students in a portable setting. Brittany discussed how space limitations of different types of planetariums directly impacted the type of content she could teach. Different planetarium technologies have strengths and weaknesses that should be considered when planning planetarium content.

**Implications**

The results of this study have a number of implications for planetarium educators and science centers. First, educators should be aware of the factors that influence their teaching methods, and how they decide on what content to address in live-planetarium shows. In this study, one of the largest influential factors on planetarium educators was experience. Educators should be aware of their own experiences and find ways to incorporate that into their planetarium programs. It may also be beneficial for educators to seek out additional astronomical experiences that they can then bring back into their educational programs. Additionally, having a well-defined understanding of the purpose for planetarium education as well as the goals hoped to be achieved can lead to refinement of planetarium programs.

The findings of this study are also valuable for leaders at science centers and museums who are responsible for professional development of planetarium educators. Professional development should embrace the diversity of educator experiences and address content appropriate for the diversity of audiences served in the planetarium. It will also be important to incorporate reflective opportunities into professional development sessions so that planetarium educators can understand the importance of their own experiences in how they teach. Just as formal educator training has shifted “its focus from skills to knowledge and reflection,” (Grossman, Hammerness, & McDonald, 2009, p.274) so too must professional development for planetarium educators. Additionally, workplace experience and collaborations with other planetarium educators were influential factors for the participants in this study. It will be important for professional development opportunities to emphasize these experiences and provide opportunities for educators to collaborate with each to share ideas and help with professional growth.

**Limitations**

There are several limitations with this study. First, due to the limited size of this case study the presented findings may not be generalizable to the larger planetarium educator community. Another potential limitation of this study is that one aspect of data collection relied on participant self-report. One way this study sought to address this limitation is by collecting data using multiple methods, including interviews and observations. Finally, there may be possible limitations that come from researcher positionality and post-positivist approach to the proposed study. This approach may have introduced researcher bias to both data collection and interpretation. This study sought to minimize this impact by discussing researcher positionality, and using validated instruments and methodology for data collection and analysis.

(Continues on page 78)
Areas for future research

There are several areas where this research could be extended. First, this study was conducted at a single museum with a limited number of participants. Expanding the study to include larger sample sizes may provide additional insights into the factors that influence planetarium educator teaching methods.

Another area of future research involves setting. As was revealed in the results of the study, there are key differences between fixed-dome planetariums and portable planetariums. It would be worthwhile to understand any similarities and differences of teaching methodologies between using different types of planetariums and planetarium programs.

References


