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Integrating Planetarium and Classroom Instruction to Engage Children in the Practices of Science

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Abstract. Children should be learning how to engage in science practices in ways that reflect the domain-specific nature of learning to "do science." Our work explores methods for engaging children in science practices in astronomy, such as developing representations and models, using evidence, and organizing observations into patterns. We used research literature on learning in formal and informal environments to develop learning environment design principles that integrate classroom and planetarium instruction. These were used to develop an intervention for first-grade students. Children first participated in an anticipatory lesson in their classroom. They next visited the planetarium, where they were engaged in a modular planetarium design program that mixed live interaction with video sequences. Finally, children applied what they learned as they engaged in activities in their classroom. Initial analysis of interviews conducted with children before and after instruction suggest the intervention was successful in improving students' reasoning about the Moon and illustrates successful methods of integrating a field trip with a classroom-based lesson.

1. Rationale

This project was designed to accomplish two goals: explore methods of engaging children in full-dome planetarium programs and design planetarium instruction in ways that engage students in an integration of science content and practice. The first goal was motivated by our prior research on planetarium professionals' beliefs about the design of the planetarium as a learning environment. Our research found that planetarium professionals' goals for elementary students include both increasing their interest in astronomy and in supporting their learning of scientific concepts. To reach these goals, planetarium professionals strongly support the need for live interaction with their audiences (Small & Plummer 2010). The goals, beliefs, and pedagogical choices made by planetarium professionals reflect a focus on learner-centered, motivationally-oriented, and socioculturally-centered perspectives on how to design instruction in the planetarium (Plummer & Small 2013). Further, full-dome technology, used in an increasing number of planetariums worldwide, has the capability to allow interactions with the audience as well as impressive visual experiences. And yet, commercial planetarium programs are often not designed to maximize the interaction between audience and presenter.

Using our research on planetarium professionals (Plummer & Small 2013, Small & Plummer 2010) and our understanding of how children learn (e.g. NRC 2000, 2007), we have proposed that a planetarium program built with a modular design could effectively meld the needs of the planetarium community and audiences, especially young audiences, with the capability of the full-dome planetarium. The *modular planetarium design* is built around a narrative structure and includes both short (~5 minutes) pre-rendered video segments as well as directions for the planetarium operator to engage the audience between video segments. Our research suggests that planetarium professionals are already using similar strategies by combing video segments with live interaction (Small & Plummer 2010), but few commercially available programs combined video and live interaction in this fashion. The modular design allows for shorter times between passive experiences (like watching video) and live interactions, and makes it possible for the planetarium operator to tailor a program to the needs of an audience.

Our second goal was motivated by the *Framework for K–12 Science Education* (NRC 2012), which emphasizes the importance of engaging children in learning science through the integration of core science ideas, practices of science, and cross-cutting themes. More research is needed to understand how to best support teachers and students in successfully implementing this integration and to extend this beyond the science classroom. *Learning Science in Informal Environments* (NRC 2009) suggests that designed spaces—such as museums and planetariums—can be educational venues that support science learning through engagement in science practices. We therefore worked towards contributing to the on-going conversation around engaging children in scientific practices by looking at how field trips to planetariums can be part of this endeavor.

2. Learning Environment Design Principles

Our project examined how a field trip to a planetarium can be an opportunity for children to improve their engagement in scientific practices while learning astronomy. Research literature on learning in formal and informal environments was used to develop a series of *learning environment design principles*, which can be used to guide the development of successful instructional interventions for planetariums.

Principle 1: *Embed the planetarium program between a pre-visit and post-visit lesson*. Students learn more from field trips when they are embedded between classes before and after the trip (DeWitt & Storksdieck 2008).

Principle 2: *Prepare students for the field trip through a pre-visit lesson that does not introduce new content but engages children in thinking about their prior knowledge, allowing for pre-assessment*. Students learn more on field trips when they are oriented to the nature of the field trip and expected experiences (DeWitt & Storksdieck 2008).

Principle 3: *During the planetarium program, engage children in a combination of pre-recorded segments interspersed with live discussion*. Our modular program design takes advantage of a structured planetarium program using digital visualization on the planetarium dome with the flexibility to engage the audience in live discussion between short video segments (Small & Plummer 2010). These live interactions are important because children need to be actively engaged to learn (NRC 2004). Further live engagement and video segments should engage children using strategies that help them focus on key conceptual elements, such as checking predictions and mimicking patterns kinesthetically (Plummer 2009).

Principle 4: *Use the planetarium program to go beyond delivering content, such as through modeling engagement in science practices*. With appropriate support, young children are capable of sophisticated engagement in the practices of science (NRC 2007). Planetarium programs can model engagement in science practices, such as providing a character that engages in a scientific investigation, or by the presenter engaging children in making and checking their predictions.

Principle 5: *Focus the post-visit lesson on applying ideas learned during the planetarium program rather than on presenting new content*. Applying the concepts they observed during the program aids their memory retention and provides additional opportunities for making sense of the concepts with their peers. Building on the same content as was covered in the program may allow elementary teachers to more effectively implement the activities in their classrooms.

3. Application of the Design

We used the learning environment design principles to develop a program for a set of first grade classes. The children engaged in a pre-visit lesson in their classroom, then visited the planetarium on the next day, and participated in a follow-up lesson in their classroom on the final day.

During the pre-visit lesson, our goal was to engage children in making critical observations of the world around them. Children were asked, “What can we see in the daytime sky?” They then went to the classroom windows to make observations of the sky, followed by recording their observations. They engaged in a discussion of what they can see in the nighttime sky, followed by categorizing objects they identified in the day and night sky as being found in space or not. The children were asked, “How do you think we could find out whether the Moon can be up during the daytime or only at night?” Our goal was to encourage the children to think about how astronomers focus their investigations on using observational evidence. The final discussion provided an overview of their upcoming planetarium visit.

The planetarium program *The Moon* was written by the second author, Kim Small, and produced by Audio Visual Imagineering. Each video clip focuses on a different element of observing the Moon: the surface features of the Moon, the apparent motion of the Moon, and the cycle of lunar phases. Each module is accompanied by a pre-module discussion and post-module discussion. For example, Module 1 focused on the surface features of the Moon: craters, maria, and highlands. Before the children watched the video, the planetarium director led the children in comparing and contrasting observations of the Earth and Moon. After the video, the children compared and contrasted their observations of the near and far sides of the Moon. The animated child in the planetarium modules modeled many scientific practices, such as recording observations in a science notebook.

The next day, children had the opportunity to apply what they learned about the Moon in their classroom, with their peers. For example, the first activity corresponded to the surface features of the Moon module from the planetarium show. Small groups of children were given a series of six images of the Moon ranging from views from the Earth to close-up views, including ones of astronauts on the Moon. Children were asked, “Which of these pictures help you understand what the ground on the Moon is like?” Children were then asked to share with the class which images they chose and why they thought that image helped them better understand the surface of the Moon. This activity encouraged children to think about how images can be used as evidence for claims about the nature of the Moon. Other post-instruction activities engaged children in developing representations and making predictions based on representations.

4. Evaluating Our Design and Next Steps

We are in the process of evaluating the instructional intervention described above. Thirty-six first grade students were interviewed before and after the three-day intervention. Interviews questions addressed both conceptual understanding and the children’s engagement in science practices. Analysis shows improvement in students’ reasoning about the Moon. For example, children were asked to draw pictures of the Moon, before and after instruction. Prior to instruction, 68% of the children only drew craters, and few used the scientific term “craters.” The remaining children drew only blank images of the shape of the Moon, without any surface features. After instruction, 86% drew at least one feature and 59% drew two or more features on the Moon, now including lunar maria and highlands. Children learned both conceptual knowledge of the surface of the Moon and demonstrated their ability to create a scientific representation that communicates their understanding of the Moon.

Our goal in this work was to build on the broad literature on how to support learning across formal and informal environments towards creating experiences that support children in learning about astronomy in both the classroom and the planetarium. The framework presented here allowed us to create an environment in which children were engaged in scientific practices while learning about the Moon; their experiences were seamlessly connected across classroom lessons and field trip experiences. However, we also had a high level of control over the experiences: the second author taught both the classroom lessons and the planetarium lesson. More work is needed to investigate how classroom teachers and planetarium educators can work together to support student learning using these principles.

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