Impact on children's conceptual constructs regarding observational features of the Moon: A look at elements of program and instruction design for early elementary-aged students

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With the increased impact of fulldome technology on the planetarium community, now seems like a reasonable time to pause and reflect on the educational impact and potential of the presentations and programs delivered in these unique learning environments. Similar to research within the planetarium and other informal science education (ISE) fields decades ago (Bishop, 1980; Freidman, Schatz, and Sneider, 1976), prior to the invention of fulldome projectors, several more recent studies have concluded that professionals in the planetarium field believe that the inclusion of active learning in planetarium presentations and programs is important for conceptual learning (Croft, 2008; Littman, 2009; Small and Plummer, 2010). This is consistent with educational research findings that indicate that active experiences for audiences are more effective in promoting the types of cognitive engagement that produce affective and cognitive changes (e.g., Bell et al., 2009; Brazell and Espinoza, 2009; Donovan and Bransford, 2005). Providing active learning experiences for younger audiences is especially important.

This study looks at how a modular designed (combination of live interaction and pre-recorded video segments) planetarium program combined with classroom instruction affected children's conceptual understanding of observational features of the Moon. It includes a discussion of how program elements and instructional design may have supported change in student understanding. Our research goals were to: a) investigate how to support young children in learning astronomy using a modular planetarium design and b) explore elements of program and instruction design that support children in learning astronomy in ways that integrate science practices, such as observation, and cross-cutting concepts, such as patterns.

Our second research goal may have implications for education beyond the planetarium field as it reflects the goals of the *Next Generation Science Standards* (NGSS Lead States, 2013) to engage children in a fusion of core ideas, science practices, and cross-cutting concepts.

To explore our research goals we worked with Audio Visual Imagineering in creating a modular designed planetarium program called *The Moon*. Practices of science, appropriate to early elementary school and this domain, were embedded in the program including: scientific observation and creating and using models and representations. Students in our study also participated in two classroom lessons (before and after the program) that engaged them with three observational astronomy constructs targeted by *The Moon* program: lunar surface features, the Moon's apparent motion, and the changing lunar phases. Our study was guided by the following research questions:

1. How do children's ideas about the Moon change as a result of this instructional intervention?

2. How did elements of program and instruction design impact student learning?

Students in four 1st grade classrooms from a suburban U.S. elementary school participated in this study. The first author taught each of the lessons over the span of three days: an introductory classroom lesson, the planetarium program, and the final classroom lesson. A sample of students from each classroom (N=36) was interviewed about a week before and after instruction. Each student was only asked questions relating to two of the three Moon topics:

1. The surface features of the Moon (n = 22)

2. The apparent motion of the Moon (n = 25)

3. The monthly cycle of lunar phases (n = 26)

Codes describing students' ideas were developed for each interview protocol. We began this process by considering prior research on children's conceptions about the Moon (e.g. Plummer, 2009; Trundle et al., 2007) and then developing additional codes based on the interviews. To determine whether or not codes could be used reliably, both authors coded a subset of the interviews (~20%). An inter-rater agreement of at least 80% was reached for each category; all disagreements were discussed leading to agreement.

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Analysis: Our findings show that students' conceptual understanding improved in all three categories. To address our first research question, we include the categories that most compellingly convey how students' conceptual understanding changed. To address our second research question, we discuss those elements of instruction that appear to have influenced the change observed in student understanding.

<u>Surface features of the Moon</u> – Students were asked to draw a picture of the Moon. Codes were developed to indicate the number of scientifically correct surface features (craters, Maria, highland) students included on their drawings. Table 1 shows the shift in the number of scientific features children included in their drawings with fifteen students (68 %) improving and no students regressing.

Table 1.	**Pre (n=22)**	**Post (n=22)**
Maria, Highlands, Craters	0	8 (36%)
Two scientific features	0	5 (23%)
One scientific feature	15 (68%)	6 (27%)
None or other	7 (32%)	3 (14%)

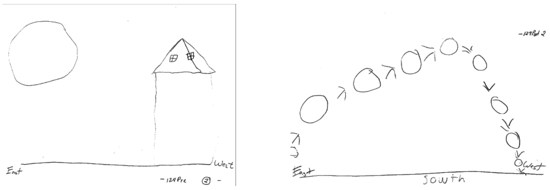
Example: *Before & after instruction*

The scientific process of sketching one's observations is illustrated within *The Moon* program as the main character draws an image of the Moon, labeling the craters, Maria and highland as part of his lunar observations. Further, the live components of *The Moon* program allowed students additional opportunities to be actively engaged; they discussed the Moon's surface features by comparing and contrasting the surface of the Moon and the Earth as well as the near side and far side of the Moon. These instructional elements may have provided students with a path to create conceptual constructs of the targeted knowledge by actively engaging students with visually representations of the concepts.

<u>The apparent motion of the Moon</u> - Students were given a piece of paper with a ground and the directions East and West labeled at the bottom. They were then asked to draw a picture of how the Moon would appear throughout the day/night. A set of codes were developed featuring levels of understanding with the scientific correct conception including that the Moon rises in the East, moves across the sky in a curved path, and sets in the West. Table 2 shows that approximately half of the students did not believe that the Moon moved prior to instruction with another 44% describing a motion that was not scientifically accurate (not rising E and setting W). After instruction, most students (80%) improved in how they described of the Moon's apparent motion.

Table 2.	**Pre (n=25)**	**Post (n=25)**
Moon rises E to W	2 (8%)	18 (72%)
Moon rises/sets on opposite sides of sky	0	1 (4%)
Moon appears to move	11 (44%)	5 (20%)
No motion described	12 (48%)	1 (4%)

Example: *Before and after instruction*



Again, this concept was modeled in the planetarium program as the main character drew the apparent motion of the Moon in his notebook. This motion was also kinesthetically presented to the students as they were asked several times throughout the program to point and follow the apparent motion of the Moon across the planetarium dome. Prior to viewing this portion of *The Moon* program, students addressed their personal constructs of the Moon's apparent motion as they were asked to predict by drawing with their finger how they thought the Moon would move across the sky in a single day. Classroom instruction after the planetarium visit also challenged students to demonstrate how the Moon appears to move through an activity where students had to put several images of the Moon throughout the day in the correct order. The combination of modeling in the program, the use of kinesthetic activities, the realization and confrontation of personal constructs through prediction and post-planetarium visit reinforcement all seem to have played a major role in changing students understanding of daily apparent motion of the Moon. This particular topic used a large amount and variety of active instruction and science practices as instructional elements, which may explain why the greatest improvement of student conceptual understanding was observed in this area.

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The monthly cycle of lunar phases – Students were given eight photographs of the Moon, representing each of the major phases, and were asked to put them in the correct order of how we would see them in the sky. Codes reflected the sophistication of how students arranged the eight cards; an arrangement of a waxing then waning cycle was considered the scientifically normative goal as displayed in Table 3. Half of the students improved in their understanding of the lunar cycle, 12 stayed at the same level of understanding, and 1 student regressed.

Table 3.	**Pre (N=26)**	**Post (N = 26)**
Repeating cycle waxing & waning	4 (15%)	9 (35%)
Repeating cycle but phases not all ori-	2 (8%)	6 (23%)
Waxes or wanes then repeats	4 (15%)	3 (12%)
Waxes or wanes, phases not oriented	10 (38%)	6 (23%)
Did not descript pattern as repeating	6 (23%)	2 (8%)

Students were provided with several opportunities to explore the lunar cycle throughout instruction and in the planetarium. As part of the live portions of *The Moon* program students were asked to state shapes that they have seen the Moon appear in the sky. As students responded that particular Moon phase was put on the dome for students to see. Within the pre-recorded portion of the program the main character (and the audience) predicts which Moon phase comes next in the lunar cycle. *The Moon* program also highlights a lunar phase calendar where the concepts of waxing and waning are presented. Post-visit instruction included an activity where students were asked to predict future Moon phases.

Although many students improved, few reached the target understanding that the Moon's phases increase and decrease over the course of a month. This suggests that students need more practice observing the lunar phases and then organizing images into the pattern of the lunar phases.

Conclusions – This study examined a modular designed planetarium program that includes live presentation embedded within short pre-recorded video segments. The instructional design elements of a modular planetarium program, supported by classroom instruction, showed significant impact on 1st grade students' conceptual understanding of the Moon. The combination of instruction in the planetarium and in the classroom provided students with multiple opportunities to reflect on their current concepts and actively engage with new ideas. Students were actively engaged by using science practices during the planetarium program as well as in the classroom. For example, in the planetarium program children compared and contrasted their observations, used their own bodies to mimic representation of the Moon's apparent motion, and made predictions about the phases of the Moon. These findings demonstrate an effective method of actively engaging children during a planetarium program towards improved understanding of astronomy. Planetarium professionals need to remain committed to using planetariums in ways that maximize their potential. They should also consider opportunities to provide teachers with ways to apply ideas learned in the planetarium during follow-up lessons in the classroom.

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Tech Tip: UPS Batteries

Kevin Conod, Newark Museum

I don't know if you use Uninterruptable Power Supplies (UPS) in your planetarium, but we've been using several in Newark. These come in really handy if the power goes out or if your area suffers from frequent brownouts. You can't run a whole show off of them but at least you can bring a program to a graceful stop and shut down computers, etc., without plunging an audience of little kids into darkness and silence!

The batteries in a UPS are generally rated for up to 5 years. In practice we've found that it is more like 3 to 4 years, but a battery's lifetime can be significantly shortened by heat. For every 15°F above 77°F, battery life can be reduced by 50%. We had a small UPS stored underneath a projector pedestal. We thought we had enough ventilation under there but recently the battery expired prematurely (we've now added a small fan for extra cooling).

I knew our other UPS batteries were 3 to 4 years old and wanted to be proactive about replacing them. But with OEM battery prices and shrinking budgets that's not easy.

We have units made by APC and they of course want you only to use their replacement batteries. In reality a lot of batteries are made by a small number of companies with different brand names and private labels slapped on them. I decided to go with a third party supplier so I could fit this into our budget.

I was able to get a set of Amstron batteries at almost half the cost of OEM from atbatt.com, though there are many other choices (i.e. we've also used refurbups.com in the past). The only problem I ran into is that APC recently changed their connectors so the battery seemed plugged in OK but we were getting a "no connection" error from the UPS. The solution was to unscrew the simple wiring harness from the old battery and put it on the new set (this was fairly easy, you just have to be careful not to short the terminals together and ruin your new battery. Put a piece of electrical tape on one terminal while you work on the other).

Another tip: when ordering make sure you know how many batteries you need. Many replacements are sold as a "cartridge" which contain multiple batteries. You don't want to order too many or too little and pay for extra shipping.

Keeping your power supplies fat and happy will protect your valuable planetarium equipment - especially when a custodian accidentally flips off the wrong breaker in the middle of a show!

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