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# Assessing the Effect of a Digital Planetarium Show on the Astronomical Understanding of Fifth Graders

Kristine Larsen and Marsha Bednarski

*Central Connecticut State University, 1615 Stanley St., New Britain, Connecticut 06050, USA*

**Abstract.** Although one-time planetarium shows have been popular field trips for elementary school classes over the past few decades, research on the effectiveness of these shows in increasing student understanding of astronomical concepts is spotty and mixed. There is even less research on the efficacy of new digital full-dome planetarium technology. This talk discusses the results of a study done with fifth grade students to test the relative efficacy of hands-on 3-D models and a digital full-dome planetarium show in teaching the sun-earth-moon system.

## 1. Introduction

For many elementary school students, a field trip to a local planetarium has been a commonplace event. However, due to "No Child Left Behind" and increasing emphasis placed on measuring student success through standardized tests, school systems are under pressure to increase classroom time devoted to test preparation. A 2006 study by the Center on Education Policy found that this has led to a cutback of time devoted to science, history, and the arts. Coupled with decreases in school funding and increased transportation costs, this has resulted in a widespread reduction in field trips (Winerip 2006).

The Children's Museum in West Hartford was established in 1972. Its Gengras Planetarium has a well-respected field trip program targeting grades pre-K through 8$^{th}$ grade and above. However, between 2004–2008 there was a 30% decline in field trip attendance. Teacher surveys from open houses indicated that while teachers understand the value of field trips, all extracurricular activities must clearly demonstrate relevance to science testing. Unfortunately, there have been relatively few critical studies of the educational value of the planetarium. For example, a 2009 meta-analysis of 19 previous planetarium studies by Brazell and Espinoza suggested that although individual studies showed both positive and negative results (comparing the planetarium to the traditional classroom), the overall results are positive. However, in his 2007 literature review on planetarium research, Palmer found that there was little research on whether or not planetarium shows increased students' understanding of science concepts.

In recent years, approximately 10% of the 3,000 planetariums in the world have replaced their original star projectors with new digital projectors, and the number continues to grow. These new technologies allow for full-dome computer simulations and 3-D immersive visualizations, which allow the viewer to experience the universe from a multitude of different frames of reference in real time, rather than the static, geocentric viewpoint (Yu 2005). In 2007, the Gengras Planetarium made the transition to full-dome immersive digital technology. Although the entertainment value of these new systems has been clearly demonstrated, their educational value is debated in the planetarium community, and rigorous assessment is in short supply (Wyatt 2005; Yu 2005). One of the claims is that these technologies will aid in the teaching of astronomical concepts which are inherently 3-D in nature, such as the motions of the earth and phases of the moon. Studies have shown that instructional techniques using manipulation of 3-D models of the earth-moon-sun system improve the learning of these concepts (e.g., Stahly et al. 1999). Hindering the learning process are widespread and deep-rooted misconceptions held by elementary school students, elementary pre-service teachers, and practicing elementary teachers on these fundamental astronomical topics, as shown by numerous studies (e.g., Stahly et al. 1999; Trundle et al. 2002). This study sought to measure the effect of both 3-D models and a digital full-dome planetarium show on fifth grade students' understanding and misconceptions concerning seasons, eclipses, and lunar phases.

## 2. The Study

Three elementary schools from Bristol, Connecticut, were selected for this study. The earth-moon-sun system is taught in fifth grade, and the Gengras Planetarium has a special show called *Sun, Earth, Moon* (live narration paired with prepared graphics) developed in alignment with the Connecticut State Education Frameworks. Teachers in each school received professional development in the use of the Delta Company's Earth-Moon 3-D model and the classic Styrofoam ball lunar phases demonstration. Each teacher agreed to utilize the same 3-D activities. A knowledge test was developed, comprising of three questions, each of which requiring a written explanation and a drawing as the answer:

1. Draw a picture showing where the sun, earth, and moon are when it is a full moon. Explain what you think is going on.
2. Draw a picture showing where the sun, earth, and moon are when there is an eclipse of the sun (solar eclipse). Explain what you think is going on.
3. Why is it hot in Connecticut in the summer? Explain what you think is going on and draw a picture.

The same three questions were given to the fifth grade students on three occasions: a pretest before classroom instruction, a post-test administered a few days after classroom instruction was completed, and a post-post-test administered several days after the planetarium show.

## 3. The Findings

The intention of the study was to have all three schools follow the same timeline: pretest, classroom instruction using 3-D models, post-test, planetarium show, post-post-test. However, one of the three schools (labeled 3 below) was faced with scheduling conflicts and attended the planetarium show during the middle of the classroom instruction unit. The test was only administered twice—as a pretest and after the completion of the unit.

The tests were coded by the teachers to assure the anonymity of the students but allowing for longitudinal analysis of individual student changes in understanding. The university researchers, therefore, only knew the students by a numeric code which included the identity of the school. Each question was graded out of a possible two points, one point for a correct written explanation and one point for a correct drawing. A perfect score for the entire test was, therefore, six points. Results are shown in Table 1.

Table 1. Test results.

| | School 1 | School 2 | School 3 |
|---|---|---|---|
| Pre-test (N = 162) | 1.79 | 1.67 | 1.18 |
| Post-test (N = 106) | 2.55 (+42%) | 2.73 (+63%) | – |
| Post-post-test (N = 114 + 53) | 3.53 (+38%; +97%) | 3.11 (+14%; +86%) | 1.85 (+57%) |

The results demonstrate that while instruction using 3-D models does increase student understanding of these topics, providing a planetarium show after instruction increases student understanding even further. For example, while students in school 1 improved their scores on the test by 42% after the classroom instruction, their scores improved an additional 38% after attending the planetarium show, for an over-all gain of 97% as compared to the pre-test. While it may be tempting to interpret School 3's lower gains as evidence that the planetarium show is most effective when viewed after the completion of in-class instruction, it should be noted that School 3 has been the lowest-performing school on state mastery tests of the three schools, so no conclusions should be drawn from just this study.

While students showed gains on all three questions, the gains were not uniform. For example, comparing the questions on lunar phases, eclipses, and seasons, overall average student gains for Schools 1 and 2 were 55% and 18%, 91% and 63%, and 288%, and 667%, respectively, comparing pre-test and post-post-tests. The smallest gains were made between the post-test and post-post test for lunar phases and the greatest for seasons.

The effect of both 3-D models and the planetarium show on dispelling and deepening misconceptions was also noted in this study. For example, while the percentage of students who correctly drew the alignment of the sun, earth and moon during a full moon slightly improved from 52% to 53% to 59% for Schools 1 and 2 combined, there was an increase in two particular misconceptions—that the moon is between the sun and earth, and that the sun, moon, and earth are at an exaggerated angle—between the pre-test and post-test (increasing from 18% to 25% for the first, and from 11% to 16% for the second). In the first case the misconception decreased from 25% to a low of 16% after the planetarium show, but in the second case the results remained flat (17%). For a solar eclipse, the percentage of students who could correctly draw the alignment of the three bodies also increased steadily over the study (46% to 61% to 77%), but the misconception that the earth lies between the sun and moon increased from 14% to 23% from the pre-test to post-test for Schools 1 and 2, but dropped to a low of 11% after the planetarium show. A similar effect was seen in the written responses. For example, for a solar eclipse, a misconception espoused by some students was that the sun moves in front of the moon. Five students wrote this in the pre-test, six in the post-test, but only one in the post-post-test (from among Schools 1 and 2). While no students mentioned eclipses when explaining a full moon on the pre-test, six students espoused the belief that a full moon meant there was an eclipse on the post-test, while only two students gave this response after the planetarium show (for Schools 1 and 2). Five students wrote that the sun and moon were both involved in seasons on the pre-test, eight gave this response on the post-test, and only two claimed this to be true after the planetarium show (for Schools 1 and 2).

## 4. Conclusions

The findings from this study agree with previous studies in suggesting that 3-D models in the classroom improve student understanding of astronomical concepts involving the sun-earth-moon, and they further suggest that including a digital full-dome planetarium show on this topic after the completion of the in-class unit results in additional gains in student understanding. Furthermore, it appears that 3-D models, when used alone, can result in increased misconceptions in the minds of some students, while the planetarium show decreases the incidences of these same misconceptions.

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