**Overview of Study**

A Moon Phases Visualization Lab

We designed a middle school lab experience to help students understand the cause of the Moon’s phases and eclipses, using a combination of physical models (using styrofoam balls and lamps) and computer models.

**Phase 1: 2D vs 3D computer models**

We compared learning gains from two different kinds of computer models (a simplified 2-dimensional model "Textbook Simulator" vs. a complex 3-dimensional model, "WorldWide Telescope," "WWT").

**Phase 2: Which model order?**

All students used the 3D computer model (WWT), but half the students used the physical model first, while the other half used the computer model first.

**Learning Measures**

- Open Response: Knowledge Integration & Student Ideas
- Learning Measures
  - Textbook-driven multiple choice (MC) questions from the Astronomy and Space Science Concept Inventory (Sadler et al., 2010): 7 questions about Moon Phases and Eclipses on pre/post-assessments.
- Open Response questions embedded throughout lab activities, and on pre/post assessments. Scored using a Knowledge Integration (KI) rubric (Linn, 2000; Linn and Eylon, 2011).

**Phase 1 Results**

All students used the styrofoam ball model first. Half the students then used a 2D computer model (TS), while half the students used a 3D computer model (WWT). Students in both Phase 1 groups (WWT and TS) showed strong learning gains, but the WWT group outperformed the TS group by a statistically significant amount (t = 2.15, p = 0.033; N = 77). The table shows pre/post test scores on the multiple choice assessment, gain, and Cohen’s d effect size.

**Phase 2 Results**

Students in Phase 1 expressed such a strong preference for WWT over the TS that we were not able to find teachers willing to put half their students into a "control" group that did not use WWT. Instead, all students used WWT, but we tested the model order: styrofoam model then WWT vs. WWT then Foamball.

**Regression Analysis**

The factor that best predicts the pre-post test GAIN is the pre-test multiple choice score. As expected, students with lower pre-test scores tend to have higher gains because they have more room to grow.

**Model order is a statistically significant predictor of learning gain.** Students who used WWT first are expected to have a gain of 1.7, while students who use the foam model first are expected to have a gain of 1.3.

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**Visualizing Three-Dimensional Spatial Relationships in Virtual and Physical Astronomy Environments**

Patricia Udomprasert, Alyssa Goodman, Philip Sadler, Erin Johnson, Erin Lotridge, Jonathan Jackson, Ana-Maria Constantin, Harvard College Observatory

Zhihui Helen Zhang, Concord Consortium

Susan Sunbury, Qin Wang, Mary Dussault, Smithsonian Astrophysical Observatory

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**Open Response: Knowledge Integration & Student Ideas**

**Sample Open Response Question on Pre/Post Assessment**

We scored open response questions using a KI progression where a score of 0 indicates no scientifically valid response; 1 indicates a response with only misconceptions; and 2 or higher indicates a response with scientifically valid statements.

**Most students (80%) began the Moon Lab with a KI score ≤ 1, showing that misconceptions and lack of understanding are common. After using only one model, a small proportion of students who used WWT have KI scores ≤ 1. At the posttest, 18% of students who used WWT first have KI scores ≤ 1, compared with 40% of students who used the Foamball first.**

**Student Ideas after the First Model**

After Day 2, all students have only used one model (either foamball or WWT). Students shared what they learned from the first model. The chart to the left tells what proportion of students named each idea.

**For 2 cohorts we have coded KI responses (A13, A14), students who used WWT first then the foam model expressed fewer misconceptions about the cause of the Moon’s phases on the post-assessment.**

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**Student Model Preferences and Choosing Model Order**

**Model Order Preference**

45% of students from 2013-2014 school year liked having the styrofoam model first, then WWT, or wishes they'd had that order. 36% said the model order didn’t make a difference to them. Only 19% of students liked having WWT first, then foam, or wished they'd had that order.

**Conclusions**

- In Spring 2011, we found that level of prior knowledge may influence which model order would be more beneficial to student learning.
- After adding 3 more teacher cohorts in 2013-2014, this trend no longer holds. Performance on the MC assessment is comparable regardless of model order, with a regression analysis showing a slight benefit to using WWT first.

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