Thinking Spatially about the Universe: A Physical and Virtual Laboratory for Middle School Science

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Project Overview

ThinkSpace labs teach astronomy while supporting spatial thinking skills, such as imagining a scene from multiple viewpoints.

The Three Labs
1) Moon phases and eclipses
2) Scenes
3) Celestial motions within the broader universe

Spatial Thinking and STEM
Spatial skills correlate with performance in science domains, and likelihood to enter a career in STEM (e.g., Hegarty, 2004, Wu et al. 2009)

Perspective Taking Assessment
Perspective-taking: the skill of identifying how a scene might look from a viewpoint other than one's own position or line of sight (Liben & Dowens, 1993)

Table 1: School/Student Demographics, 2015–2016

<table>
<thead>
<tr>
<th>Date</th>
<th>Town</th>
<th>Grade</th>
<th>District</th>
<th>Social</th>
<th>Total Students</th>
<th>Students Interviewed</th>
</tr>
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<tbody>
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<td>8</td>
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<td>Jun 2015</td>
<td>8</td>
<td>8</td>
<td>B</td>
<td>urban</td>
<td>130</td>
<td>8</td>
</tr>
</tbody>
</table>

Interview Coding
Explicit connection between mechanism or model with the phenomenon
Perspective taking: Describes how an object will look from the viewer’s location and how this is explained by using the relative position of objects in space.
2. No perspective taking: Does not use a change in perspective (viewing from a different location or situation).
3. No connections: Does not show how the model or a mechanism can explain the phenomenon

Open Response: Knowledge Integration & Student Ideas

Project Open Response Question on Pre/Post Assessment

Sample student response to open response question using a 11-point Likert scale where a score of 0 indicates no scientific validity, and a 11 indicates a high degree of scientific validity (Lin, 2020).

Sample Open Response Question on Pre/Post Assessment

Distractor-driven multiple choice (MC) questions from the MOSART Astronomy and Space Science Concept Inventory (Sadler et al., 2010): 11 questions about Moon Phases and Eclipses on pre/post-assessment.
A subset of 6 questions given after students used a single model (Foam vs. WWT) to assess learning on whether each of the two different models helps students understand particular topics better than the other.

Mid-Assessment Results
No statistically significant difference in scores’ gains between WWT vs foam model on mid-assessment (after half of students used only WWT and other half used only foam model).
1. Students who only used foam model had larger gains on Question 2 regarding Earth-Moon.
2. Students who only used WWT had larger gains on Question 3 that asks to predict what the Moon would look like when in a particular position relative to the Sun and Earth.

Next Steps
2015–2016: Complete field testing of ThinkSpace Moon Lab at School 2 in June 2016.
2016–2017: Complete development of Seasons Lab and begin testing in classrooms.

References

American Astronomical Society

MOSART Data - Distractor Driven Multiple Choice Astronomy Questions

Overall Results
For 2 cohorts who have completed the ThinkSpace Moon lab (Teacher 1 and 2), students show significant gains for both Moon phases content and perspective taking.
For 11 MOSART Moon content MC questions, Cohen’s effect size = 1.71±0.08.
For 15 Perspective taking (PT) questions, Cohen’s effect size = 0.31±0.05 (even with 46% of students scoring 50% on the pre-assessment).

Next Steps
2015–2016: Complete field testing of ThinkSpace Moon lab at School 2 in June 2016.
2016–2017: Complete development of Seasons Lab and begin testing in classrooms.

Complete field testing of Moon Lab in additional classrooms.

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References
Linn, R.-C., 2002. Dynamic blackboards and being good at it: A didactic analysis of making and sharing diagrams in dyads. Learning and Instruction 12, 55–73.