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, like imagining a scene from multiple viewpoints. The topics covered:
1) Moon phases and eclipses
2) Seasons

ThinkSpace labs blend interactive computer-based astronomy visualizations in WorldWide Telescope (WWT) with hands-on modeling activities. The lessons are purposefully designed to give students opportunities to connect Earth-based views of the Sun and Moon with space-based perspectives. (Plummer, Bower, & Liben, 2016).

Context

ThinkSpace Labs were implemented at middle schools across four school districts in the greater Boston area, with eight different sixth and eighth grade science teachers from 2015-2018. A member of the research team taught all lessons:
- Moon Phases Curriculum, N=400
- Seasons Curriculum, N=300
- Seasons + Moon Phases Curriculum, N=200
- Spatial control, N=150

Research Questions

- Did students’ conceptual understanding, perspective-taking skill, and use of perspective taking during explanations improve, after participation in the curriculum?
- How does a student’s prior perspective-taking skill relate to a) content knowledge and b) use of perspective taking during explanations, after instruction?
- How well does perspective-taking skill predict gain in students’ use of perspective taking in explanations?

Key Findings

- ThinkSpace students had significant pre-post content learning gains. The table shows the Cohen’s d effect sizes for the MOSART pre vs. post-score concepts for each lab.

<table>
<thead>
<tr>
<th>Science Concepts MOSART Assessment</th>
<th>(ALL students)</th>
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<tbody>
<tr>
<td>Distraction-driven multiple choice (MC): ten to twelve questions from the MOSART Astronomy and Space Science Concept Inventory about seasons and/or moon phases (Sadler et al, 2010)</td>
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<td>Knowledge Integration: one-to-two open response question (Linn, 2000), where students explain their thinking in more detail and sketch diagrams to share their reasoning.</td>
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Assessment Interviews (Audit: ~70% of students): Students were asked questions about why they used a crescent moon from Earth (hyp. 4th grade).

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<td>&quot;That side's supposed to be lit up.&quot;</td>
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<tr>
<td>&quot;But there's still a bit of light coming from here. You see a sliver.&quot;</td>
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<tr>
<td>&quot;You see a crescent moon because the Earth - say there was a person right there. They would see the crescent moon.&quot;</td>
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Data Collection

- In video-recorded interviews, students used a model Sun/Moon/Earth/Moon to answer questions about lunar phases and seasons. We coded for how they applied perspective taking in their explanations.
- Equal numbers of students chosen with high/Middle/Low perspective-taking pre-test scores.
- Equal numbers of boys and girls chosen.

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Instructor demonstrating web tool to help students connect overhead space-based and Earth-based perspectives of the Earth-Sun-Moon system.

Discussion

How did ThinkSpace curricula support student learning in spatially?
- Training on perspective taking was infused across their experience in the curriculum.
- Practice using perspective taking was an active part of their experience in the classroom environment, using questions and experiences that connected physical and virtual representations of astronomical views.
- Spatial thinking wasn’t something they passively observed; it was a skill applied to a scientific problem using perceptual and motor actions to generate mental representations.

How do students’ pre-test spatial skills impact how students learn using the ThinkSpace curricula?
- High spatial skill students made greater gains. Curricula, though helpful for both low and high spatial skill students, do not close the gap.
- Environments that provide physical and virtual support to guide spatial thinking will help high spatial skill students over their lower spatial skill peers. We have added additional scaffolds to better support students with lower spatial skills in the final version of the Labs.

Implications

- Spatial skills training can be embedded into existing curricula.
- Explicitly include opportunities to practice spatial skills while students are learning about domain-specific phenomena.

A backwards design approach to spatial thinking
- Begin by unpacking the central elements of spatial thinking and design opportunities for students to practice these skills, while they are also making sense of central phenomena.

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References

