How do students learn spatial thinking through sensemaking practices?

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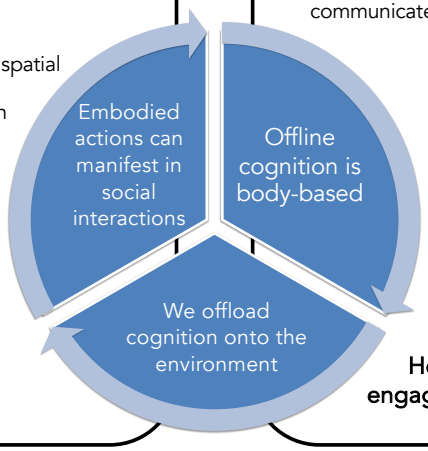
RESEARCH PROBLEM

- Spatial thinking is an important predictor of students' success in STEM education (Uttal et al., 2013)
- There is limited research on:
  - how K-12 students learn spatial thinking
  - which practices might improve students' spatial thinking
  - how to facilitate students' engagement in spatial sensemaking practices

OUR STUDY

- Investigation of students' use of *spatial sensemaking practices* through a spatially-enriched seasons and lunar phases curriculum
- Focus on students' use of *perspective-taking skill* (PT skill) -- how a scene might look like to an observer from a different perspective or a different line-of-sight (Liben & Downs, 1993)



CONCEPTUAL FRAMEWORK: SPATIAL SENSEMAKING PRACTICES

Spatial sensemaking practices are are used to interpret and communicate spatial information (Ramey & Uttal, 2017)

List of *spatial sensemaking practices* found through interaction analysis in this study:

- Using iconic gestures
- Using pointing gestures
- Use of body movement
- Epistemic object manipulation
- Explanatory object manipulation
- Use of fixed objects for referencing
- Epistemic sketching
- Explanatory sketching

RESEARCH QUESTION

How might a spatially-enriched curriculum engage students in spatial sensemaking practice?

METHODS

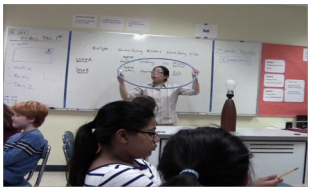
Setting & subjects	6th grade classrooms, N=185 (11-12-yr old)
Curriculum	10-day ThinkSpace curriculum on Seasons and Lunar Phases
Data	Classroom videos (total of 900 min of data)

DATA ANALYSIS

- **Interaction Analysis** (Jordan & Henderson, 1995) – analysis of students gestures, their use of materials and tools from the learning environment, and observable actions and interactions with their peers & teacher.
- **Coding**: Deductive approach to pattern coding – classroom instruction was broken down into units of analysis called *PT sensemaking episodes*, which showed students' use of spatial sensemaking practices.
- **Validity**: Established inter-rater reliability calculating Cohen's *Kappa* for each spatial sensemaking practice and the type of perspective (gestures (0.616), obj. manipulation (0.767), sketching (0.750), use of fixed artifacts for referencing (0.5), type of perspective (0.645)

FINDINGS – Patterns in Use of Spatial Sensemaking Practices

The practice of object manipulation was the most important in engaging students in visualizing singular and multiple perspectives



Teacher's PT questions, along with the use of object manipulation, was most productive in eliciting students' connections between multiple perspectives

The practice of sketching was useful for visualizing space-based perspective

Use of fixed artifacts may have created an immersive experience for students to visualize different perspectives by fixing their reference point

DISCUSSION – Learning through embodied cognition (Wilson, 2002)

We offload cognitive work onto the environment – *Using* physical and virtual models created ways for students to concretize their mental visualization in physical entities and supported their perspective-taking

Offline cognition is body-based – Gestures and bodily actions were useful when simulating processes that are removed from the context such as replicating the moon's cycle using their body or using hand gestures for showing earth-based view of the sun's path

Embodied actions can manifest in social interactions – The teacher's prompts about gesturing, sketching, and using objects elicited students' use of perspective taking

Implications: The findings suggest that intentional use of questions to elicit students' PT skill, providing them appropriate materials that support externalization of their mental visualization, and using a variety of resources in combination instead of in isolation might support students' use of PT skill in different ways for studying astronomical phenomena.

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