



Marking Up Maps:

How Drawing Enhances Middle School Students' Engagement with Spatial Data



Lauren C. Pagano¹, Milla Metlicka², Anne Catherine Johnson², Grace Ocular², David H. Uttal³, & Catherine A. Haden²

¹Dominican University, ²Loyola University Chicago & ³Northwestern University

INTRODUCTION

- Interpreting data visualizations such as tables and maps requires learners to construct and coordinate multiple mental representations, processes which are central to cognitive development (Taylor et al., 2023).
- Drawing may support learning by externalizing and reorganizing these representations of scientific information (van Meter & Garner, 2005).
- Gesture can act as an embodied representational system that can support conceptual understanding of math and science (Novack & Goldin-Meadow, 2015).
- In this study, we examined how drawing and gesture supports middle school students' science learning from multiple data visualizations formats during a climate-focused field trip.

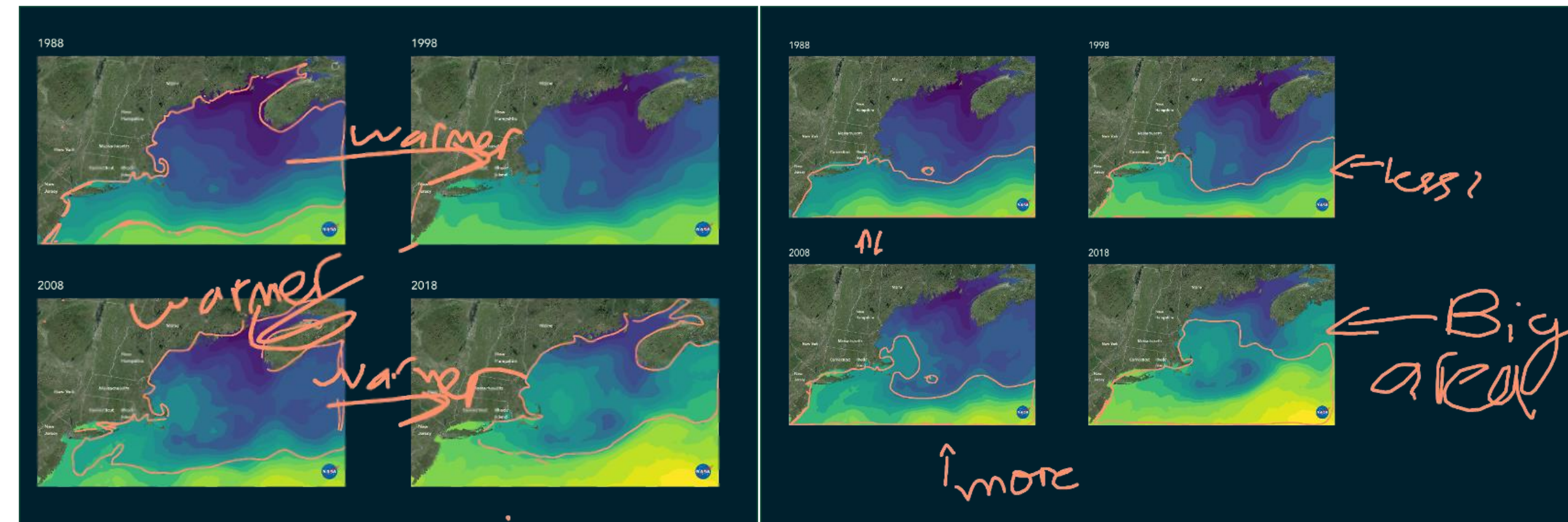
METHODS & PARTICIPANTS

- 238 5th-6th grade student groups from 46 schools attended a fieldtrip to the Gulf of Maine Research Institute (61% coastal, 39% non-coastal).
- During the field trip, students did two activities at interactive touchscreen tables:
 - A virtual dissection of a black sea bass in which stomach contents were sorted into a data table to evaluate impacts on Maine's lobster populations
 - A map-based task tracing changes in lobsters' ideal temperature habitats in the Gulf of Maine across four decades
- After each activity, students recorded video reflections about their learning. Reflections were transcribed and coded for STEM talk and use of gesture (see Tables).

CODING

Drawing During the Activities

- Writing
- Circling/ Tracing
- Drawing
- Lining
- Shapes/Arrows

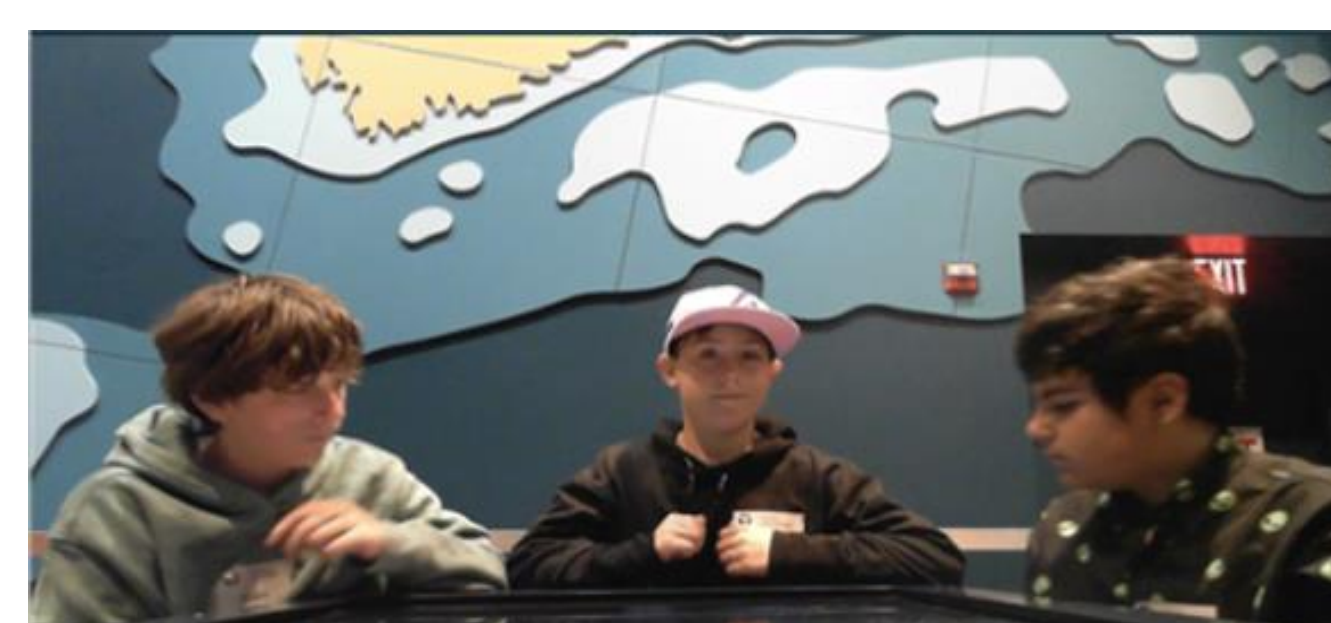


Gesture Use at Reflection (Kendon, 2004)

Code	Definition
Beat	Rhythmic hand movements used to emphasize speech
Deictic	Pointing or gesturing to information onscreen
Conventional	Common gestures that may be used in place of language
Imagistic	Gestures that represent real objects, actions, sizes, or metaphorical concepts

STEM Talk at Reflection

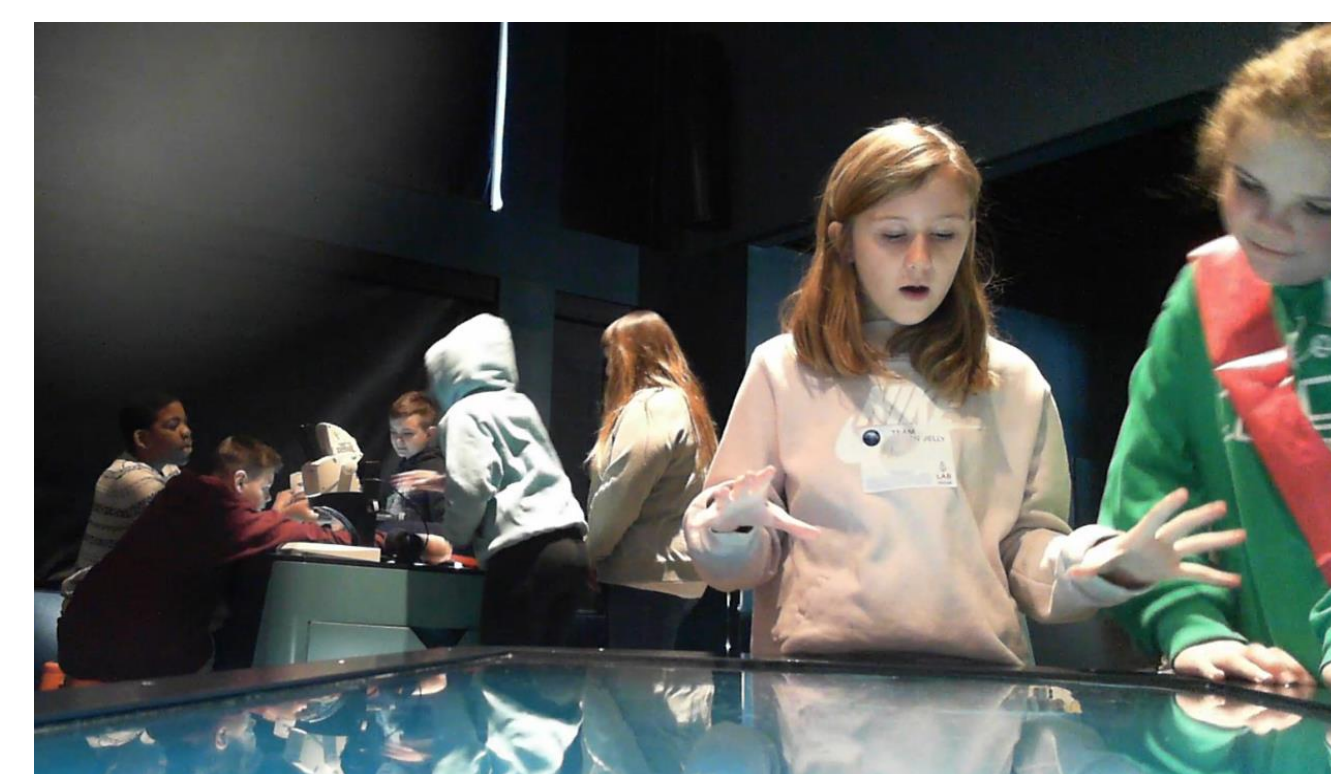
Code	Definition
Biology	Talking about biological processes (eating, dying), marine species (lobster, black sea bass), or marine habitats
Spatial	Describing spatial locations, patterns, features, orientations, etc.
Data Analysis	Making data observations or referring to visualizations (map, table)



Annotations on Black Sea Bass Dissection Table

Tag	Location	Lobster	Fish	Squid	Crab	Star Ling
#0222	Maine	✓	✓	✓	✓	✓
#0207	Maine	✓	✓	✓	✓	✓
#0177	Maine	✓	✓	✓	✓	✓
#0247	Maine	✓	✓	✓	✓	✓
#0205	Maine	✓	✓	✓	✓	✓
#0241	Maine	✓	✓	✓	✓	✓
#0213	Maine	✓	✓	✓	✓	✓
#0282	Maine	✓	✓	✓	✓	✓
#0217	Maine	✓	✓	✓	✓	✓
#0211	Maine	✓	✓	✓	✓	✓
#0251	Maine	✓	✓	✓	✓	✓
#0255	Maine	✓	✓	✓	✓	✓
#0219	Massachusetts	✓	✓	✓	✓	✓
#0177	Massachusetts	✓	✓	✓	✓	✓
#0216	Massachusetts	✓	✓	✓	✓	✓
#0171	Massachusetts	✓	✓	✓	✓	✓
#0183	Massachusetts	✓	✓	✓	✓	✓
#0182	Massachusetts	✓	✓	✓	✓	✓
#0199	Massachusetts	✓	✓	✓	✓	✓
#0089	Massachusetts	✓	✓	✓	✓	✓
#0134	Massachusetts	✓	✓	✓	✓	✓
#015A	Massachusetts	✓	✓	✓	✓	✓
#0149	Massachusetts	✓	✓	✓	✓	✓
#0127	Massachusetts	✓	✓	✓	✓	✓
#0084	Massachusetts	✓	✓	✓	✓	✓
#0081	Rhode Island	✓	✓	✓	✓	✓
#0088	Rhode Island	✓	✓	✓	✓	✓
#0066	Rhode Island	✓	✓	✓	✓	✓
#0083	Rhode Island	✓	✓	✓	✓	✓
#0024	Rhode Island	✓	✓	✓	✓	✓
#0004	Rhode Island	✓	✓	✓	✓	✓
#0022	Rhode Island	✓	✓	✓	✓	✓
#0007	Rhode Island	✓	✓	✓	✓	✓
#0071	Rhode Island	✓	✓	✓	✓	✓
#0073	Rhode Island	✓	✓	✓	✓	✓

Annotations on Sea Surface Temperature Map



Results

Black Sea Bass Data Table

- When reflecting on the black sea bass data table, regressions showed that there were no effects of drawing on students' science talk ($Bs < 1.28, ps > .13$).
- However, students talked more about biology ($B = 2.54, p < .001$), data ($B = 1.31, p < .001$), and spatial patterns ($B = 0.68, p < .001$) when using beat gestures.

Sea Surface Temperature Maps

- As seen in Figure 1, for the sea surface temperature mapping activity, drawing arrows was associated with more talk about biology ($B = 1.24, p = .02$) and spatial patterns ($B = 1.36, p = .05$).
- Writing was associated with more biology talk ($B = 0.88, p = .041$).
- Beat gestures were again linked to more talk about biology, data, and spatial patterns ($Bs > 0.66, ps < .03$).
- As seen in Figure 2, imagistic gestures were also associated with increased talk about STEM (biology: $B = 1.15, p < .001$, data: $B = 2.21, p < .001$, spatial patterns: $B = 2.08, p < .001$).
- Deictic gestures were linked to increased talk about data ($B = 1.68, p < .001$) and spatial patterns ($B = 0.89, p = .01$).

Figure 1. STEM Talk in SST Activity by Use of Arrows on Maps

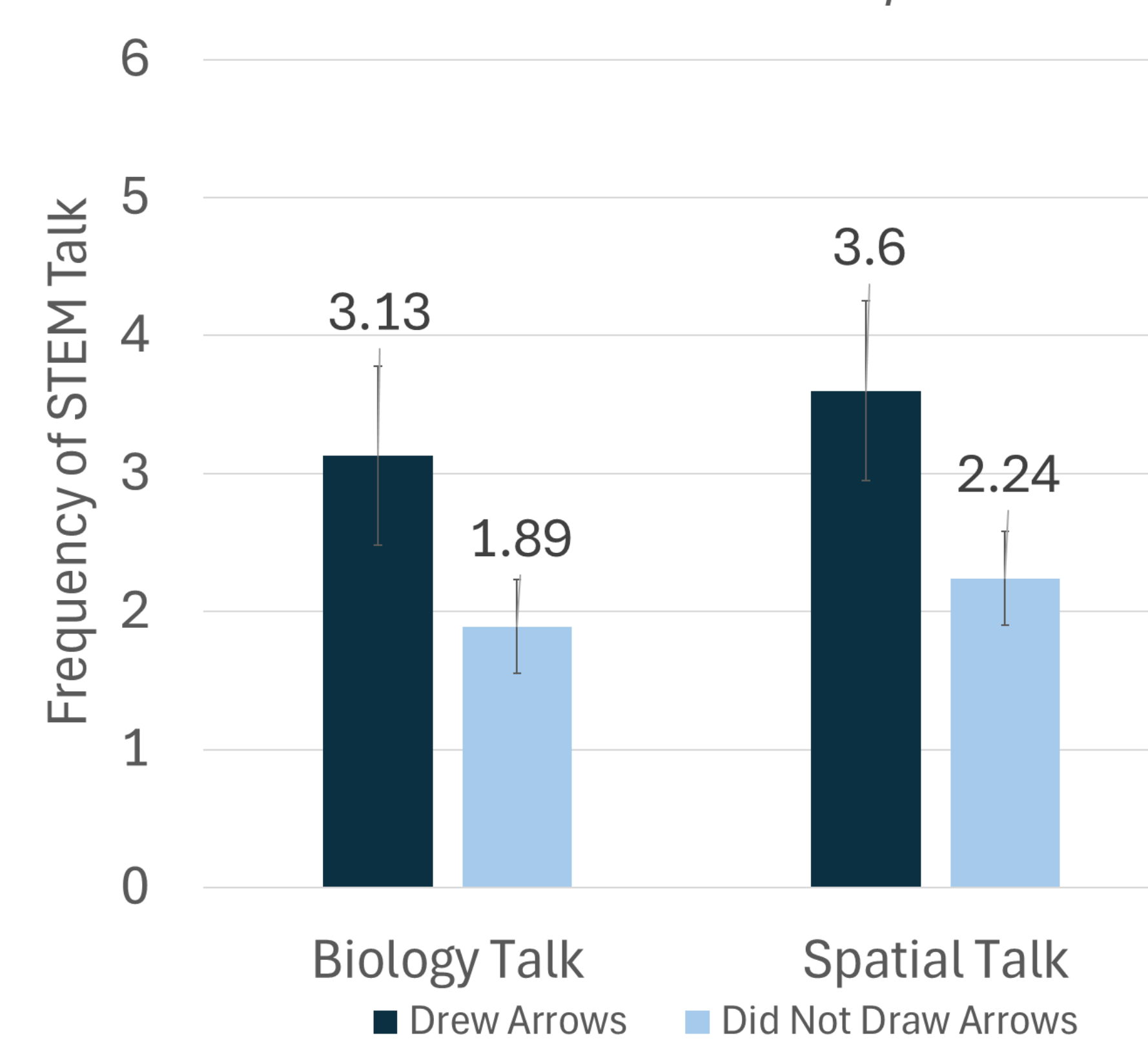
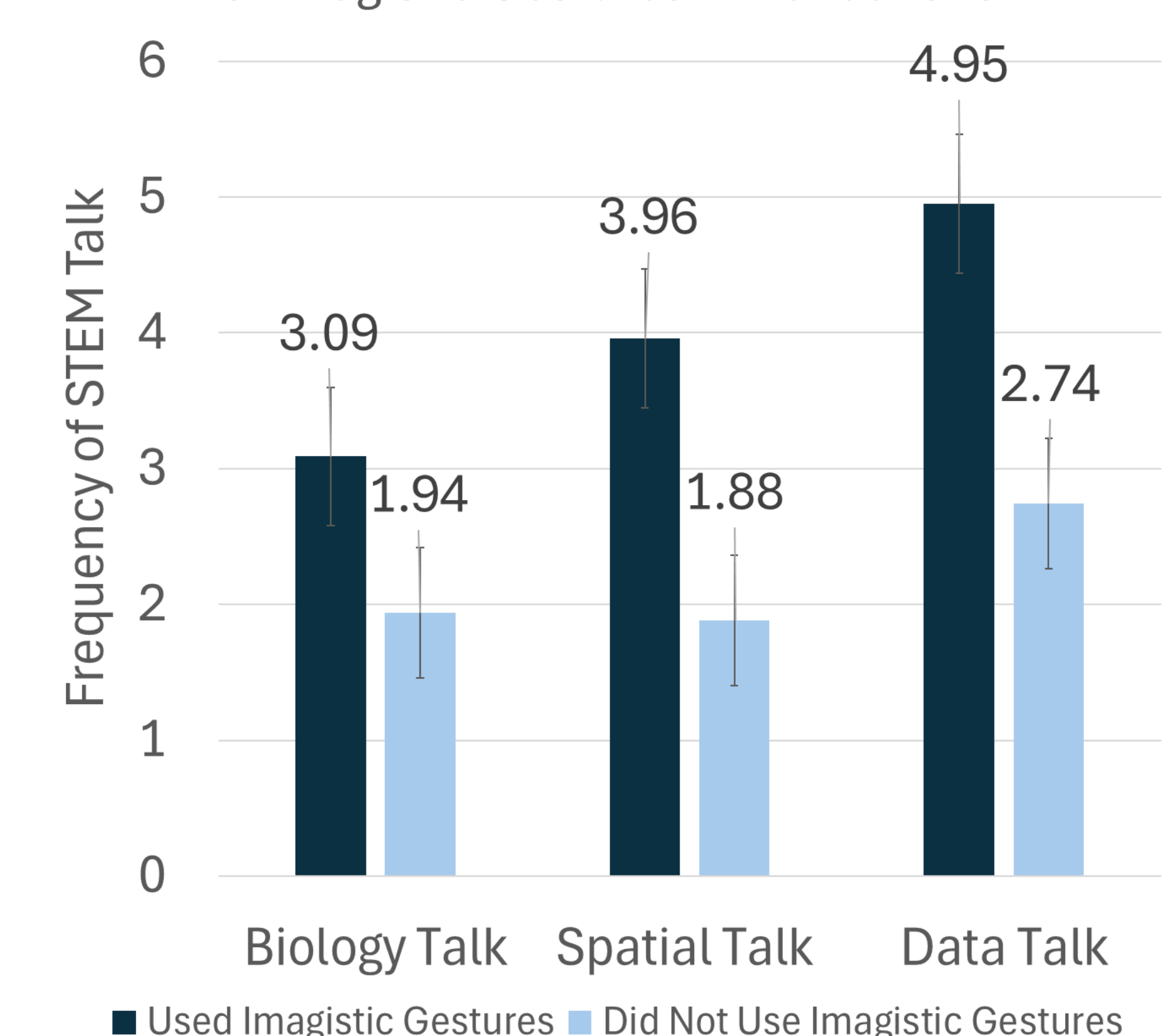


Figure 2. STEM Talk in SST Activity by Use of Imagistic Gestures in Reflections



DISCUSSION

- In line with past work, drawing—particularly arrows—may be uniquely beneficial for learning from spatial visualizations like maps, but not from data tables.
- Beat gestures are linked to science talk across activities, but questions remain regarding the direction of this association.
- Also consistent with past work, deictic and imagistic gestures may be specifically important for understanding and communicating about spatial data.

This material is based upon work supported by the U.S. National Science Foundation under Grant No. 2115905/2115603/2115610

