Teachers' Experiences of Implementing Alberta's K-3 Mathematics and Science Curricula in the Context of Visualization

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Research Question: How does professional learning on visualization as an interdisciplinary process for thinking and communicating mediate teachers' experiences of implementing the new K to 3 Mathematics and Science curricula?

STUDY OVERVIEW

In 2022 and 2023, Alberta teachers in grades K to 6 implemented new mathematics and science curricula. In addition to changes in the structure and content of specific learner outcomes, the roles of *big ideas* in these curricula also changed. **Visualization**, which is a critical component of spatial reasoning associated with achievement in mathematics and science, is one such big idea. In this project, we investigated how changes in Alberta's elementary math and science curricula interacted with teachers' planning and instruction in the context of visualization and spatial reasoning. Our research yielded three distinct but related outcomes: **1)** a comparison of the role of visualization in Alberta's outgoing and incoming math and science curricula, **2)** an analysis of teachers' enactments of spatial reasoning in the context of professional learning, and **3)** some preliminary theorization about the body's role in teachers' enactments of visualization through sketching and gesture.

OUTCOME #1: CURRICULUM CONTENT ANALYSIS

Context: In Markle et al. (2024), we used content analysis to report on how the role of visualization in math and science learning outcomes had changed between the outgoing and incoming curricula. To perform our content analysis, we defined visualization as including: 1) *the process of developing, interpreting, and using mental imagery* and 2) *the process and products of developing, constructing, and using spatial inscriptions, which can include graphs, pictures, and diagrams*.

Results:

1. **A Diminished and Varied Emphasis on Visualization.** Each learning outcome of the outgoing and incoming curricula was analyzed and coded for explicit reference to visualization based on the above definition. The table below presents our results.

Outcomes with Explicit Reference to Visualization
(by subject and year of implementation)

Type of Visualization	Mathematics		Science	
	2007/2016 *(out of 71 outcomes)*	2022 *(out of 448 outcomes)*	1996 *(out of 180 outcomes)*	2023 *(out of 419 outcomes)*
Mental Imagery	0	2	0	0
Inscriptions	14	45	8	14
Both	0	1	0	0
None	57	400	172	405

<u>Key Takeaways</u>

a) Only a small proportion of outcomes in the outgoing and incoming mathematics and science curricula explicitly referenced visualization;

b) The proportion of outcomes with explicit reference to visualization **declined** by **46%** and **25%** in the incoming math and science curricula, respectively;

c) The incoming math curriculum contained some references to mental imagery, while in science there was an exclusive focus on external representations (inscriptions), such as models and diagrams.

2. **An Ambiguous use of Spatial Language:** In mathematics, the term *visualize* shifted from referencing the process of creating and using mental imagery to being synonymous with pictorial representation.

3. **Changing Role of Visualization in Science:** An increased emphasis in incoming science curriculum on visualization through the use of external representations is accompanied by a decreased emphasis on scientific communication through visualization.

Implications: Teachers may require professional development to support the interpretation of new math and science outcomes to mitigate a decrease in explicit references to visualization, attend to the ambiguous use of spatial language across all mathematics and science concepts, and implement classroom practices that recognize students' rich spatial experiences, intuitions, and capabilities.

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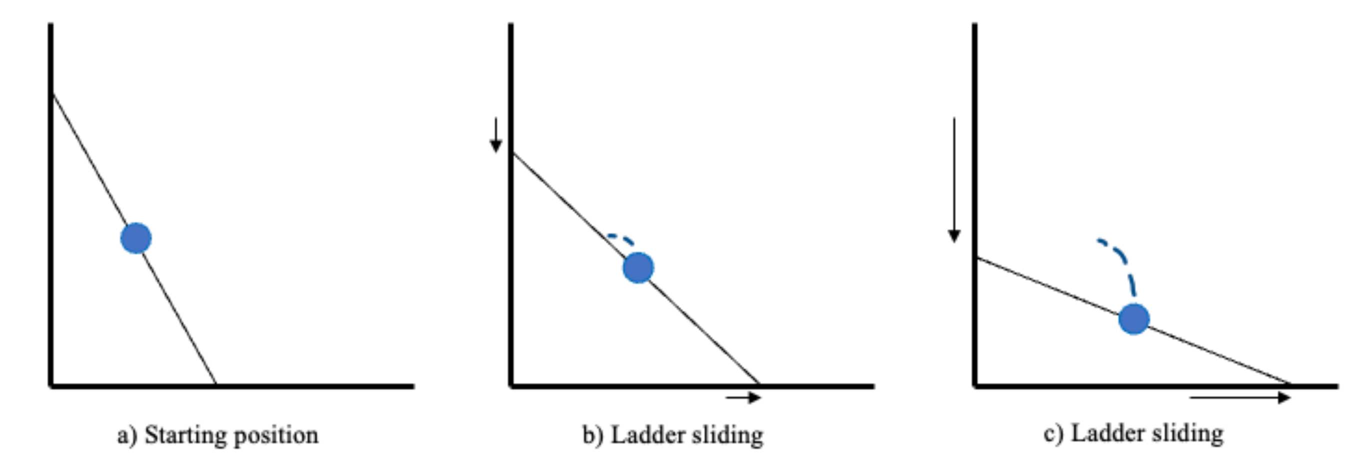
SELECTED PUBLICATIONS AND PRESENTATIONS

OUTCOME #2: TEACHERS' SPATIAL REASONING

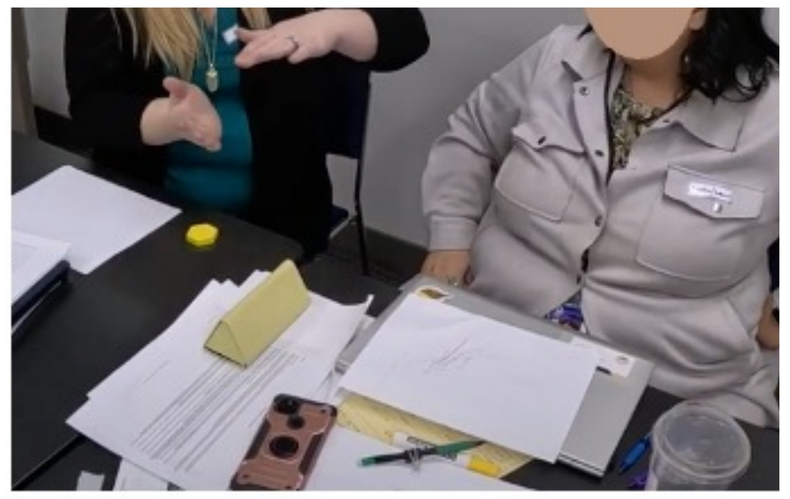
Context: Teachers enact curriculum in their classrooms in complex ways. We used a discursive approach to report on how teachers' spatial reasoning practices changed as a result of engaging with spatially rich tasks. Specifically, we investigated the role of agency in their mathematical actions and the degree to which those actions were compatible with their current teaching practices.

Results: We found that: 1) teachers had varied individual histories of spatial reasoning; 2) those previous histories played an important role in how they performed in novel mathematical situations; 3) their performances could be distinguished using the construct of agentivity; and 4) their professional learning, content-specific, and general pedagogies interacted in complex ways.

Implications: Interventions to support teachers' spatial reasoning should explicitly attend to their individual experiences, use tasks that support the development of agency in problem solving, and be mindful of how the ways existing practices might interact with learning content-specific pedagogies.



The panels above depict the outcome of the Sliding Ladder task. Teachers were asked to visualize standing on a ladder (blue dot). Then they were asked to imagine and describe the path their bodies traced out as the ladder slid down the wall.



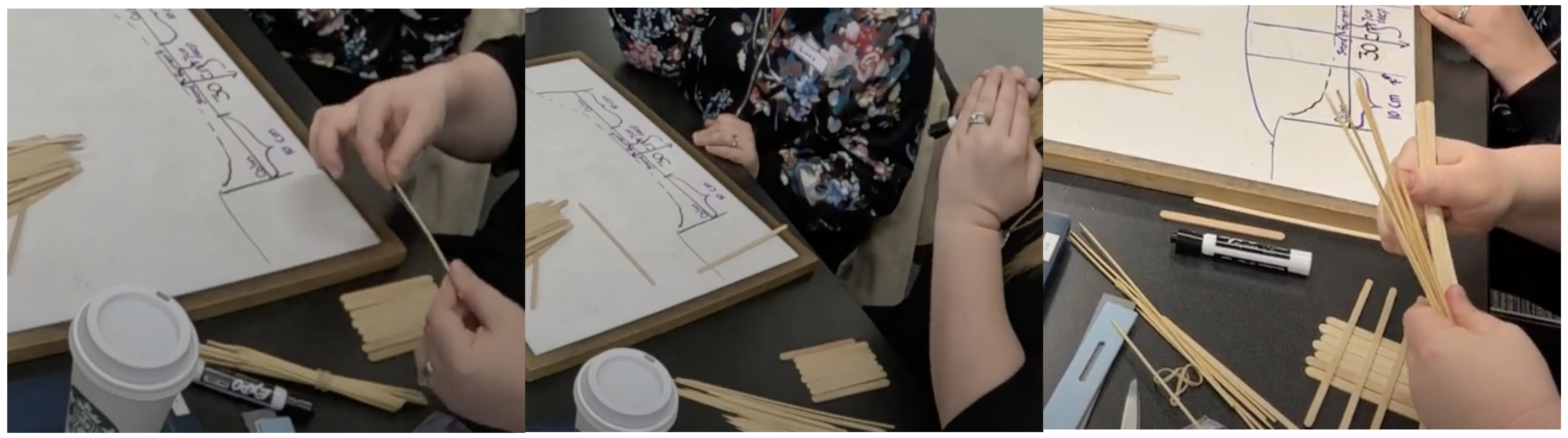
Teachers demonstrated spatial reasoning through speech, drawing, and gesture as they engaged in the Sliding Ladder task.

OUTCOME #3: TALKING SKETCHES AND VISUALIZATION

Context: Drawing on theories of embodied cognition, we see visualizing as a process dependent on learners' bodies and their problem-solving contexts. Children draw not only with internal conceptual understanding but also bodily thinking and reasoning. In this part of the study, we investigate the pedagogical implications of visualization, captured by what we call *talking sketches* (Ferguson, 1992), when teachers engage in design-based problem solving.

Results: We found that 1) teachers enacted visualization as embodied reasoning process through talking, drawing, touching, manipulating, imagining and gesturing to understand problem solving contexts and 2) the affordances of the materials and haptic feedback were critical to STEM problem solving.

Implications: Visualization in classrooms should be further studied as an embodied and non-linear process that can be applied to understand problem contexts and solutions. Additionally, further study is needed to understand the role of visualization teachers' classroom practice. Teachers' pedagogical reflections should be investigated for further theorization.



The photos above depicts two teachers working on the Bridge Design task. In a) a teacher grabs and bends one wooden stick to feel its potential for bending; in b) the teacher gestures with her hand and says, "arch like this," referencing the bridge's span; in c) the teacher gathers a handful of wooden sticks to test their strength and bendability.