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Manipulatives for Multivariable Calculus: Unorthodox Lessons for Active Learning, Collaboration, and Visualization

In this talk, I will describe several hands-on lessons embedded into a 500-student, proof-based multivariable calculus course. Designed to promote active learning, collaboration, and visualization, these lessons explore course concepts through structured group activities centred around three types of physical manipulatives:

- a 3D printed model of a function's graph used for lessons on critical points, Lagrange multipliers, and Darboux sums;

- a wooden wedge used for a lesson on integration in Cartesian coordinates; and

- a foam bead used for a lesson on integration in cylindrical and spherical coordinates.

I will discuss the qualitative benefits and challenges of these lessons, and how they were implemented at scale, including brainstorming and fabricating manipulatives, designing and executing lessons, and making revisions based on classroom observations and participant feedback. Sample models will be available for attendees to play around with!

This is joint work with Yuzhe Liu, Sydney Pinkalla, and Asif Zaman.