UC San Diego
Cognitive Science

Akshay Nagarajan's Dissertation Defense

Learning Environments as Instruments: Designing Technologies that Shape and Measure Cognition in Situ

Thursday, August 20, 2026
10:30 am - 12:30 pm, Public Engagement Building, Room 622
or https://ucsd.zoom.us/j/92155395125
Meeting ID: 921 5539 5125

Abstract:

Learning unfolds across bodies, social interaction, and internal states, yet classroom assessments typically register only its outcomes. This dissertation investigates learning as a layered system through three interconnected studies that develop and evaluate novel learning environments for real classrooms, each instrumented to capture activity in real time and make those layers visible.

The first chapter asks how externalizing computational structure into manipulable physical form supports reasoning. In a tangible game designed for computational thinking, children construct and perform sound-and-action sequences using physical beads on strings, giving abstract computational structures a form they can manipulate, debug, and coordinate with peers. In middle-school deployments, embodied play surfaced computational reasoning, and rhythm emerged spontaneously as a resource for coordinating execution across multiple performers.

The second asks how children reason inductively from data they generate themselves. In a classroom-scale game designed for this question, students wearing proximity sensors investigate a simulated infection spreading through their own movement, analyzing the data their bodies produce on a real-time visualization platform. In deployments at two middle schools, journal and interface records show that students reaching identical conclusions arrive by different routes, some committing early and defending a claim, others revising as evidence accumulates, a distinction outcome measures cannot recover. These routes carry familiar signatures of human judgment: claims anchored early, held without evidence, or adopted because peers hold them, sometimes converging the whole class on a confident but mistaken answer.

The third chapter asks whether cognitive stress can be inferred from children's speech without extensive annotation. The approach pairs interpretable acoustic features with neural embeddings trained on proxy labels, alongside a preprocessing pipeline that prepares noisy classroom audio for analysis. It performs well on adult speech but degrades substantially on children, establishing pediatric affect sensing as a distinct problem requiring child-specific data and calibration.

Together, these three chapters demonstrate that learning environments can both shape cognition and sense it in real time. The dissertation contributes a new class of educational technologies, an integrated multi-layer framework for learning design, and empirical insights into how embodied, social, and affective dimensions of learning interact in practice.

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