



A Micro-Phenomenological Approach to Investigating Mathematical Problem Solving



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Abstract Emerging first-person methodologies and enactivist perspectives in cognitive science afford new ways of investigating the embodied phenomenology of mathematical problem-solving. This pilot study ($n=4$) evaluated the affordances of an interview-based methodology, micro-phenomenology, for investigating experiential aspects of metacognition and diagrammatic reasoning. Preliminary analysis suggested that moments of transition in problem-solving behavior may be modulated by affective states (e.g. a need to slow down, a sense of doubt, perceived difficulty of an upcoming step) and by reference to prior scratchwork. The analysis further provided fine-grained characterizations of disciplinary perceptuo-motor skills involved in diagrammatic reasoning (e.g. the virtual manipulation of diagrams) which may inform future instruction design.

Research Questions

- Q1:** What kinds of experiences accompany metacognitive moments of transition/control during problem-solving activities?
- Q2:** Which, if any, perceptuo-motor skills are leveraged in diagrammatic reasoning?
- Q3:** What are the methodological affordances of micro-phenomenology in research on mathematical problem solving?

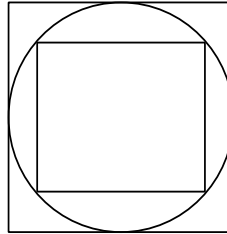
Methods

Participants: Four volunteering graduate students from UC Berkeley.

Protocol: Participants were invited to an individual 75-min video-recorded session. Each participant first worked on a mathematical problem (Figure 1) for up to 10 min before participating in a 50-min micro-phenomenological interview about their problem-solving experience.

Mathematical Problem

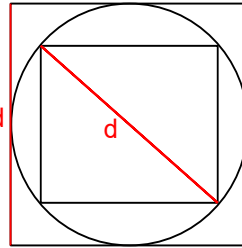
“The diagram shows a circle with one square inside and one square outside. What is the ratio of the areas of the two squares?”



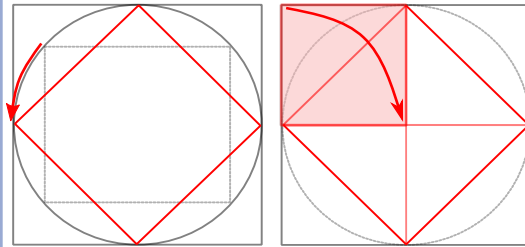
Results

Two different solution strategies

The first strategy ($n=2$, Laura, Jade) uses the diameter as a common measure of both the inside square and outside square.



The second strategy ($n=1$, Ben) consists of virtually rotating the inside square, and then folding in the corners of the outside square onto the inside square.

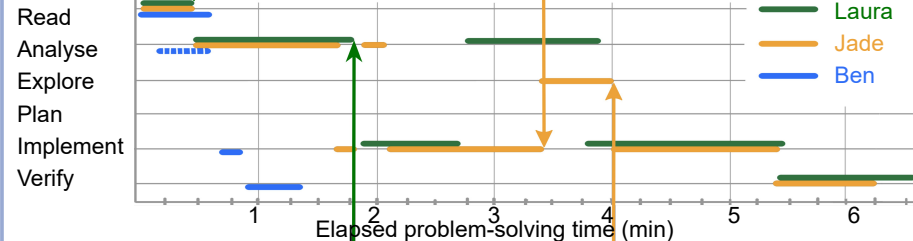


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Metacognition: Moments of transition and their affective aspects

- (1) “a feeling of racing ahead; (...) a sense of making myself slow down.”
- (3) “I actually had like a moment of panic and anxiety.”



- (2) “I have two areas that I want to find (...) And I figured that finding the area of the circumscribed square was a little bit easier, a little more straightforward.”
- (4) “I think I wasn't looking for it (...), but I noticed it again. And just noticing it again, kind of brought me back to what I needed to do.”

Moments of transition were...

- ...delayed because of a deliberate effort to slow down.
- ...modulated by the perceived difficulty of a next step.
- ...preceded by a moment of panic or anxiety.
- ...solicited by accidentally catching a glimpse of earlier scratch work.

Diagrammatic Reasoning: Virtually manipulating a diagram

“I was literally tracing my attention across the middle of the big square (...) In my mind I was trying to rotate it and checking to see what sort of things are forcing the square (...) so that this corner of the square ends up being where the circle meets the line. (...) And it's gonna make that horizontal line here perfectly horizontal.”

Such virtual manipulations of a diagram can be theorized in terms of Hutchin's (2003) notion of a *material anchor for a conceptual blend*, and Merleau-Ponty's (1945/2012) notion of *perceptual/motor habits*.

