

From Gesture to Design: Building Cognitively Ergonomic Learning Tools

Dor Abrahamson

University of California, Berkeley

Abstract

I introduce a design-research methodological framework for creating cognitively ergonomic learning tools through close analysis of learner–tools interaction. By ‘*cognitively ergonomic*’ (Artigue, 2002) I mean artifacts supporting tacit negotiation between “naïve” kinesthetic schemas from comportment in everyday situations and “scientific” *epistemic forms* (Collins & Ferguson, 1993) of mathematical problem-solving practice, such as symbolic representations (Abrahamson, 2004).

Spatial–numerical mathematical representations in use today evolved over millennia. Presumably, humans’ embodied strategies played roles in creating, selecting, and perpetuating these objects. These same embodied strategies could enable students’ re-invention of the historical artifacts—an ontogeny/phylogeny recapitulation underlying implementation of constructivist pedagogical philosophy (von Glasersfeld, 1987; Wilensky, 1997).

I demonstrate with empirical data of 28 4th-6th graders and 30 college students who each participated in a 1-hour Piagetian interview about a probability situation. I focused on students’ gesture (Alibali, Bassok, Olseth, Syc, & Goldin-Meadow, 1999) when they came up against the obduracy of available objects. For example, students estimating the ratio of green and blue marbles mixed in a box say “about half half” while gesturing “separating, measuring, and weighing.” This ‘mismatch’ (Church & Goldin-Meadow, 1986) may indicate negotiation between embodied, dynamic, visuo–spatial knowing (gesture) and explicit, typological, “math talk” (speech; Abrahamson, 2003). A cognitively ergonomic learning tool, e.g., a 0-100 number-line placed alongside the box, would accommodate the embodied knowing and enhance its quantitative precision.

I present the gesture-to-design development of a computer-based dynamic visualization of the binomial function (<http://edrl.berkeley.edu/Histo-Blocks.shtml>). I compare students’ behavior without- and with the tools to show how students’ images are materialized in the tools’ affordances.

References:

- Abrahamson, D. (2006). NetLogo model *Histo-Blocks*. University of California, Berkeley: Embodied Design Research Laboratory. Interactive applet accessible at <http://edrl.berkeley.edu/Histo-Blocks.shtml>
- Abrahamson, D. (2003). *Text talk, body talk, table talk: A design of ratio and proportion as classroom parallel events*. Paper presented at the Twenty Seventh Annual Meeting of the International Group for the Psychology of Mathematics Education, Honolulu, Hawaii.
- Abrahamson, D. (2004). Embodied spatial articulation: A gesture perspective on student negotiation between kinesthetic schemas and epistemic forms in learning mathematics. In D. E. McDougall & J. A. Ross (Eds.), *Proceedings of the Twenty Sixth Annual Meeting of*

- the North American Chapter of the International Group for the Psychology of Mathematics Education* (Vol. 2, pp. 791 – 797). Toronto, Ontario: Preney.
- Alibali, M. W., Bassok, M., Olseth, K. L., Syc, S. E., & Goldin-Meadow, S. (1999). Illuminating mental representations through speech and gesture. *Psychological Sciences, 10*(327-333).
- Artigue, M. (2002). Learning mathematics in a CAS environment: The genesis of a reflection about instrumentation and the dialectics between technical and conceptual work. *International Journal of Computers for Mathematical Learning, 7*(3), 245-274.
- Church, R. B., & Goldin-Meadow, S. (1986). The mismatch between gesture and speech as an index of transitional knowledge. *Cognition, 23*, 43-71.
- Collins, A., & Ferguson, W. (1993). Epistemic forms and epistemic games: Structures and strategies to guide inquiry. *Educational Psychologist, 28*(1), 25-42.
- von Glasersfeld, E. (1987). Learning as a constructive activity. In C. Janvier (Ed.), *Problems of representation in the teaching and learning of mathematics* (pp. 3-18). Hillsdale, NJ: Lawrence Erlbaum.
- Wilensky, U. (1997). What is normal anyway?: Therapy for epistemological anxiety. *Educational Studies in Mathematics, 33*(2), 171-202.