Resources

Abrahamson

Embodied Design Research Laboratory at UC Berkeley (https://edrl.berkeley.edu/). EDRL is a design-based research laboratory studying mathematical cognition and instruction by creating and evaluating theory-driven educational innovation using both traditional and cutting-edge media.

Abrahamson, D. (2012). Seeing chance: Perceptual reasoning as an epistemic resource for grounding compound event spaces. In R. Biehler & D. Pratt (Eds.), Probability in reasoning about data and risk [Special issue]. *ZDM Mathematics Education, 44*(7), 869–881.

Abrahamson, D. (2014). Rethinking probability education: Perceptual judgment as epistemic resource. In E. J. Chernoff & B. Sriraman (Eds.), *Probabilistic thinking: Presenting plural perspectives* (pp. 339–260). Springer.

Abrahamson, D. (2021). Grasp actually: An evolutionist argument for enactivist mathematics education. *Human Development, 65,* 77–93.

Boaler

Youcubed resources:

- Finger training activities: https://www.youcubed.org/wp-content/uploads/2017/03/Finger-Activities-vF.pdf
- Summer camps: https://www.youcubed.org/evidence/our-teaching-approach/
- Various mathematics resources: https://www.youcubed.org/tasks/ and https://www.youcubed.org/week-inspirational-math/
- Data science K-12 initiative: https://www.youcubed.org/resource/data-literacy/

Flood, Shvarts, and Abrahamson

- Mathematical Imagery Trainer: https://edrl.berkeley.edu/projects/gesture-enhancement-of-virtual-agent-mathematics-tutor
- Mathematical Imagery Trainer for Proportion (MIT-Proportion): Abrahamson, D., Lee, R. G., Negrete, A. G., & Gutiérrez, J. F. (2014). Coordinating visualizations of polysemous action: Values added for grounding proportion. *ZDM Mathematics Education, 46*(1), 79–93.
- Mathematical Imagery Trainer for Parabolas (MIT-Parabola): Shvarts, A., & Abrahamson, D. (2019). Dual-eye-tracking Vygotsky: A microgenetic account of a teaching/learning collaboration

in an embodied-interaction technological tutorial for mathematics. *Learning, Culture, and Social Interaction, 22,* Article 100316. https://doi.org/10.1016/j.lcsi.2019.05.003

- Embodied design implementations are available at https://embodieddesign.sites.uu.nl/activity/ (see Functions, Activity 1 for MIT-Proportion and Activity 2 for MIT-Parabola).

Gómez and Glenberg

Embodied reading resources:

- Video demonstration: Glenberg, A. M. (2021). Embodiment and learning of abstract concepts (such as algebraic topology and regression to the mean) [Manuscript submitted for publication]. *Psychological Research.*
- EMBRACE books: https://www.movedbyreading.com/embrace-books/
- Moved by Reading program (Glenberg, 2011; Glenberg, Goldberg, & Zhu, 2011). https://www.movedbyreading.com/
- Adams, A., Glenberg, A., & Restrepo, M. A. (2018). Moved by Reading in a Spanish-speaking, dual language learner population. *Language, Speech, and Hearing Services in Schools, 49*(3), 582–594. https://doi.org/10.1044/2018_LSHSS-16-0032. Evaluates the effectiveness of an English-only version and a Spanish-support version of an embodied reading comprehension intervention (Moved by Reading) consisting of three stages (physical manipulation, imagined manipulation, and transfer) for Spanish-English dual-language learners.

Hutto and Abrahamson

The Mathematics Imagery Trainer (MIT)is an interactive technological system designed to create opportunities for students to develop new sensorimotor schemes that emerge from mathematical concepts. In particular, MIT for Proportion is geared to support the construction of proportional equivalence. For more on the MIT and MIT for Proportion, visit https://edrl.berkeley.edu/design/mathematics-imagery-trainer. See the work of Anna Shvarts at https://embodieddesign.sites.uu.nl/activity and interact with several mathematics imagery trainers covering a variety of topics. See also the references to MIT and MIT-Proportion in Flood and Tancredi (chapter 12 in this volume).

James

The Cognition and Action Neuroimaging Laboratory at Indiana University-Bloomington, Karin James' Lab-Cognition and Action Neuroimaging Lab (CANLab) focuses on how actions affect cognition. Visit the laboratory online at https://canlab.sitehost.iu.edu/people.html.

Johnson-Glenberg

AR-VR-XR

- For more on SMALLab Learning, go to https://www.smallablearning.com/videos.
- *Catch a Mimic* and *Mimic Go*, the new WebXR version, can be found at www.embodied-games.com.
- For more on *Titans of Space-Mobil* version in the Go headset, v. 2.5.5, go to http://www.drashvr.com/titansofspace.html.
- For more on *Virtual Be Einstein* to improve self-esteem, see Banakou, D., Kishore, S., & Slater, M. (2018.). Virtually being Einstein results in an improvement in cognitive task performance and a decrease in age bias. *Frontiers in Psychology 9,* Article 917. https://doi.org/10.3389/fpsyg.2018.00917. The video for the report is at https://www.youtube.com/watch?v=TAEM5OlFbnw.

- Also see Lindgren, R., Tscholl, M., & Moshell, J. M. (2014). *MEteor: Developing Physics Concepts through Body-based Interaction with a Mixed Reality Simulation*. 217–220. Paper presented at 2013 Physics Education Research Conference. https://doi.org/10.1119/perc.2013.pr.042

Kaschak and McGraw

- Enacted Reading Comprehension (ERC): Kaschak, M. P., Connor, C. M., & Dombek, J. L. (2017). Enacted reading comprehension: Using bodily movement to aid the comprehension of abstract text content. *PLoS One, 12,* Article e0169711. https://doi.org/10.1371/journal.pone.0169711
- Language in Motion (LIM): Connor, C. M., Phillips, B. M., Kaschak, M., Apel, K., Kim, Y., Al Otaiba, S., Crowe, E. C., Thomas-Tate, S., Johnson, L. C., & Lonigan, C. J. (2014). Comprehension tools for teachers: Reading for understanding from kindergarten through fourth grade. *Educational Psychology Review, 26,* 379–401. https://dx.doi.org/10.1007/s10648-014-9267-1

Megowan-Romanowicz

For magnetic fields, see *Visualize the Invisible* is a tool for teaching and learning about magnetic fields with augmented reality:

- https://www.magna-ar.net/
- https://www.modelinginstruction.org/?s=embodied

*Free on Google Play

See also the American Modeling Teachers Association (AMTA), a professional organization of teachers, by teachers, for teachers, who use Modeling Instruction in their STEM teaching: https://www.modelinginstruction.org.

Schenck, Walkington, and Nathan

- uwmagiclab.org—website for the MAGIC Lab at University of Wisconsin–Madison
- Embodied Mathematical Imagination & Cognition: https://www.embodiedmathematics.com
- The Hidden Village: Mathematical Reasoning through Movement—The Hidden Village on Kinect: https://multiplex.videohall.com/presentations/1662

*And you can join in with Embodied Math on Twitter @embodiedmath.

Tancredi, Chen, Krause, and Siu

Special Education Embodied Design at the Embodied Design Research Laboratory: https://edrl.berkeley.edu/projects/special-education-embodied-design-speed/

- Balance Board Math (Tancredi): https://edrl.berkeley.edu/projects/balance-board-math/
- Magical Musical Mat (Chen): https://edrl.berkeley.edu/projects/magical-musical-mat/
- SignEd|Math (Krause): https://edrl.berkeley.edu/projects/signedmath/
- Tancredi, S., Chen, R. S. Y., Krause, C., Abrahamson, D., & Gomez Paloma, F. (2021). Getting up to SpEED: Special education embodied design for sensorially equitable inclusion. *Education Sciences & Society – Open Access*, *12*(1). https://doi.org/10.3280/ess1-2021oa11818

Vieyra and Vieyra

1. Vieyra Software: https://www.vieyrasoftware.net/
2. Magna-AR: https://www.vieyrasoftware.net/physics-toolbox-ar
3. Physics Toolbox: https://play.google.com/store/apps/details?id=com.chrystianvieyra.physicstoolboxsuite&hl=en_US

*Free on Google Play

**This work is funded by NSF Grant

4. Explorations of Static Magnetic Fields: https://www.magna-ar.net/lesson-ideas

More Embodied Design Apps

- 3D Multiplication Table: https://edrl.berkeley.edu/design/3d-multiplication-table/
  The 3D multiplication table is a three-dimensional embodiment of the 100 products in the familiar 10-by-10 multiplication chart. The result is an intriguing object-to-think-with that supports mathematical inquiry by making salient logical and quantitative properties that are embedded in the regular multiplication table yet are difficult to see therein.
- 4-Block Stalagmite: https://edrl.berkeley.edu/design/4-block-stalagmite/
  Sample Stalagmite is an interactive computer-based model. The model is a part of the ProLab curriculum designed by Dor Abrahamson initially at Uri Wilensky's Center for Connected Learning and Computer-Based Modeling (CCL) at Northwestern University and later at UC Berkeley.
- 4-Blocks NetLogo model: http://ccl.northwestern.edu/netlogo/docs/
  The 4-Blocks NetLogo model is an interactive computer-based embodiment of the 4-Block mathematical object, simulating an empirical probability experiment in which the randomness generator is a compound of four squares that each can independently be either green or blue. The model helps conceptualize relations among theoretical and empirical aspects of the binomial functions.
- Combinations Tower: https://edrl.berkeley.edu/design/combinations-tower/
  The 16 unique configurations of the 4-Block are arranged in the tower according to the number of white (green) cells in them, resulting in a 1-4-6-4-1 formation (the corresponding binomial coefficients). This is the anticipated shape of the outcome distribution from experiments with the marble box containing equal numbers of marbles of each color.
- Dice Stalagmite: https://ccl.northwestern.edu/netlogo/models/DiceStalagmite
  Dice Stalagmite is an interactive computer-based model. The model is part of the ProLab curriculum designed by Dor Abrahamson initially at Uri Wilensky's Center for Connected Learning and Computer-Based Modeling (CCL) at Northwestern University and later at UC Berkeley.
- The Eye Trick: https://edrl.berkeley.edu/design/the-eye-trick/
  The Eye Trick is an activity for grounding the concept of proportion in perceptual judgments of geometrical similitude. The "trick" is that students judge similarity by creating an optical illusion of identity. Later, they use a stretchy ruler to determine measures, and they tabulate these measures in what becomes a ratio table.
- Histo Blocks: https://ccl.northwestern.edu/netlogo/models/HistoBlocks
  Histo Blocks is an interactive computer-based model. The model is a part of the ProLab curriculum designed by Dor Abrahamson initially at Uri Wilensky's Center for Connected Learning and Computer-Based Modeling (CCL) at Northwestern University and later at UC Berkeley. The EDRL website features some of these latter models as relevant to our publications.
- Magical Musical Mat: https://edrl.berkeley.edu/projects/magical-musical-mat/
  A domain-general communicative platform that surfaces the embodied interactions of students in special education. Also see Chen, R.S.Y., Ninh, A., Yu, B., & Abrahamson, D. (2020, June 19-23). *Being in touch with the core of social interaction: Embodied design for the nonverbal* [Paper presentation]. In Proceedings of the International Conference of the Learning Sciences (pp. 1681–1684). International Society of the Learning Sciences, Nashville, TN, United States.

https://edrl.berkeley.edu/wp-content/uploads/2020/07/Chen.Ninh_.Yu_.Abrahamson.ICLS2020.MMM-1.pdf

- The Marbles Scooper: https://edrl.berkeley.edu/design/the-marbles-scooper/
  The Marbles Scooper is a random generator for probability experiments, a device for sampling a fixed number of marbles out of a vessel containing many marbles, such as a box with equal numbers of green and blue marbles. We have built scoopers that sample exact numbers of marbles—a 4-Block marble scooper and a 9-Block marble scooper. https://www.youtube.com/watch?v=SkUJxXd4qAA
- Mathematics Imagery Trainer: https://edrl.berkeley.edu/design/mathematics-imagery-trainer/
  The Mathematics Imagery Trainer (MIT) is an interactive technological system designed to create opportunities for students to develop new sensorimotor schemes from which emerge mathematical concepts. In particular, the MIT for Proportion (MIT-P) is geared to support the construction of proportional equivalence. We have done extensive research on this design and using variety of media.

Related Articles

Blaskeslee, S. (2012, April 2). Mind games: Sometimes a white coat isn't just a white coat. *New York Times.* https://www.nytimes.com/2012/04/03/science/clothes-and-self-perception.html. Article reports on an emerging field in psychology known as embodied cognition and describes a role-playing experiment on being a doctor—the effect of clothing on cognitive processes.

Boaler, J., & Chen, L. (2016, April 13). Why kids should use their fingers in math class. *The Atlantic.* https://www.theatlantic.com/education/archive/2016/04/why-kids-should-use-their-fingers-in-math-class/478053/. Evidence from brain science suggests that far from being "babyish," the technique is essential for mathematical achievement.

Cutraro, J., & Epstein Ojalvo, H. (2012, April 4). It's not all in your head: Designing embodied cognition experiments. *New York Times*. https://learning.blogs.nytimes.com/2012/04/04/its-not-all-in-your-head-designing-embodiedcognition-experiments/

McGinty, J. C., (2016, October 23). Turns out, counting on your fingers makes you smarter. *The Wall Street Journal.* https://www.wsj.com/articles/turns-out-counting-on-your-fingers-makes-you-smarter-1477065563. Research shows that children who have better perception of their hands tend to be more skilled at math.

McNerney, S. (2011, November 4). A brief guide to embodied cognition: Why you are not your brain. *Scientific American Guest Blog.* https://blogs.scientificamerican.com/guest-blog/a-brief-guide-to-embodied-cognition-why-you-are-not-your-brain/. "Cognitive science calls this entire [Western] philosophical worldview into serious question on empirical grounds . . . [the mind] arises from the nature of our brains, bodies, and bodily experiences."

Smith, C., & Walkington, C. (2019). Four Principles for designing embodied mathematics activities. *Australian Mathematics Education Journal, 1*(4), 16–20. Current research shows these types of activities have great potential to help students develop conceptual understanding. The authors present four principles for designing embodied mathematics activities and give examples of classroom activities illustrating each idea.