



INTERSECTIONS

Where Instructional Design
Meets Learning Science

University of Toronto's Teaching and Learning Symposium

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Keynote Presentation

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Co-hosted by Centre for Teaching Support & Innovation and Desautels Centre for Integrative Thinking, Rotman School of Management

University of Toronto

Translating Learning Science into Teaching Practice

PS: Are we a part of the problem or a part of the solution?

Open Learning at MIT

2001: OpenCourseWare

2011: MITx

2012: edX



But let's go back to the basics

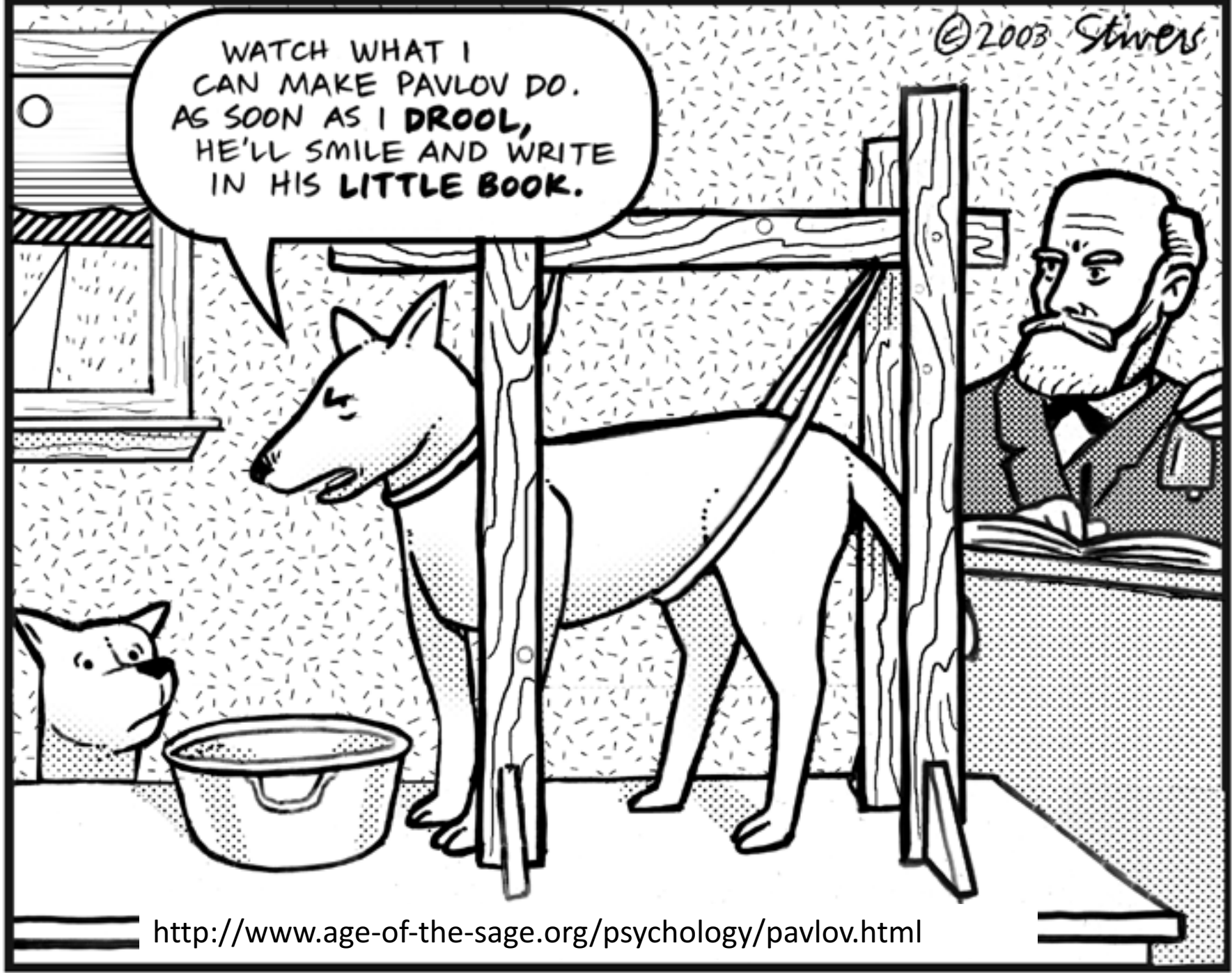
What is learning?

Why do we learn?

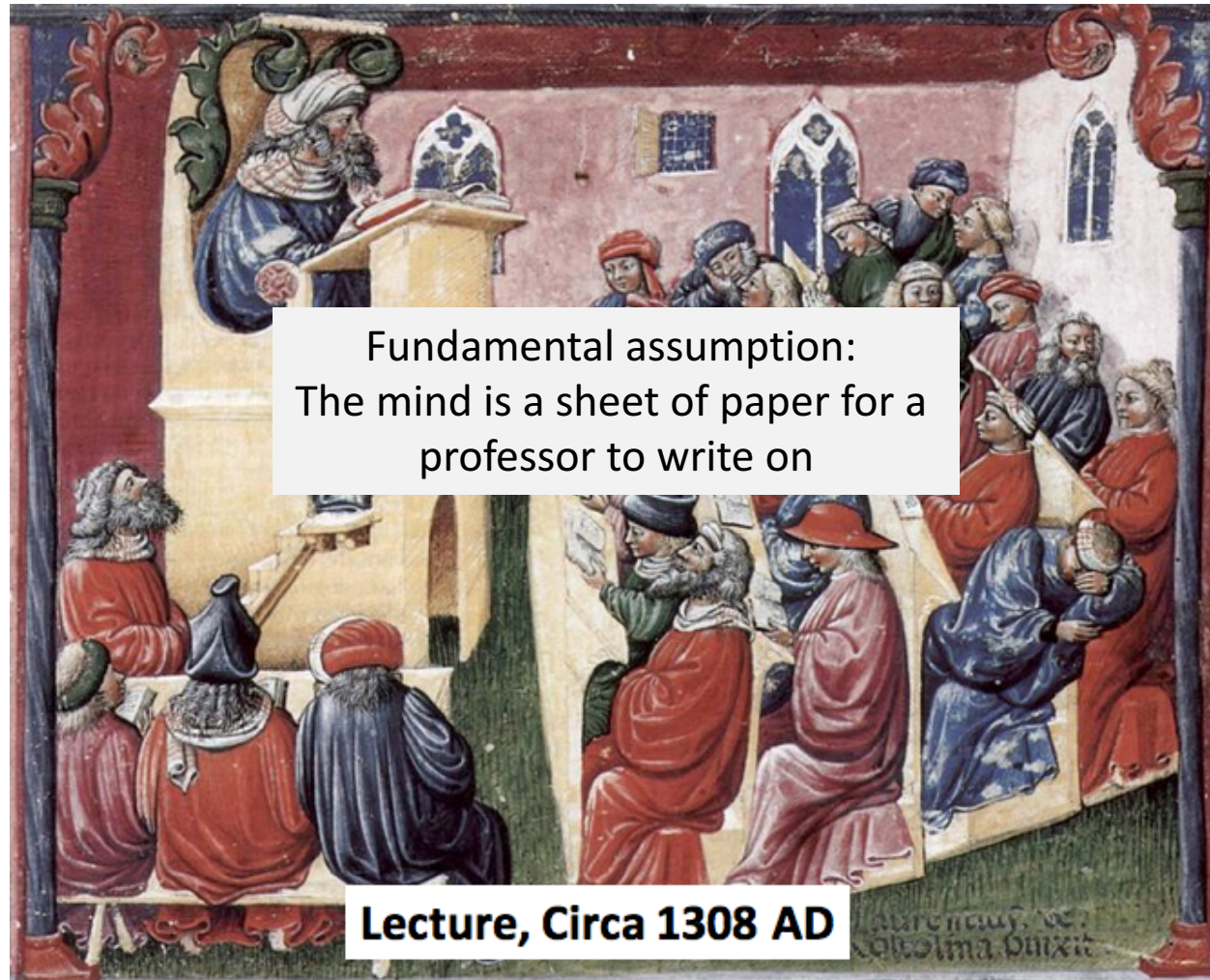
How do we learn?

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WATCH WHAT I
CAN MAKE PAVLOV DO.
AS SOON AS I **DROOL**,
HE'LL SMILE AND WRITE
IN HIS **LITTLE BOOK.**



Lecture Format is Resilient!





“Executive
Function”



Consolidation,
Integration,
Sense-making,
Saliency.



Do not tire the leprechaun

The mind is not a sheet of paper for a professor to write on, it only works by self-service – if inspired.



Notes:

Cognitive Load Theory: Working memory is limited.

Fightback:

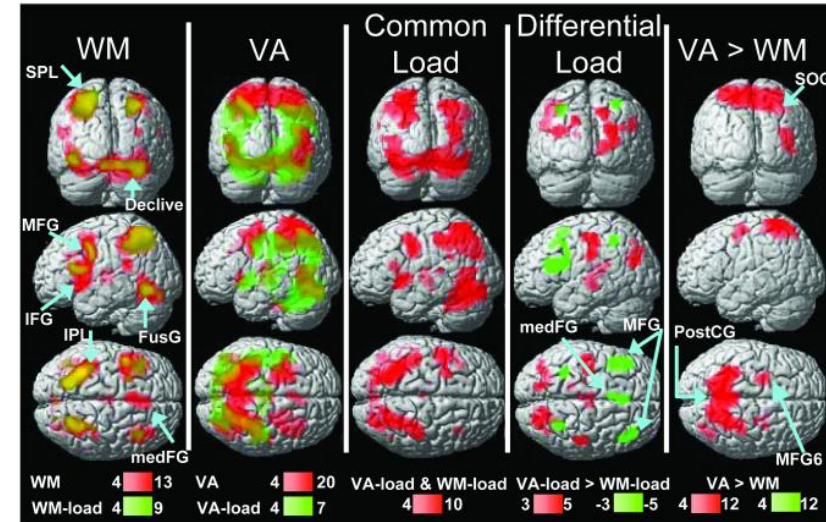
Henry Thoreau, Amos Alcott, Ralph Waldo Emerson

Maria Montessori

fMRI



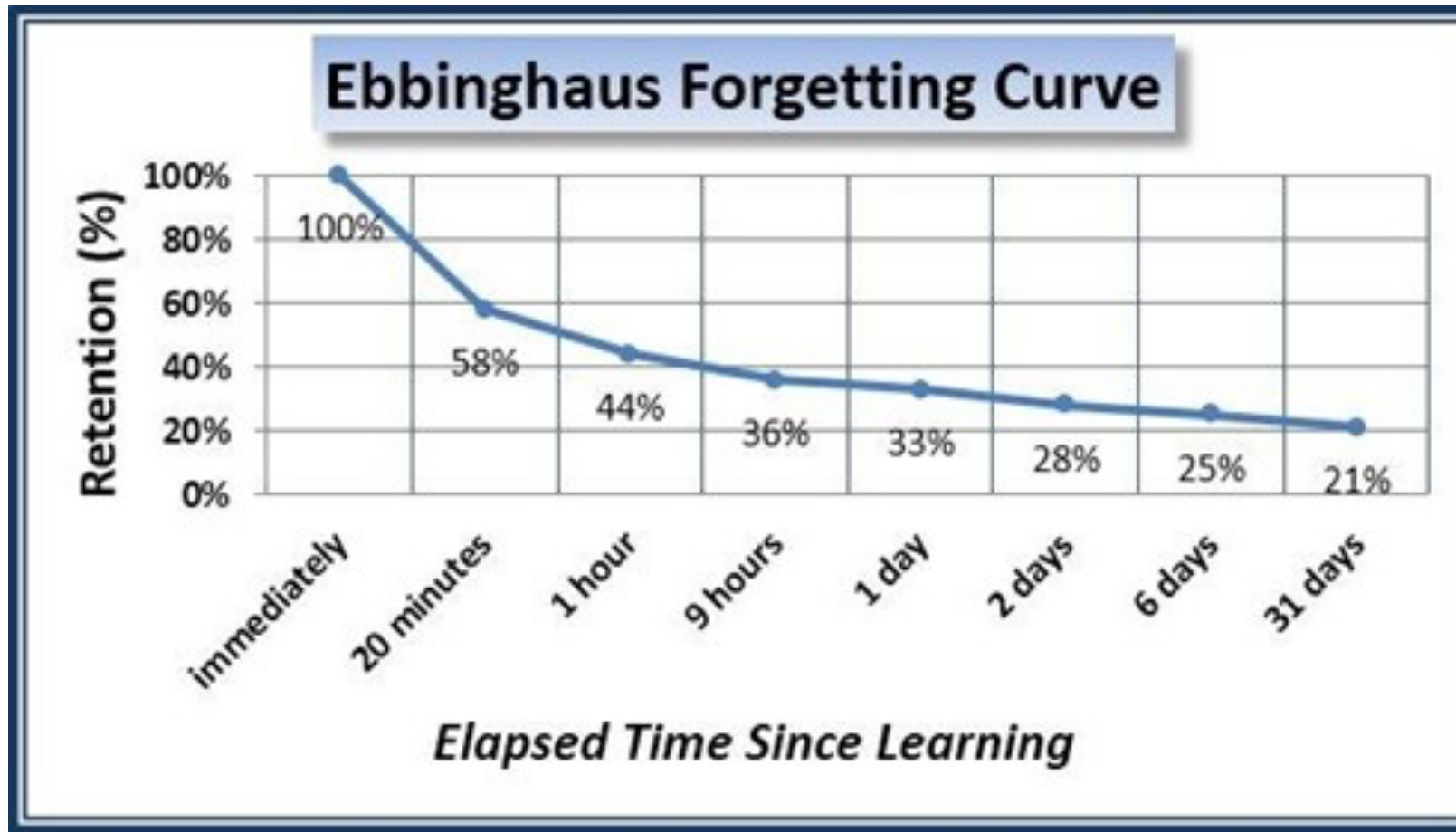
- **Mossi:** Blood flow could indicate brain activity.
- Proved experimentally by Roy and Sherrington.
- **Pauling, Coryell:** Oxygen-rich hemoglobin weakly repelled by magnetic field. dHb attracted.



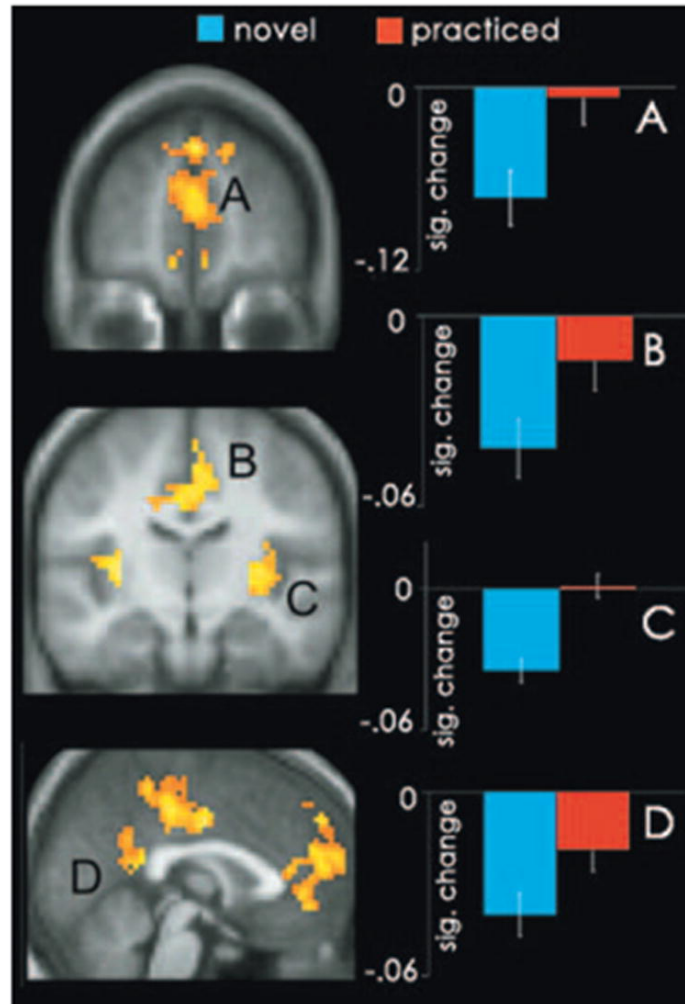
Tomasi, D., et al. "Different activation patterns for working memory load and visual attention load." *Brain research* 1132 (2007): 158-165.

- Seiji Ogawa: Realized that this could be used in MRI. Blood-oxygen-level dependent contrast imaging, or BOLD is born.
- Belliveau introduces regional brain activities. Kwong applies to humans.

Forgetting is predictable



Mind Wandering is Natural



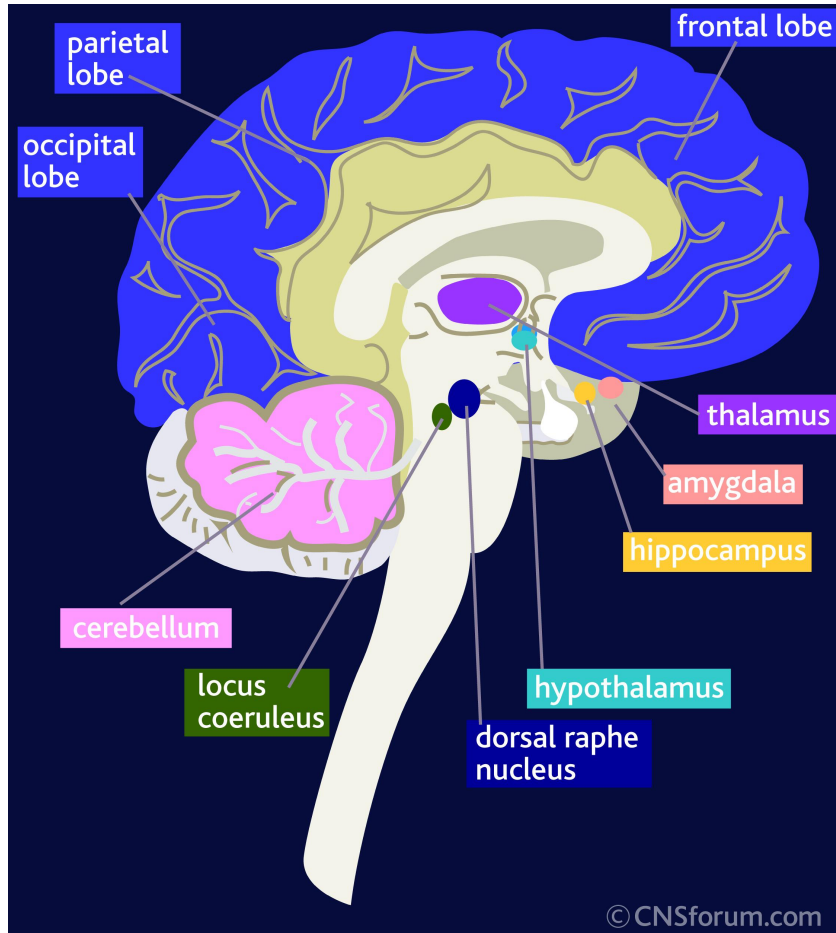
Singer, Jerome L. *Daydreaming: An introduction to the experimental study of inner experience*. New York: Random House, 1966.

Mason, Malia F., et al. "Wandering minds: the default network and stimulus-independent thought." *Science* 315.5810 (2007): 393-395.

Christoff, Kalina, Justin M. Ream, and John DE Gabrieli. "Neural basis of spontaneous thought processes." *Cortex* 40.4 (2004): 623-630.

Baird, Benjamin, et al. "Inspired by distraction mind wandering facilitates creative incubation." *Psychological Science* (2012): 0956797612446024.

Implicit versus explicit learning



<http://psychcentral.com/blog/archives/2009/09/30/10-ways-to-lower-anxiety-and-find-empowerment/brain-anatomy-amygdala-hippocampus/>

Exercise

Which is correct?

big, black dog”

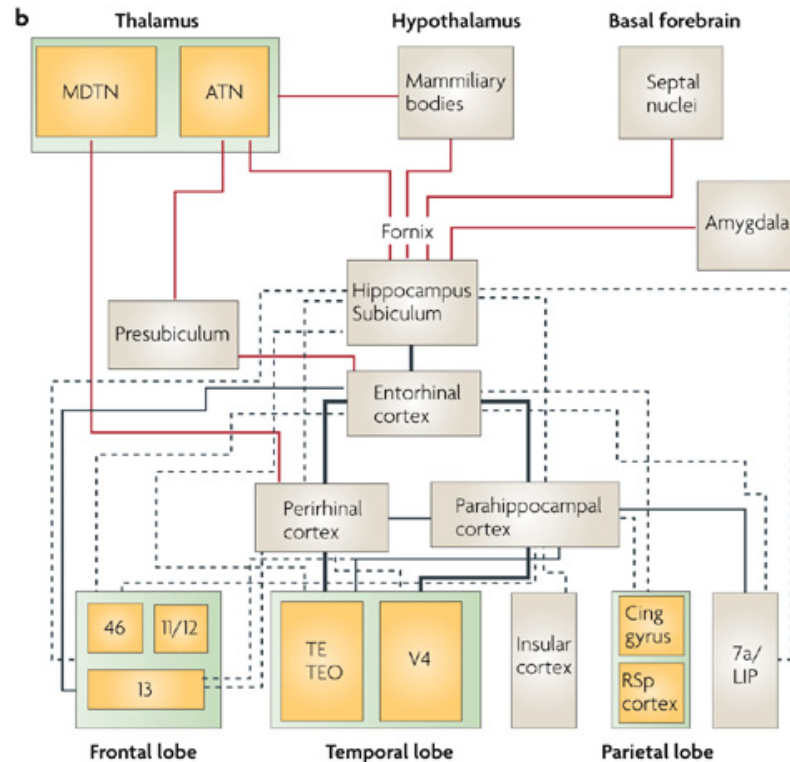
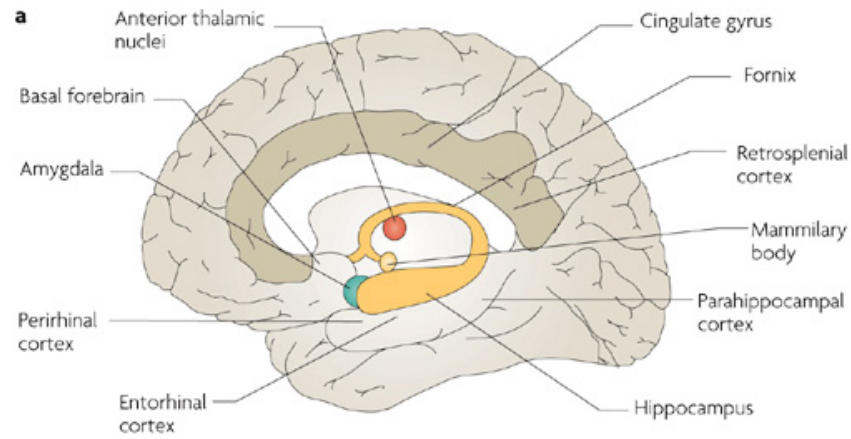
or

“black, big dog”?

Sequence of adjectives:

opinion, size, age, shape, color, origin, material, purpose

How memories form

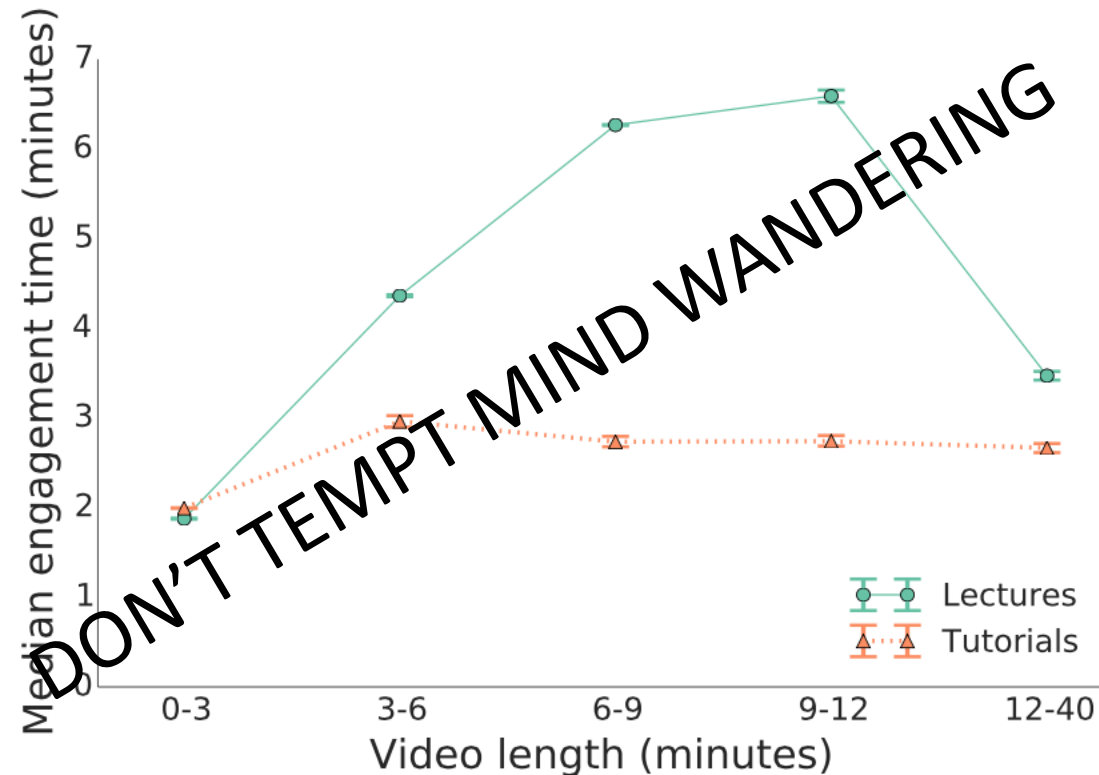


- Encoding
- Synaptic consolidation
- System consolidation

- Integration
- Schemas
- Cognitive Load Theory

Lesson #1 for Learning

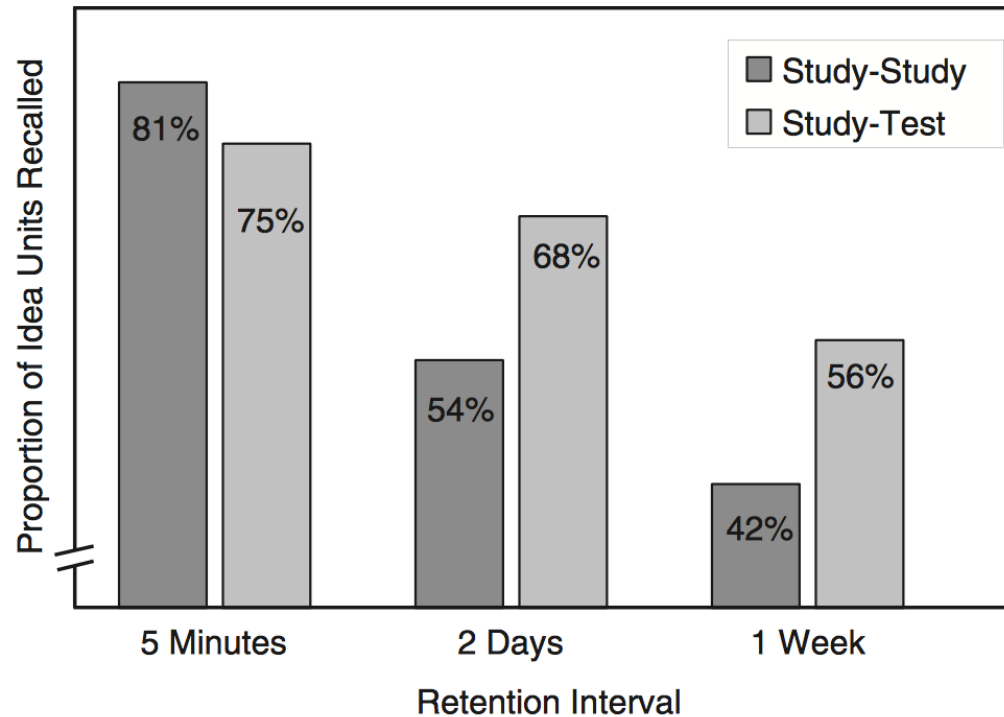
Segment learning into bite-sized chunks



Guo, Philip J., Juho Kim, and Rob Rubin. "How video production affects student engagement: An empirical study of mooc videos." *Proceedings of the first ACM conference on Learning@ scale conference*. ACM, 2014.

Lesson #2 for Learning

Retrieval Learning

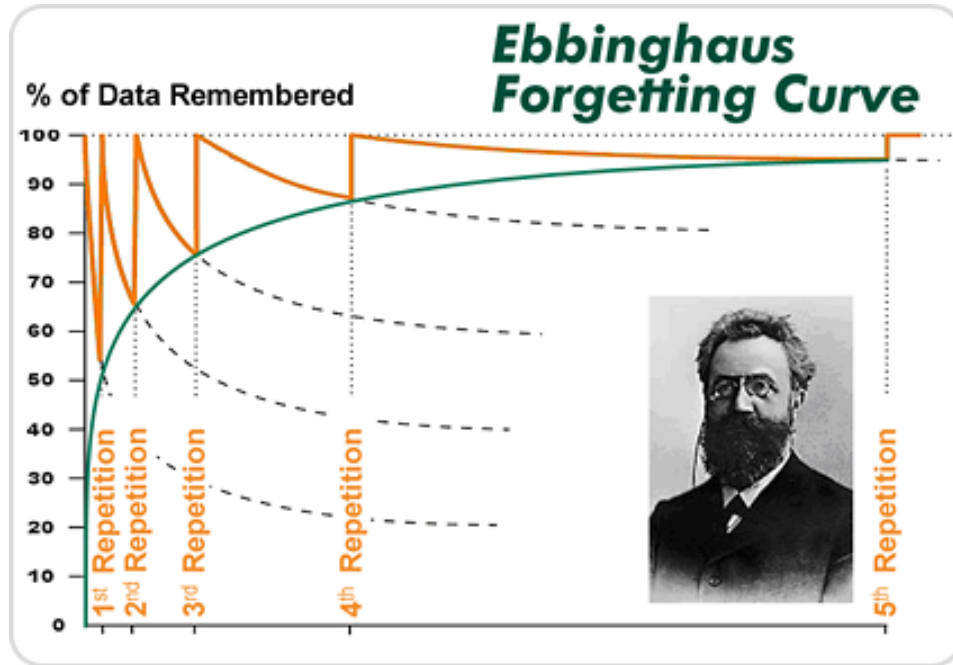


Karpicke, Jeffrey D., and Henry L. Roediger. "The critical importance of retrieval for learning." *science* 319.5865 (2008): 966-968.

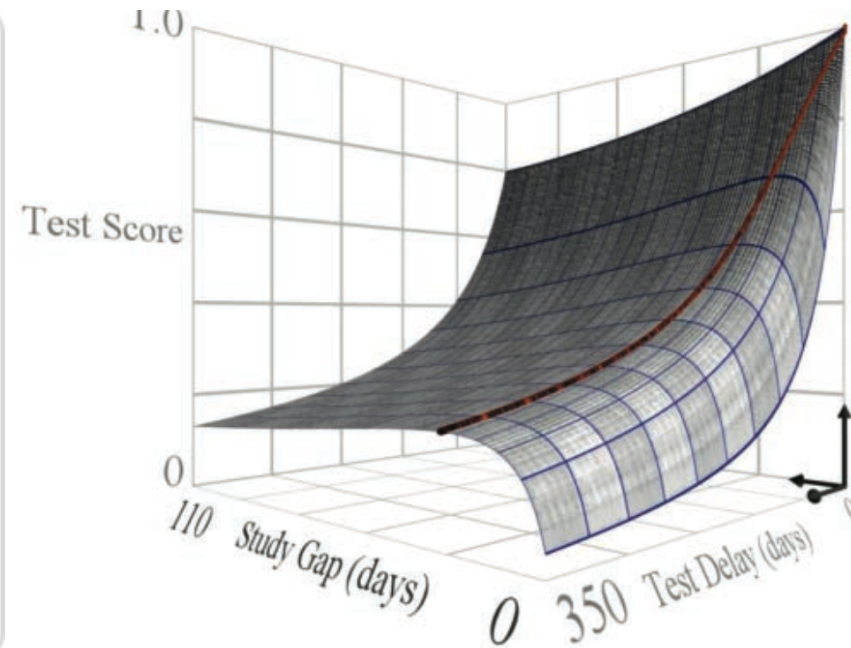
Roediger, Henry L., and Jeffrey D. Karpicke. "The power of testing memory: Basic research and implications for educational practice." *Perspectives on Psychological Science* 1.3 (2006): 181-210.

Lesson #3 for Learning

Spaced Retrieval



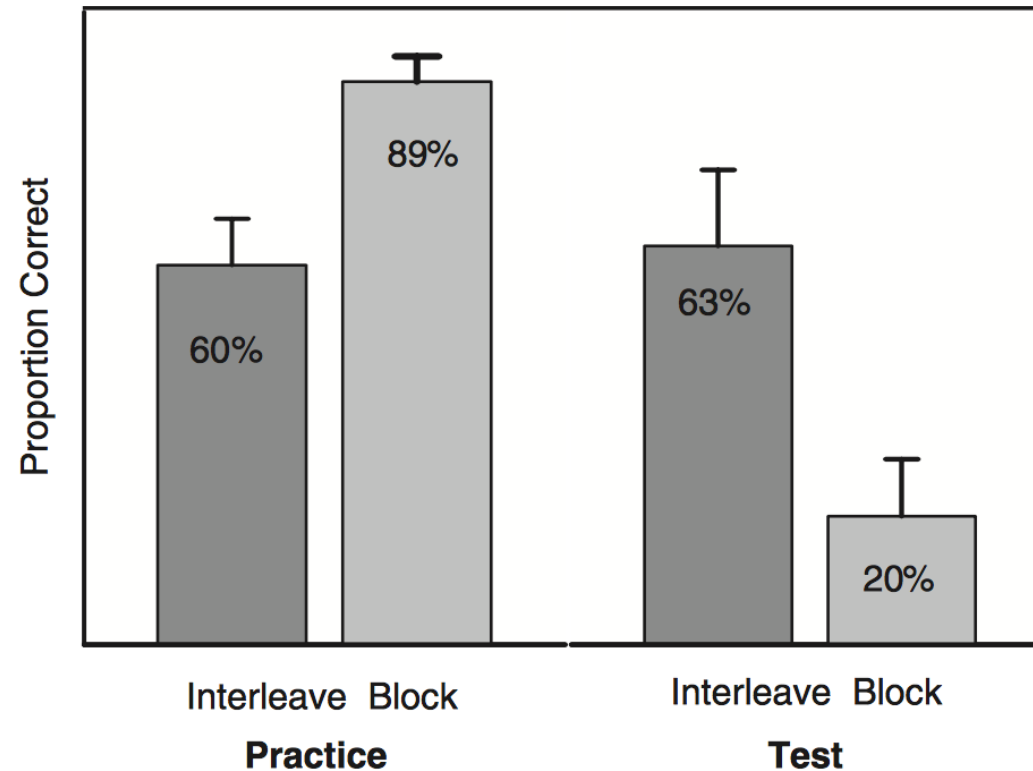
<https://p2pu.org/he/groups/studying-psychology-the-p2pu-way/content/task-21-the-ebbinghaus-forgetting-curve/>



Cepeda, Nicholas J., et al. "Distributed practice in verbal recall tasks: A review and quantitative synthesis." *Psychological bulletin* 132.3 (2006): 354.

Lesson #4 for Learning

Interleaved learning



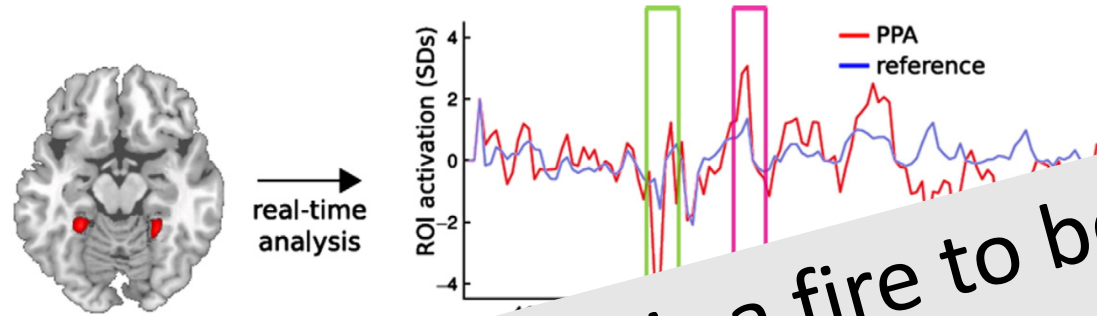
Rohrer, Doug, and Kelli Taylor. "The shuffling of mathematics problems improves learning." *Instructional Science* 35.6 (2007): 481-498.

Rohrer, Doug, and Harold Pashler. "Recent research on human learning challenges conventional instructional strategies." *Educational Researcher* 39.5 (2010): 406-412.

Lesson #5: Peer instruction helps tutor and tutee.

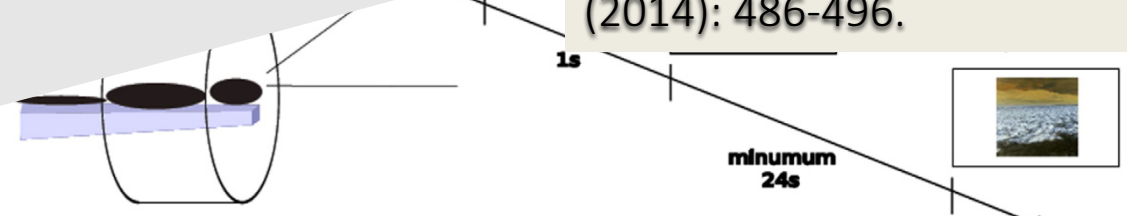
Roscoe, Rod D., and Michelene TH Chi. "Tutor learning: The role of explaining and responding to questions." *Instructional Science* 36.4 (2008): 321-350.

Lesson #6: Curiosity makes a huge difference



Plutarch: The mind is a fire to be kindled,
not a vessel to be filled.

... Gelman, and
... states of Curiosity
... Hippocampus-Dependent Learning
via the Dopaminergic Circuit." *Neuron* 84.2
(2014): 486-496.



Yoo, Julie J., et al. "When the brain is prepared to learn: Enhancing human learning using real-time fMRI." *Neuroimage* 59.1 (2012): 846-852.

More principles

- Lesson #7: Self pacing is helpful – Goldilocks principle.
 - de Jonge, Mario, et al. "The effect of study time distribution on learning and retention: A Goldilocks principle for presentation rate." *Journal of Experimental Psychology: Learning, Memory, and Cognition* 38.2 (2012): 405.
- Lesson #8: Intent makes a difference
 - Frey, Scott H., and Valerie E. Gerry. "Modulation of neural activity during observational learning of actions and their sequential orders." *The Journal of Neuroscience* 26.51 (2006): 13194-13201
- Lesson #9: Embodied Cognition
 - Kontra, Carly, Susan Goldin-Meadow, and Sian L. Beilock. "Embodied learning across the life span." *Topics in cognitive science* 4.4 (2012): 731-739.

Cognitive Load

- Lesson #9: Worked Examples for Novices

- Sweller, John, and Graham A. Cooper. "The use of worked examples as a substitute for problem solving in learning algebra." *Cognition and Instruction* 2.1 (1985): 59-89.

- Lesson #10: Unsolved Problems for experts:

The expert reversal effect

- Kalyuga, Slava, et al. "The expertise reversal effect." *Educational psychologist* 38.1 (2003): 23-31.

- Lesson #11: Germane cognitive load

- Sweller, John. "Element interactivity and intrinsic, extraneous, and germane cognitive load." *Educational psychology review* 22.2 (2010) 123-138.

Cognitive Load and Multimedia

- Lesson #12: Clean content organization – the Apple-Google look
 - Sweller, John. *Instructional Design in Technical Areas. Australian Education Review, No. 43.* PCS Data Processing, Inc., 360 W. 31st, New York, NY 10001, 1999.
- Lesson #13: *Graphic-and-text* better than text alone
 - Mayer, Richard E. "Multimedia learning." *Psychology of Learning and Motivation* 41 (2002): 85-139.
- Lesson #14: Audio-and-graphics better than text-and-graphics
 - Moreno, Roxana, and Richard E. Mayer. "Verbal redundancy in multimedia learning: When reading helps listening." *Journal of Educational Psychology* 94.1 (2002): 156.

Key principles

Mind wandering

Faded examples

Peer learning

Retrieval learning

Situated learning

Peer mentoring

Spaced learning

Embodied cognition

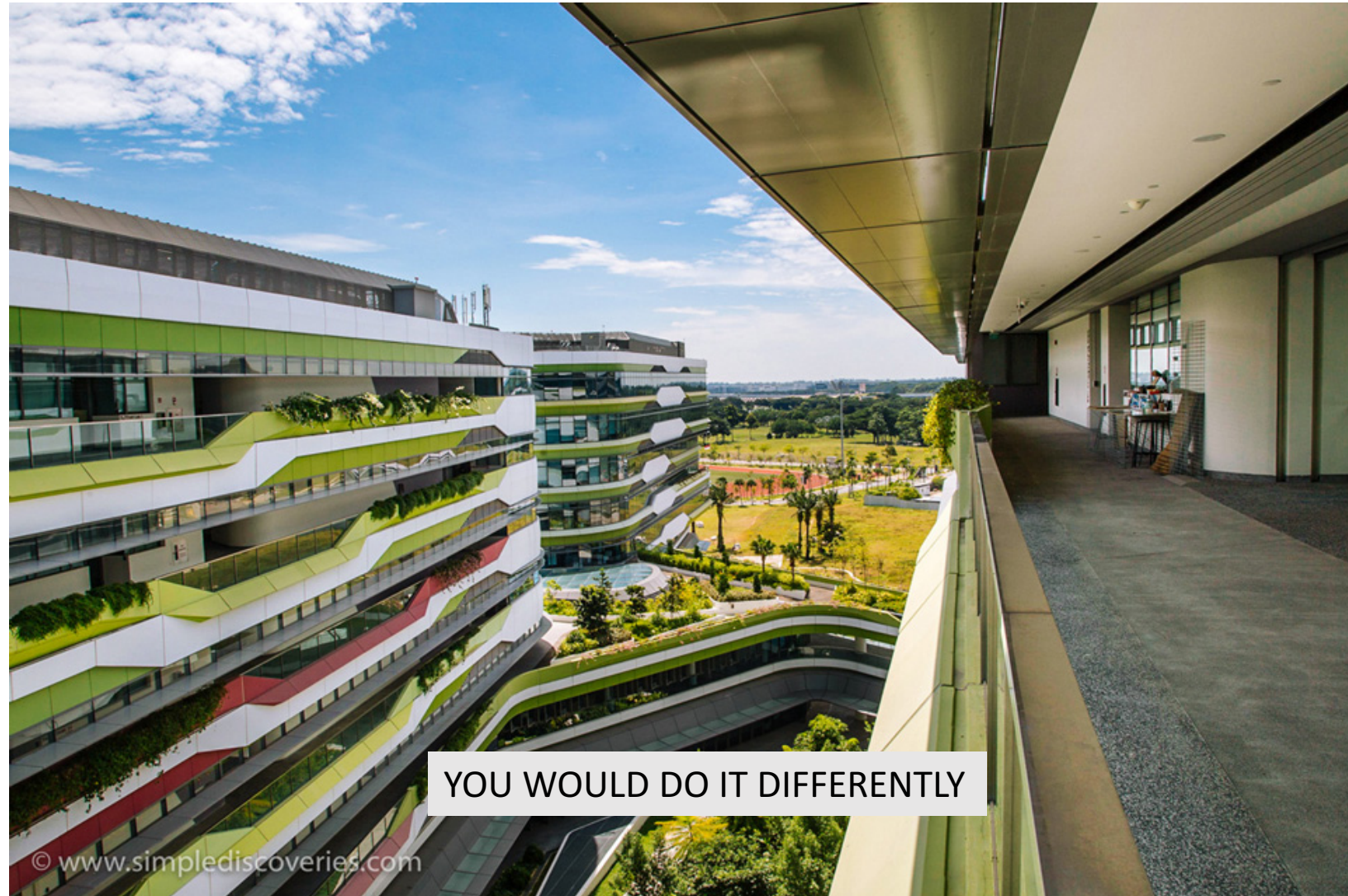
Synthesis

Interleaved learning

Generative learning

Metacognition

If you had to start a university today



YOU WOULD DO IT DIFFERENTLY

EVERYTHING

- “Lectures”
 - Labs
 - Curriculum
 - Assessments
 - Projects
-
- The future is blended, individuated, fluid, hands-on

At MIT

1. Internal transformation
2. Online education
 1. For us first!
 2. For everyone else as well!
3. New academic programs
 1. MicroMasters
 2. Bootcamps
4. Lifelong education
5. World Education Lab



Thank you