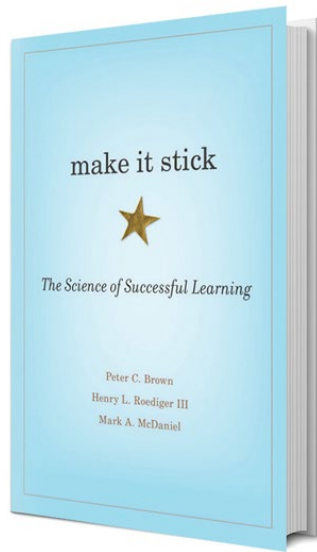


Science of Learning



Just as the Larner College of Medicine aims to teach students the necessity of evidenced-based medicine, so the Curriculum Team strives to share with students the most effective ways to learn, based on evidence.

Each incoming student receives a copy of *Make It Stick: The Science of Successful Learning* by Peter C. Brown, Henry L. Roediger III, and Mark A. McDaniel in an effort to help students study smarter, not harder.

We are not only encouraging evidence-based learning, but also correlating the ways in which we've embedded the science of learning into our curricular design. Below are the chapter titles of *Make It Stick*, and we've also included a page detailing the

research and application of each of the primary strategies in the science of learning.

1. Learning Is Misunderstood.
2. To Learn, Retrieve.
3. Mix Up Your Practice.
4. Embrace Difficulties.
5. Avoid Illusions of Knowing.
6. Get Beyond Learning Styles.
7. Increase Your Abilities.
8. Make It Stick.



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Learning Theory: Spaced Practice

Definition: Spacing out learning of new knowledge

Effect: Superior long-term retention that improves educational outcomes.

Why it works:

Research: [Spaced Repetition Promotes Efficient and Effective Learning Sean H. K. Kang, Dartmouth College](#)

Key Points from the article:

- The timing or arrangement of review/practice affects learning.
- Practice is more effective when spaced out over time, instead of massed or grouped together (equating total practice time).
- Spaced practice enhances memory, problem solving, and transfer of learning to new contexts.
- Spaced practice offers great potential for improving students' educational outcomes.

Curricular Design Application at the Larner: Students need to recall content at increasingly longer intervals. We structure pedagogy in a way that encourages spaced review and discourages massed practice. The Integrated curriculum pulls threads forward so that key topics are covered over a longer period of time, avoiding massed practice.



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- 1. Assign Independent Learning**, ideally with knowledge checks built in
- 2. Require Knowledge Check** Recall information for Quiz or IRAT)
- 3. In-class application.** Recall foundational knowledge to apply in class.
- 4. Block Exam/ Course Exam/Board Exam:** Prepare by recalling/revisiting material that is was previously learned.
- 5. Review of FoCS material in subsequent courses/clinical settings disrupts forgetting while capitalizing on elaboration**

Other Resources: [Osmosis Video](#)

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Learning Theory: Retrieval Practice

Definition: Retrieval practice is a strategy in which bringing information to mind enhances and boosts learning. Deliberately recalling information forces us to pull our knowledge “out” and examine what we know.

Effect: Struggling to learn – through the act of practicing what you know and recalling information – is much more effective than re-reading, taking notes, or listening to lectures. Slower, effortful retrieval leads to long-term learning. In contrast, fast, easy strategies only lead to short-term learning. (**Pooja K. Agarwal, Ph.D.**)

Why it works:

Research: [Test-Enhanced Learning: Taking Memory Tests Improves Long-Term Retention Roediger, H.L., Karpicke, J.D. \(2006\)](#)

Key Points from the article:

- Immediate testing promotes better long-term retention than repeated studying, even without feedback from testing.
- Spaced presentation or retrieval leads to better performance on delayed tests.
- Testing, or forced retrieval practice, creates a desirable difficulty during learning that produces elaboration of existing memory traces and their cue-target relationships.

Curricular Design Application at the Learner: Students are asked to retrieve content prior to arriving to class, in-class, and after class. We structure pedagogy in a way that encourages students to capitalize on the power of retrieval (hint—it’s more effective than taking notes):

1. Knowledge Checks built into Assigned Independent Learning

2. Required Quiz or IRAT

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3. In-class questions with clickers

4. Formative Quizzes

5. Integrative Review sessions

Other Resources: [Retrieval Practice Osmosis Video](#)

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Learning Theory: Interleaving

Definition: Switching between ideas or concepts while studying to avoid mass practice. For example: studying a mixture of flashcards on anatomy, normal and pathological physiology, and pharmacology in a random order, rather than studying all anatomy flashcards, then all pharmacology flashcards, then all physiology flashcards.

Effect: Interleaving produces better scores on final tests of learning.

Why it works:

Research: [Rohrer, D. \(2012\). Interleaving helps students distinguish among similar concepts. Educational Psychology](#)

Key Points from the article:

- Interleaving makes it easier for learners to identify distinguishing features of one category compared to another.
- Interleaving inherently incorporates spacing rather than massed practice, which is known to improve learning.
- It is easy and inexpensive to implement interleaving in curriculum or in studying.

Curricular Design Application at the Larner: The Vermont Integrated Curriculum contains horizontal threads so that students avoid massed practice of a topic. We structure pedagogy in a way that encourages interleaving and spaced review and discourages massed practice:

1. Integrated Curriculum

2. Peer Teaching

3. Integrated Review as a modality

Other Resources: [Interleaving Osmosis Video](#)

Learning Theory: Elaboration and Self-Explanation

Definition: Connecting learning material to other concepts, experiences, or memories and explaining/describing concepts in greater detail.

Effect: Elaborative interrogation and self-explanation enhance learning by integrating new information with existing prior knowledge. This integration increases retention of facts and improves performance on testing.

Why it works:

Research: [Improving Students' Learning With Effective Learning Techniques: Promising Directions From Cognitive and Educational Psychology \(Dunlosky et al., 2013\)](#)

Key Points from the article:

- Elaborative interrogation strengthens associative memory in short-delay recall. More research is needed regarding its effectiveness across longer delays as well as in different educational contexts.
- Self-explanation can similarly strengthen memory, as well as comprehension and transfer, across many task domains and age ranges.
- There is not enough conclusive evidence to claim that elaborative interrogation and self-explanation are as effective as repeated and distributed practice testing but there is sufficient evidence to consider them valuable additional techniques.

Curricular Design Application at the Larner: Students need to have a rich understanding of material that spans different topics. We structure pedagogy in a way that encourages using elaborative techniques so that students can create more durable memories and transfer and apply knowledge to new situations.

1. Case Based Learning

2. Problem Based Learning

3. Integrative Review Sessions

Other Resources: [Study Strategies: Elaboration](#)

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Learning Theory: Dual Coding

Definition: Dual coding theory (DCT) explains human behavior and experience in terms of dynamic associative processes that operate on a rich network of modality specific verbal and nonverbal (or imagery) representations.

Effect: Recall/recognition is enhanced by presenting information in both visual and verbal form.

Why it works:

Research: [Dual Coding Theory and Education Clark, J. and Pavio, A.](#)

Key Points from the article:

- Additive effects from imagery and verbal coding is more beneficial than just verbal coding alone.
- Active learning sessions involving concrete information and vivid images help form better memory and comprehension than sessions that are more abstract/non-image arousing.

Curricular Design Application at the Lerner: The Vermont Integrated Curriculum is delivered in a multimedia format. The integration of text, photos, videos, and other interactive in-class activities allows content to be delivered in a way that enhances learning and memory formation.

1. Independent Learning that pairs words and images

2. Workshops that require sketching or concept mapping

Other Resources: [Study Strategies: Dual Coding \(Video\)](#)

Learning Theory: Concrete Examples

Definition: Taking an abstract concept and creating an example based off real-life experiences to solidify the meaning of the concept. For example, a “quarter” could be thought of as taking one slice of pizza out of four equally sized slices.

Effect: Presenting students with concrete examples can significantly enhance conceptual learning for declarative concepts.

Why it works:

Research: [The Power of Examples: Illustrative Examples Enhance Conceptual Learning of Declarative Concepts \(Rawson, Thomas, & Jacoby, 2014\)](#)

Key Points from the article:

- Providing illustrative examples enhances conceptual learning relative to providing concept definitions, as evidenced by more accurate classification of both studied and novel examples.
- Varying levels of familiarity may mediate the effect of illustrative examples. Lower-familiarity students achieved better classification accuracy in the definition-then-examples group than did those in the definitions-only group. There were minimal differences in achievement for higher-familiarity students.

Curricular Design Application at the Lerner: Students need to have a rich understanding of material that spans different topics. We structure pedagogy in a way that encourages using elaborative techniques so that students can create more durable memories and transfer and apply knowledge to new situations.

1. Vignette Style (Board Style) questions in assessments
2. Incorporating patient experiences and stories in pre-clinical years
3. Case-based learning sessions

Other Resources: [Study Strategies - Concrete Examples](#)