Human Learning

How We Learn…

…why it matters

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I Can Help Your Team...

Improve effectiveness of **technical learning materials**

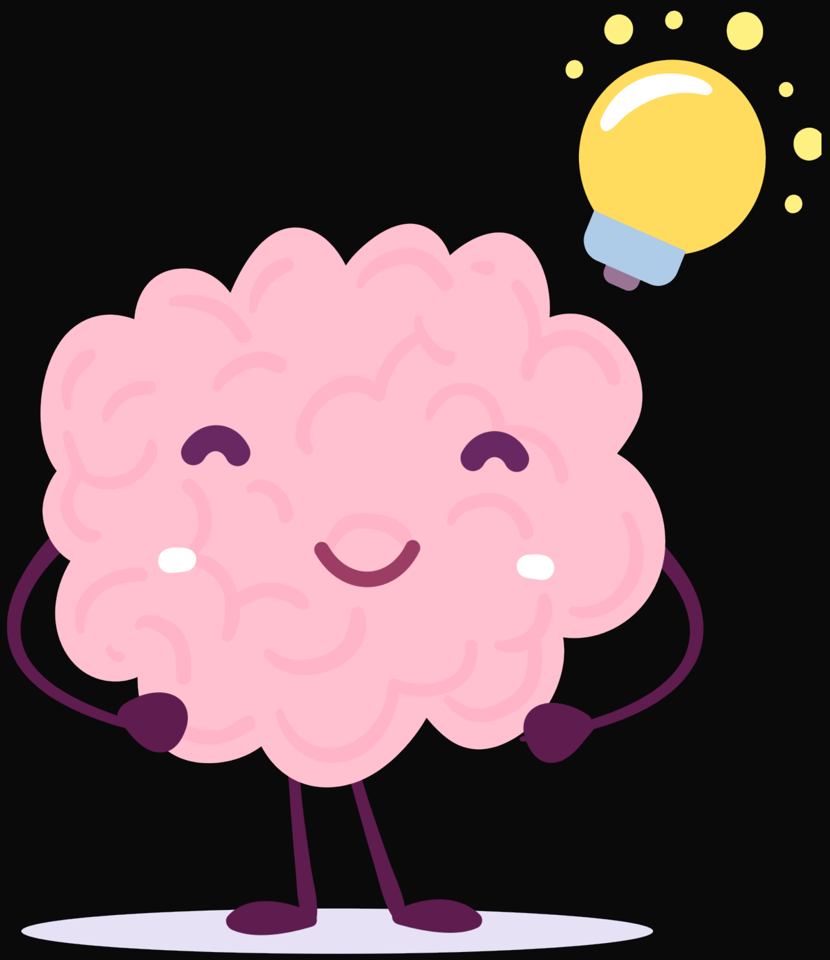
Become better developers

Be more productive in **Java & Spring**

Effectively use **TDD**

Apply **eXtreme Programming**

Ask Questions When You Have 'em



HUMAN LEARNING

Why *Human* Learning?

How to Make Learning Better?

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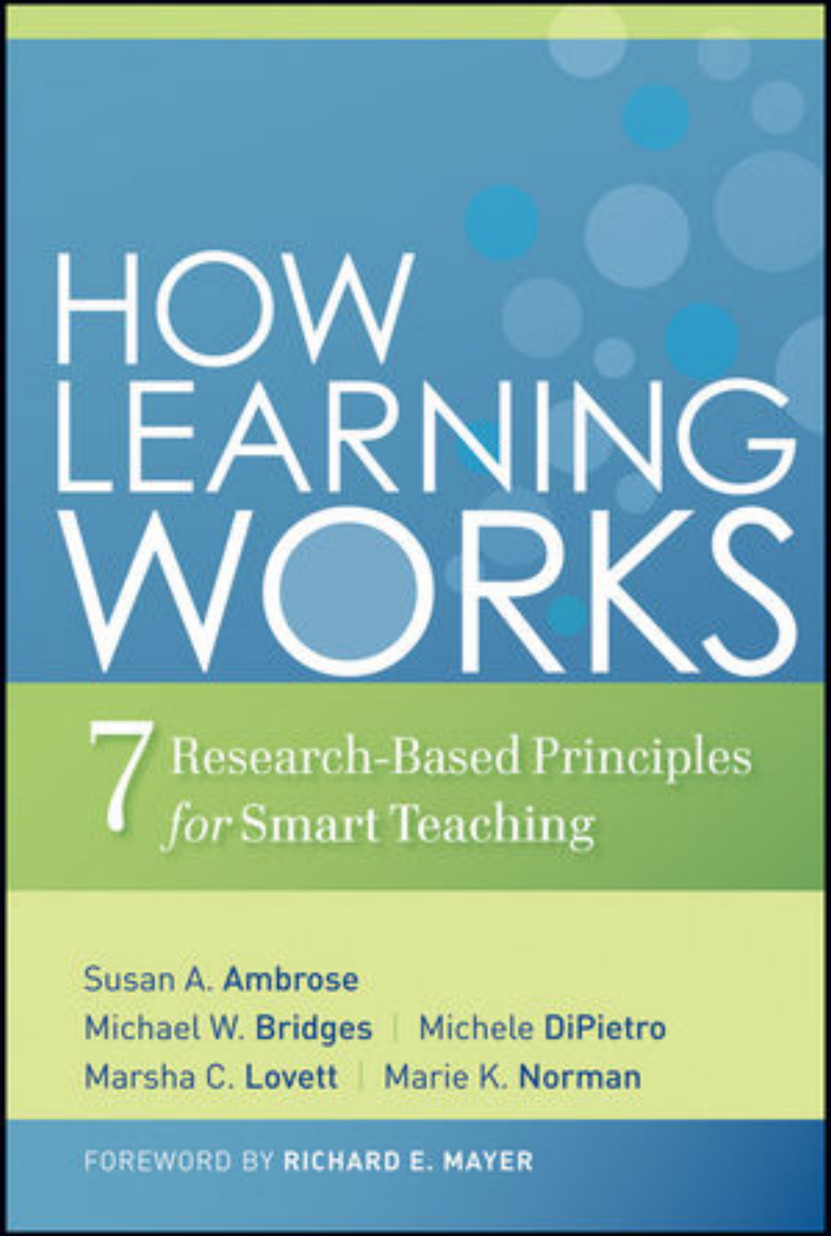
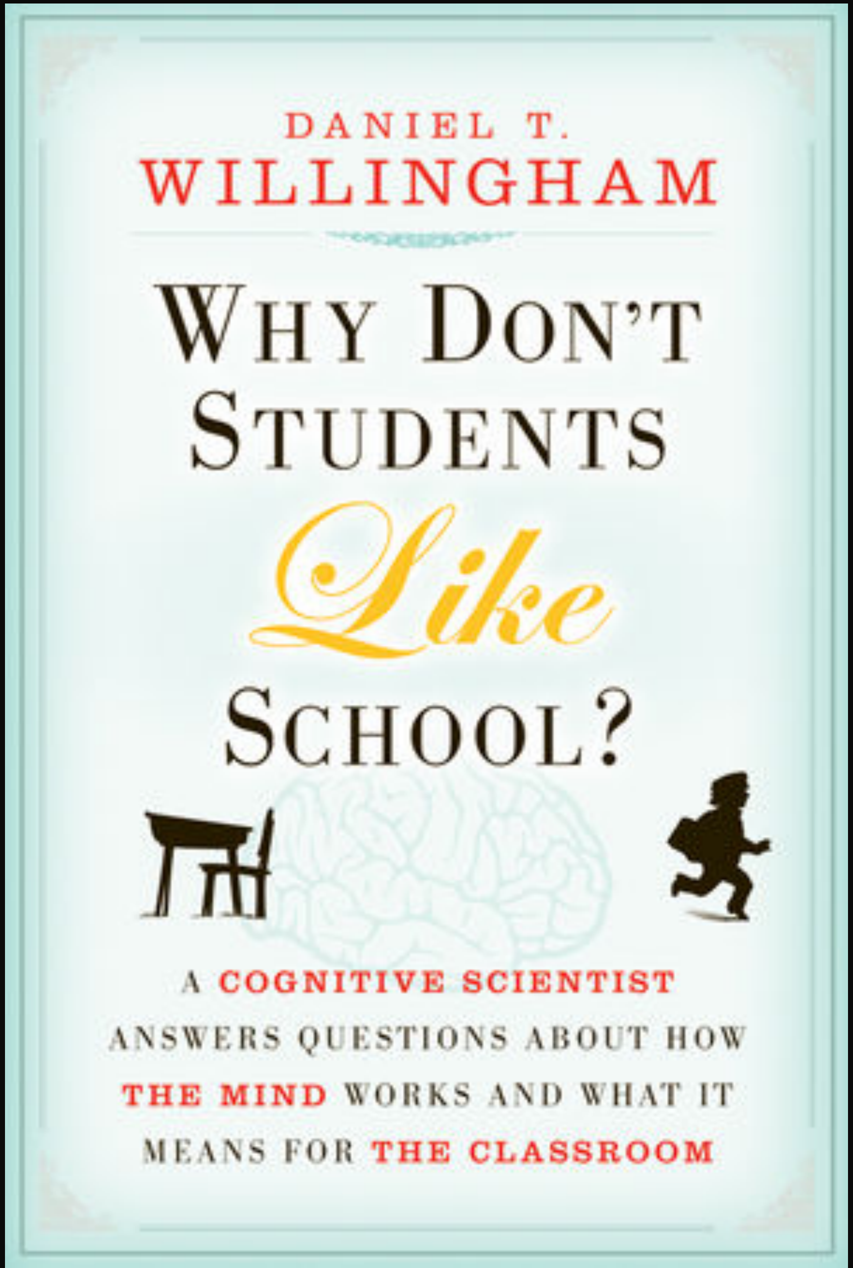
Wasted Potential


HOW LEARNING WORKS
7 Research-Based Principles for Smart Teaching
Susan A. Ambrose
Michael W. Bridges | Michele DiPietro
Marsha C. Lovett | Marie K. Norman
FOREWORD BY RICHARD E. MAYER


DANIEL T.
WILLINGHAM
WHY DON'T
STUDENTS
Like
SCHOOL?
A COGNITIVE SCIENTIST
ANSWERS QUESTIONS ABOUT HOW
THE MIND WORKS AND WHAT IT
MEANS FOR THE CLASSROOM

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journal homepage: www.elsevier.com/locate/jml

Why tests appear to prevent forgetting: A distribution-based bifurcation model

Nate Kornell[a,*], Robert A. Bjork[b], Michael A. Garcia[b]

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[b] Department of Psychology, University of California, Los Angeles, 1285 Franz Hall, Los Angeles, CA 90095-1563, USA

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ABSTRACT

Retrieving information from memory produces more learning than does being presented with the same information, and the benefits of such retrieval appear to grow as the delay before a final recall test grows longer. Recall tests, however, measure the number of items that are above a recall threshold, not memory strength per se. According to the model proposed in this paper, tests without feedback produce bifurcated item distributions: Retrieved items become stronger, but non-retrieved items remain weak, resulting in a gap between the two classes of items. Restudying items, on the other hand, strengthens all items, though to a lesser degree than does retrieval. These differing outcomes can make tested items appear to be forgotten more slowly than are restudied items—even if all items are forgotten at the same rate—because the test-induced bifurcation leaves items either well above or well below threshold. We review prior evidence and present three new experiments designed to test the bifurcation interpretation.

Introduction to Multimedia Learning

Richard E. Mayer
University of California, Santa Barbara

Abstract

People can learn more deeply from words and pictures than from words alone. This seemingly simple proposition – which can be called the multimedia learning hypothesis – is the main focus of *The Cambridge Handbook of Multimedia Learning*[1]. Each of the 35 chapters in this handbook examines an aspect of the multimedia learning hypothesis. In particular, multimedia researchers are interested in how people learn from words and pictures, and in how to design multimedia learning environments that promote learning. In this chapter, I provide a definition of multimedia learning, offer a rationale for multimedia learning, outline the research base for multimedia learning, and draw distinctions between two approaches to multimedia design, three metaphors of multimedia learning, three kinds of multimedia learning outcomes, and two kinds of active learning.

What Is Multimedia Learning?

Table 1.1 summarizes definitions of multimedia, multimedia learning, and multimedia instruction.

Multimedia

The term *multimedia* conjures up a variety of meanings. You might think of sitting in a room where images are presented on one or more screens and music or other sounds are presented using speakers – that is, multimedia as a "live" performance. Alternatively, you might think of sitting in front of a computer screen that presents graphics on the screen along with spoken words from the computer's speakers – that is, multimedia as an online lesson. Other possibilities include watching a video on a television screen while listening to the corresponding words, music, and sounds, or watching a PowerPoint

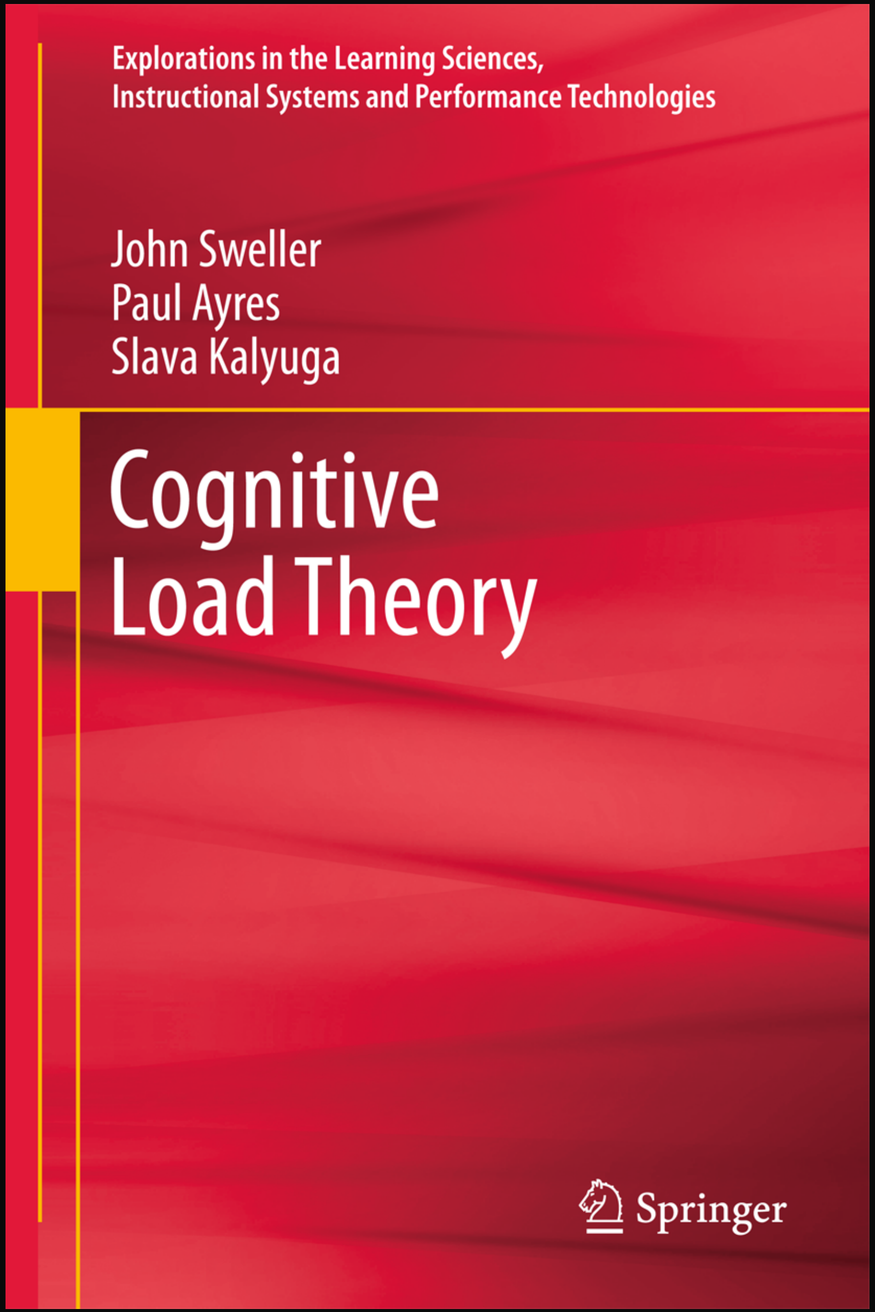
COGNITION AND INSTRUCTION, 1991, 8(4), 293–332

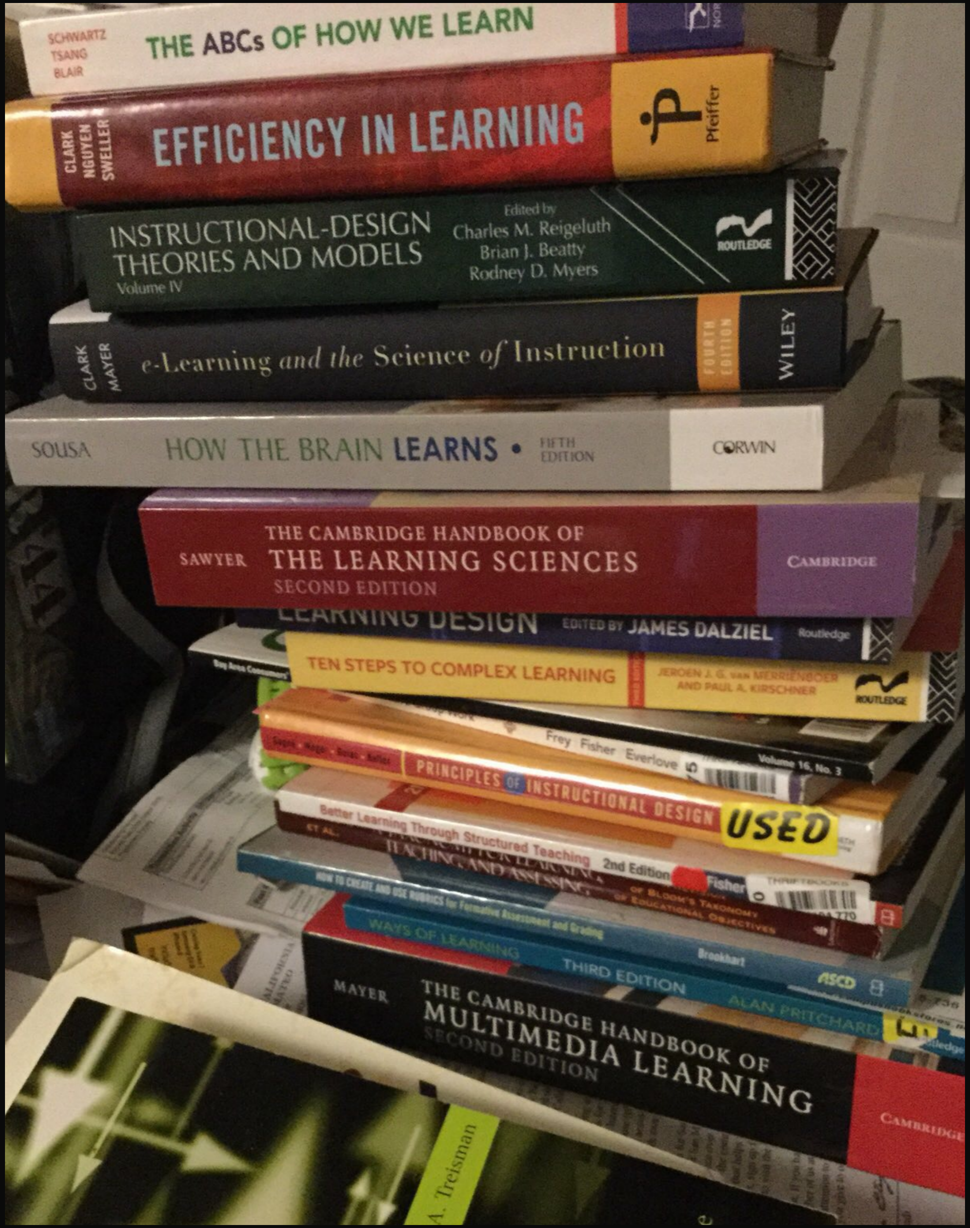
Cognitive Load Theory and the Format of Instruction

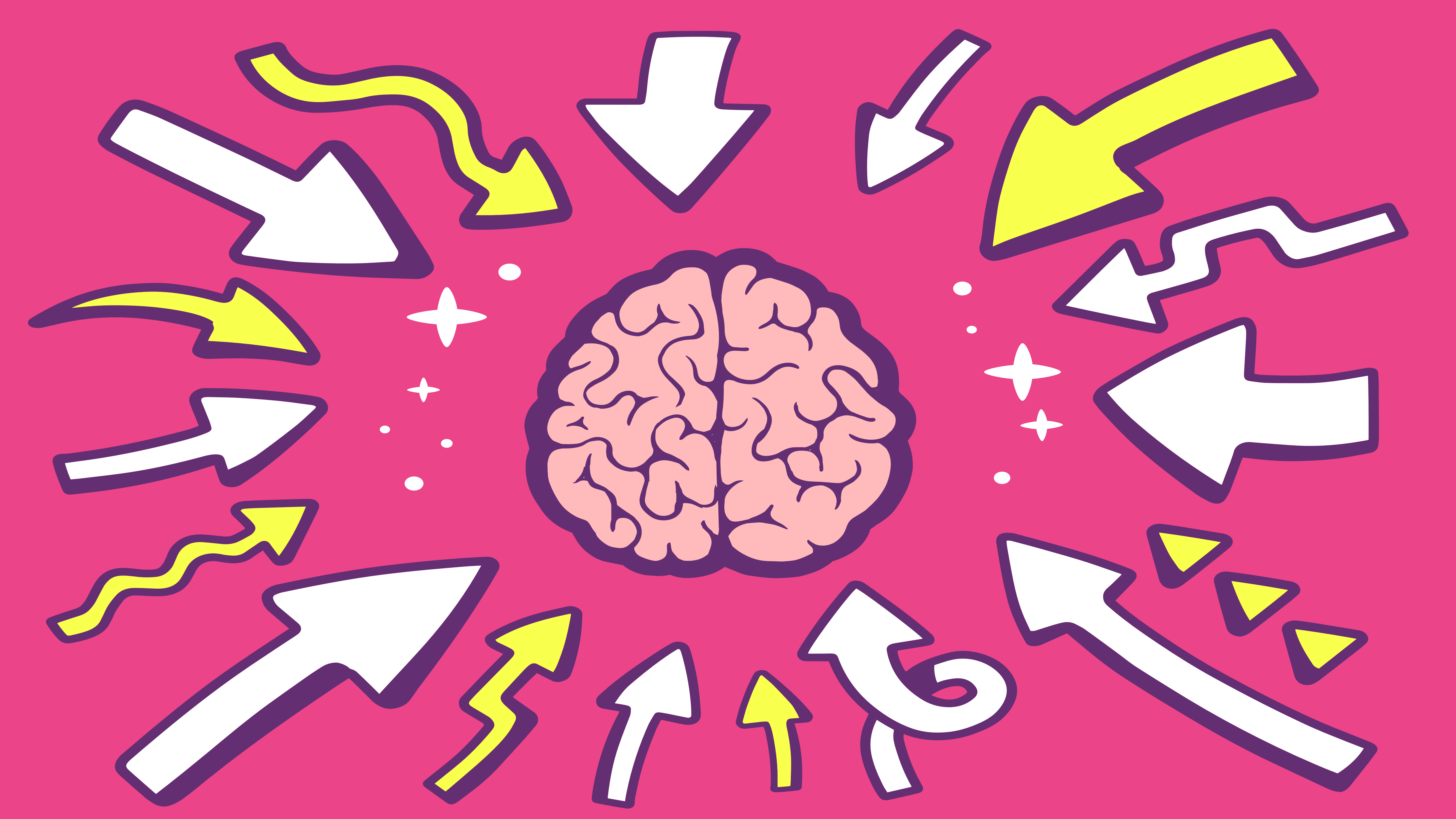
Paul Chandler and John Sweller
University of New South Wales

Cognitive load theory suggests that effective instructional material facilitates learning by directing cognitive resources toward activities that are relevant to learning rather than toward preliminaries to learning. One example of ineffective instruction occurs if learners unnecessarily are required to mentally integrate disparate sources of mutually referring information such as separate text and diagrams. Such split-source information may generate a heavy cognitive load, because material must be mentally integrated before learning can commence. This article reports findings from six experiments testing the consequences of split-source and integrated information using electrical engineering and biology instructional materials. Experiment 1 was designed to compare conventional instructions with integrated instructions over a period of several months in an industrial training setting. The materials chosen were unintelligible without mental integration. Results favored integrated instructions throughout the 3-month study. Experiment 2 was designed to investigate the possible differences between conventional and integrated instructions in areas in which it was not essential for sources of information to be integrated to be understood. The results suggest that integrated instructions were no better than split-source information in such areas. Experiments 3, 4, and 5 indicate that the introduction of seemingly useful but nonessential explanatory material (e.g., a commentary on a diagram) could have deleterious effects even when presented in integrated format. Experiment 6 found that the need for physical integration was restored if the material was organized in such a manner that individual units could not be understood alone. In light of these results and previous findings, suggestions are made for cognitively guided instructional packages.

Over the last decade, there have been considerable interest and debate in areas of cognition and education. Nevertheless, until recently, our knowledge of the cognitive processes involved in understanding instructional material has been some-


Explorations in the Learning Sciences,
Instructional Systems and Performance Technologies
John Sweller
Paul Ayres
Slava Kalyuga
Cognitive
Load Theory
Springer


SCHWARTZ TSANG BLAIR
THE ABCs OF HOW WE LEARN
CLARK NGUYEN SWELLER
EFFICIENCY IN LEARNING
Pfeiffer
INSTRUCTIONAL-DESIGN THEORIES AND MODELS
Volume IV
Edited by Charles M. Reigeluth Brian J. Beatty Rodney D. Myers
ROUTLEDGE
CLARK MAYER
e-Learning and the Science of Instruction
FOURTH EDITION
WILEY
SOUSA
HOW THE BRAIN LEARNS
FIFTH EDITION
CORWIN
SAWYER
THE CAMBRIDGE HANDBOOK OF THE LEARNING SCIENCES
SECOND EDITION
CAMBRIDGE
EDITED BY JAMES DALZIEL
Routledge
TEN STEPS TO COMPLEX LEARNING
JEROEN J. G. van MERRIËNBOER AND PAUL A. KIRSCHNER
ROUTLEDGE
Frey Fisher Everlove
PRINCIPLES OF INSTRUCTIONAL DESIGN
USED
Better Learning Through Structured Teaching 2nd Edition
Fisher
WAYS OF LEARNING
THIRD EDITION
ALAN PRITCHARD
Brookhart
ASCD
MAYER
THE CAMBRIDGE HANDBOOK OF MULTIMEDIA LEARNING
SECOND EDITION
CAMBRIDGE
A. Treisman



Human Learning: Where We'll Go

What is Learning?

How Does the Brain Learn?

Theory & Evidence of Learning Methods

Examples

Learning in a Few Words

Learning is the ability to retrieve information from Long-Term Memory when needed.

Store and Connect Knowledge in Long-Term Memory (LTM)

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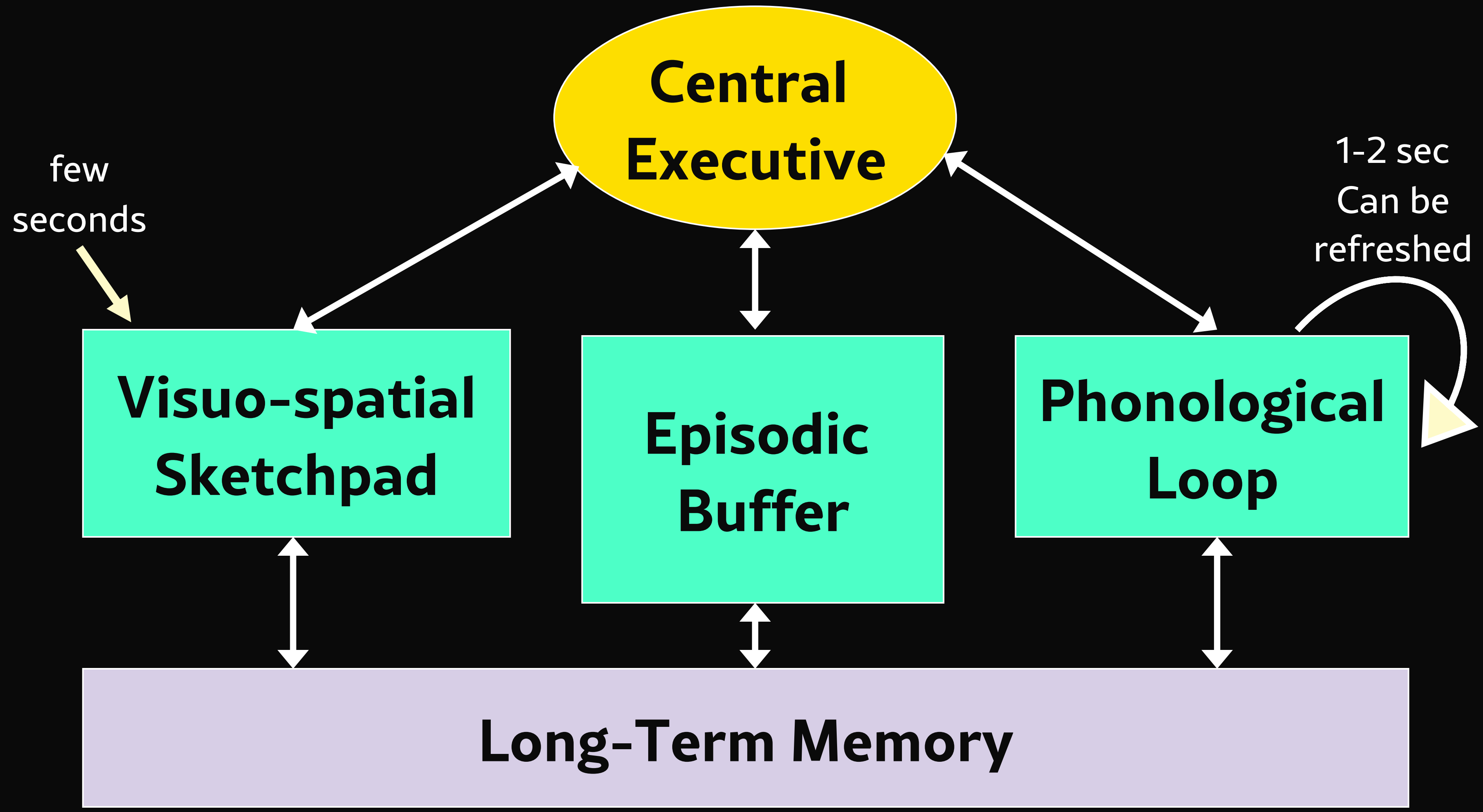
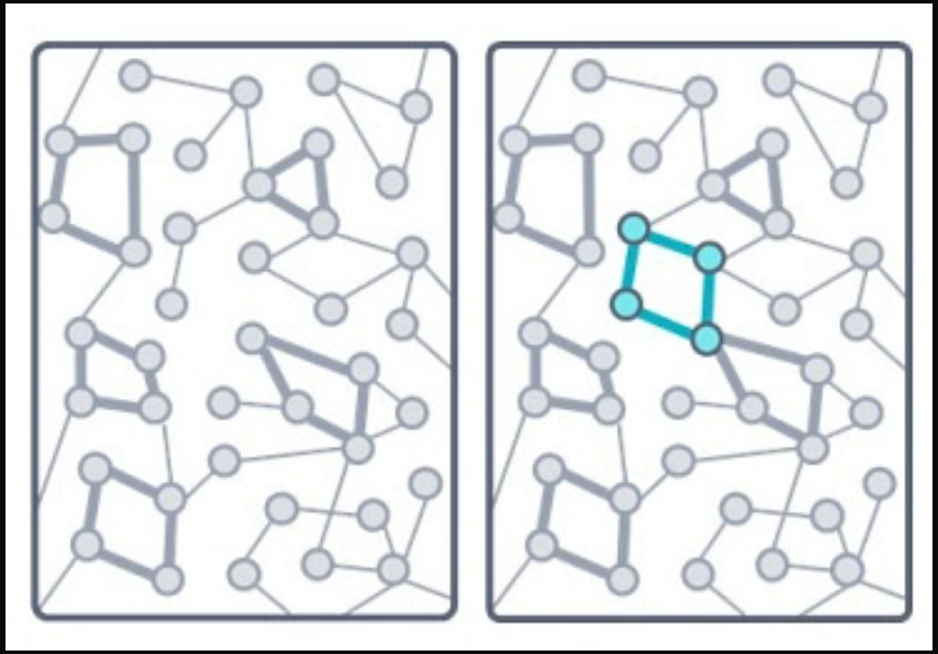
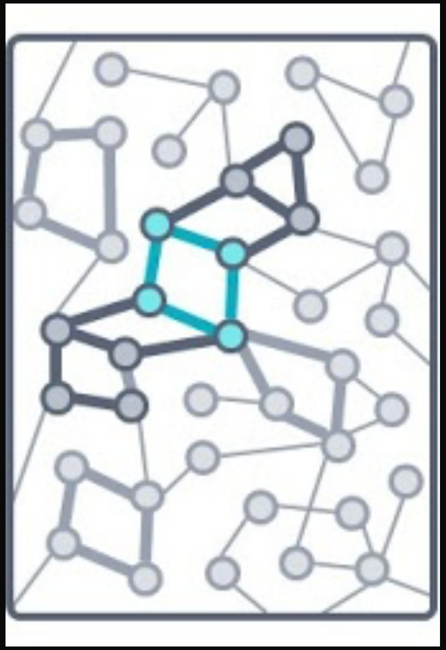
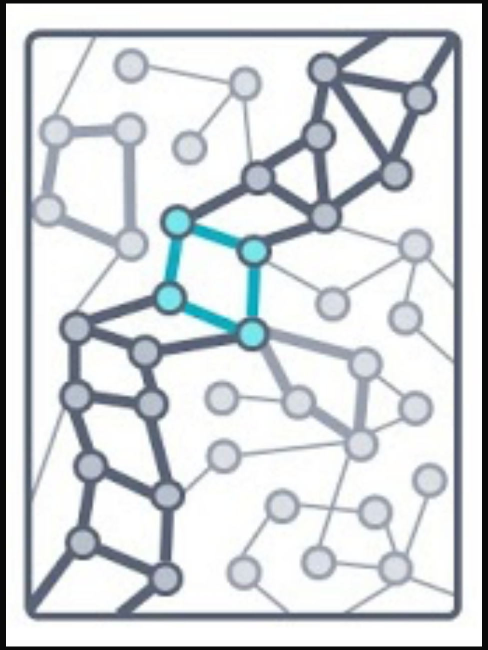
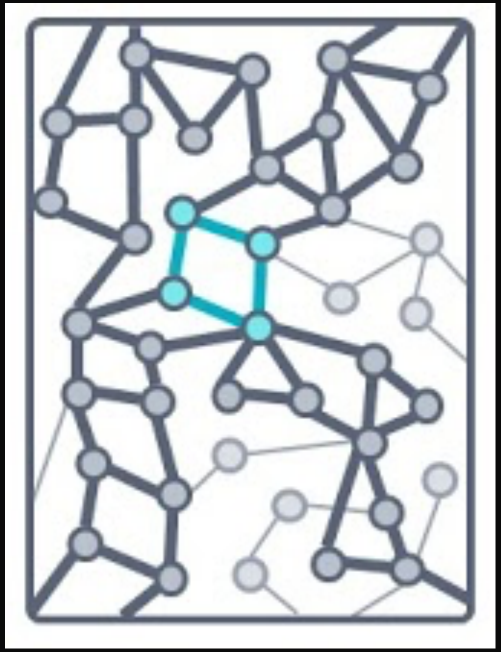
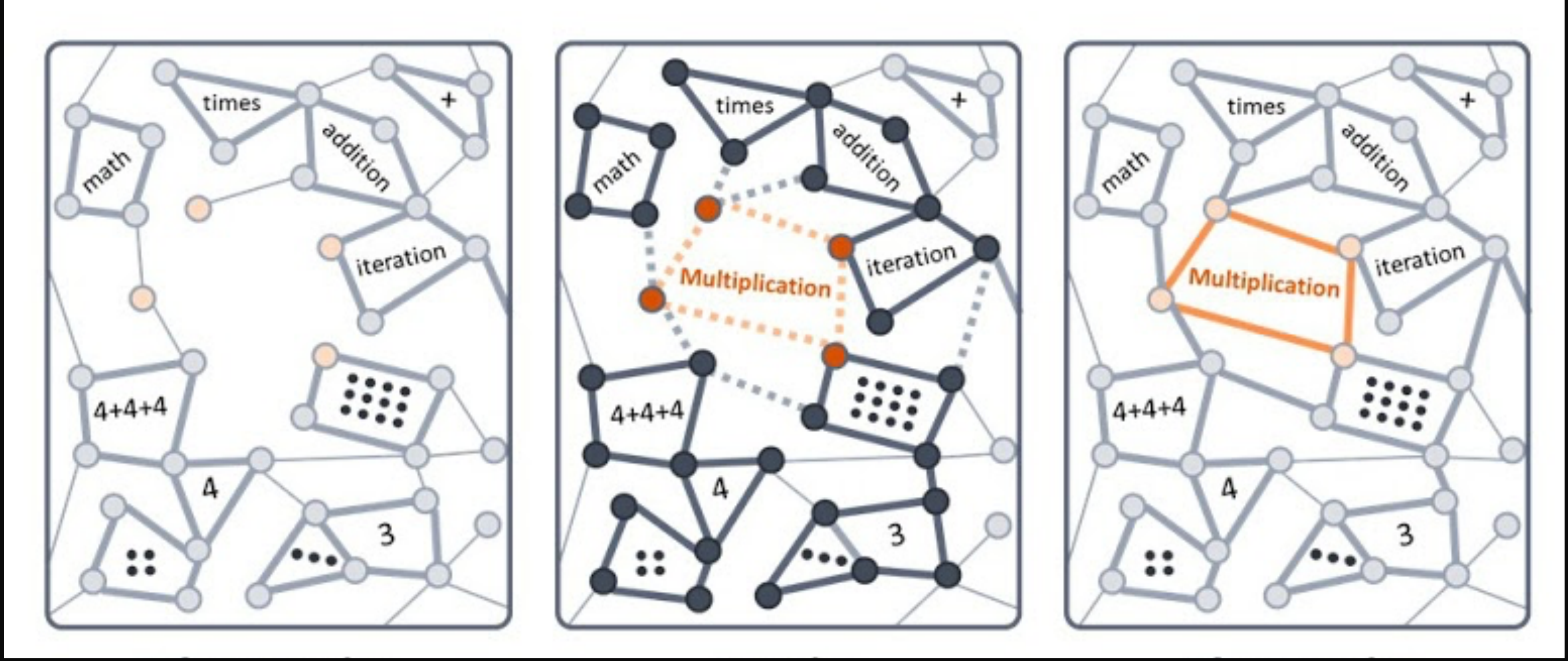
Working ~~Memory~~ Attention is Active



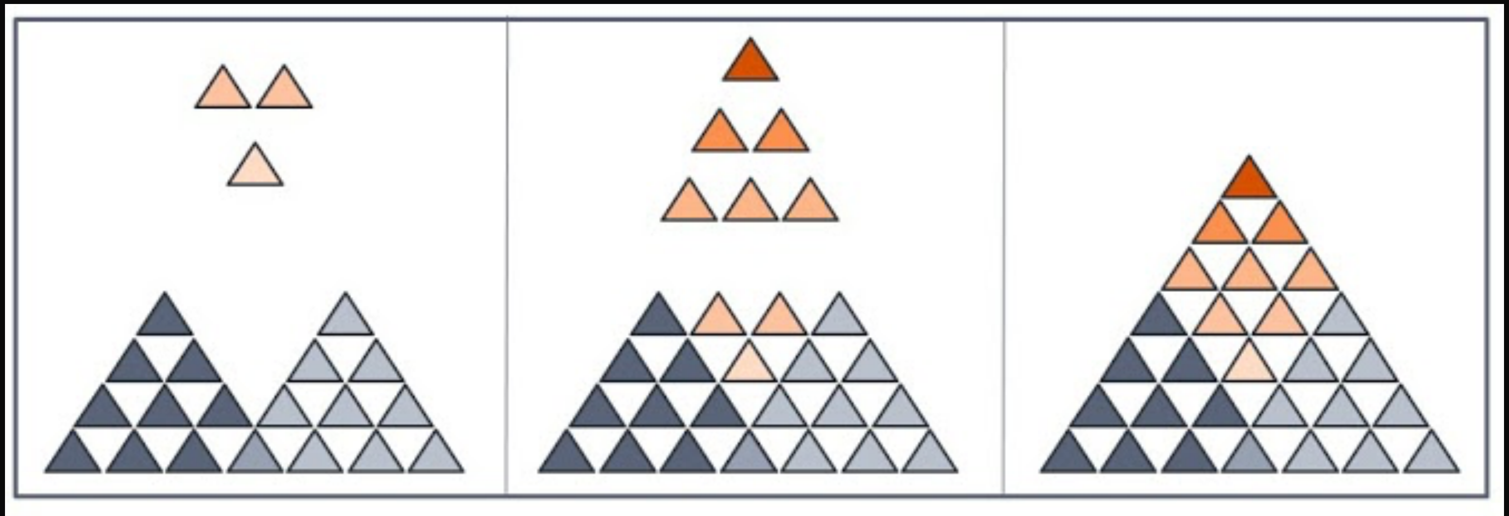
Making Connections

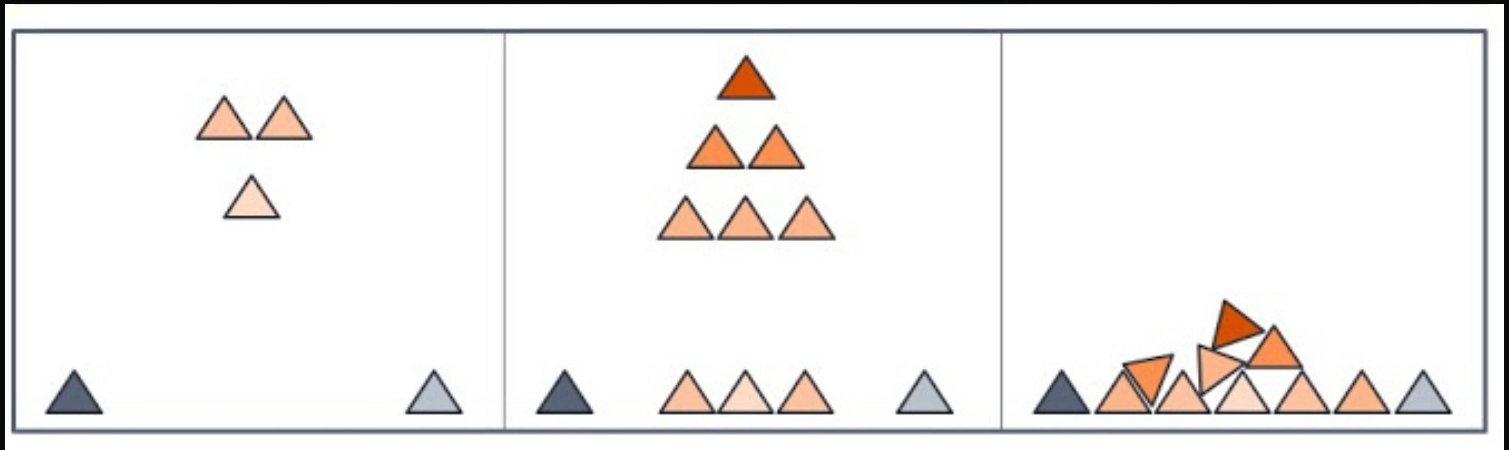





Learning New Concept



Cursed by Expertise



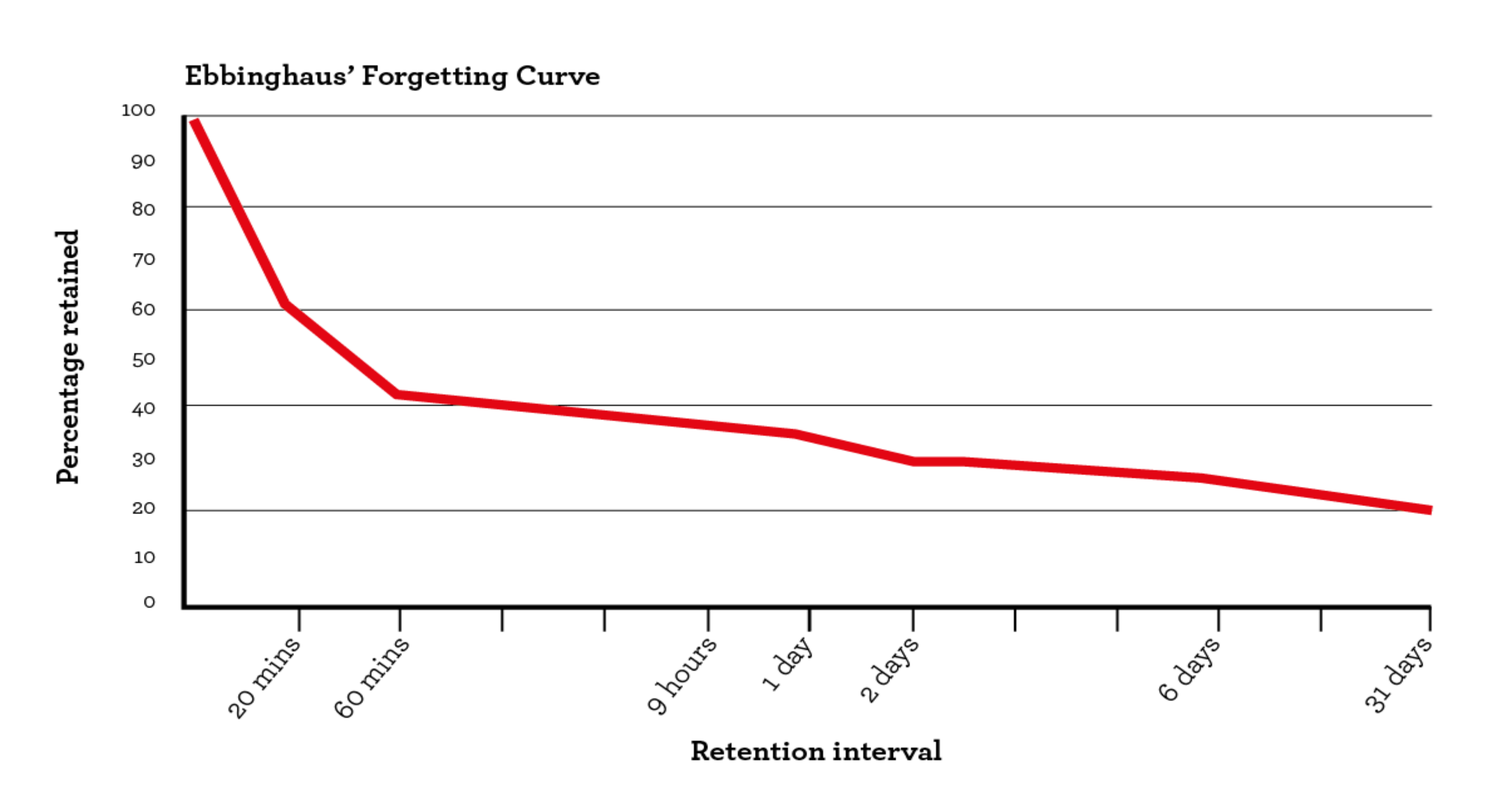


Retrieval is the Hardest Part

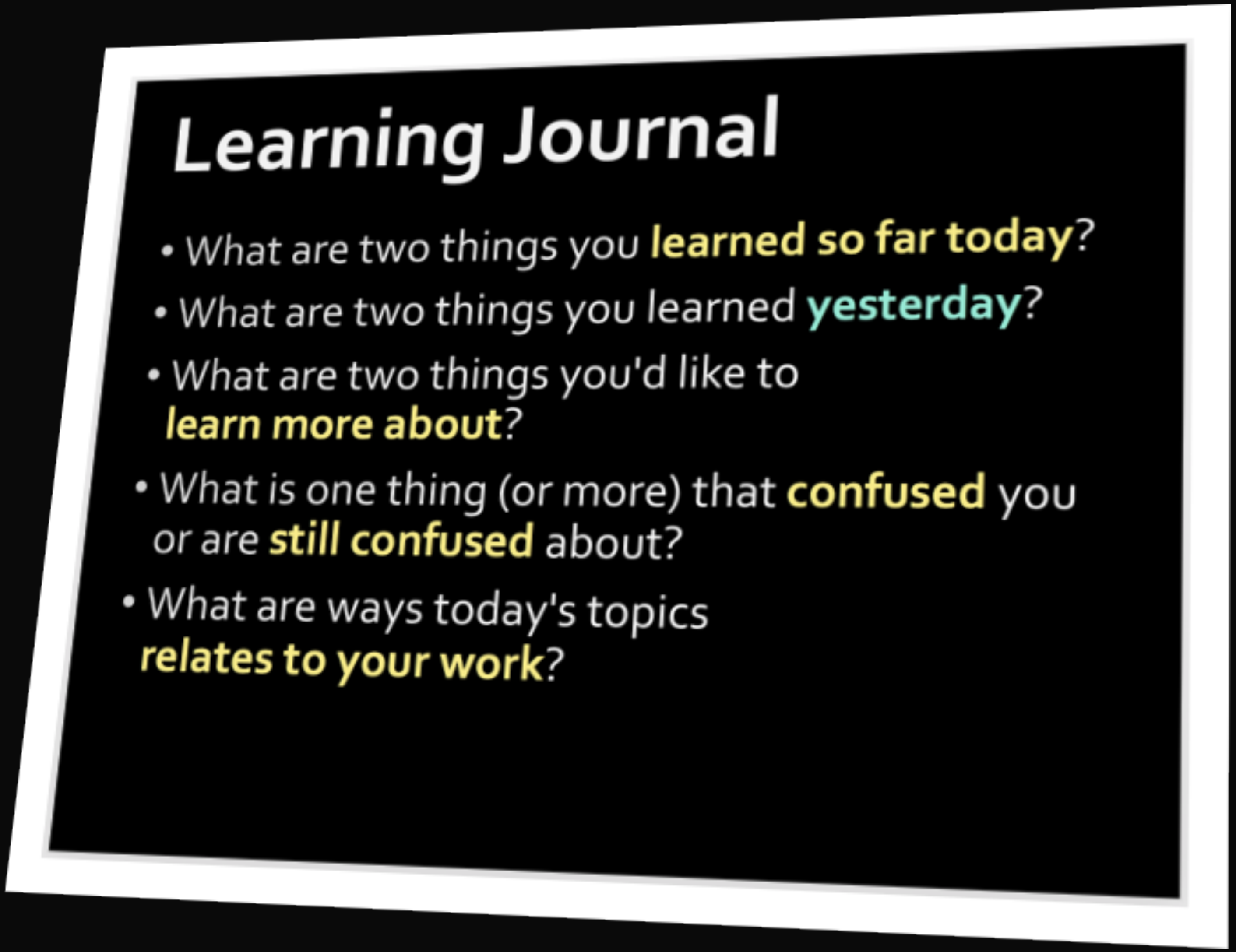
Long-term memory is huge

Hard to recall after disuse

Ebbinghaus' Forgetting Curve



Retrieval Practice

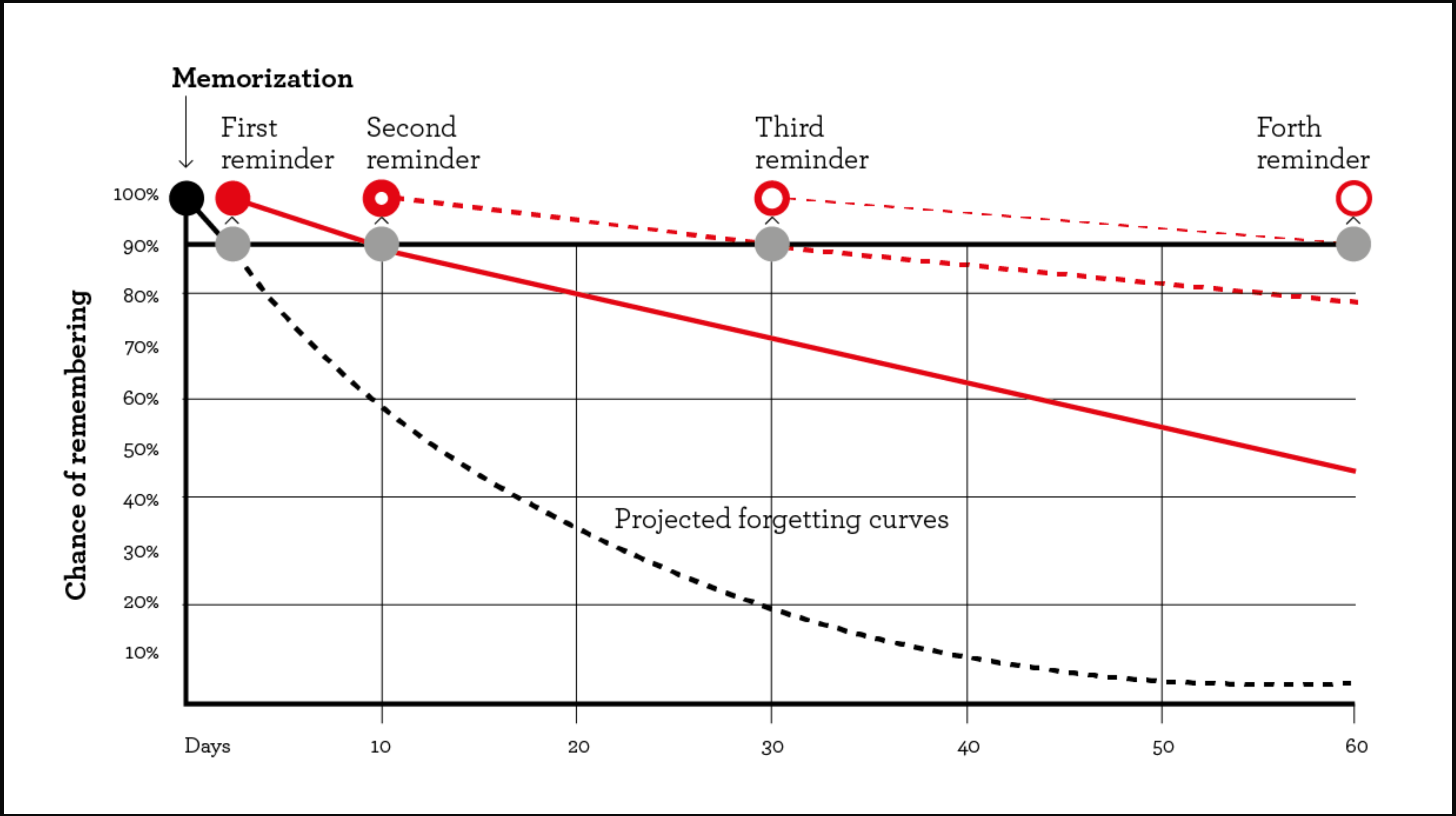


The Testing Effect

- The very act of being tested helps students learn better
- Students scored a full grade higher on tested material

https://www.retrievalpractice.org/

Spaced Repetition



Desirable Difficulties [Bjork]

- Wait before recalling
  - Spaced retrieval
- Mix it up
  - Interleaving
- Change environment
  - Prompts
  - Associations
  - Context

Makes Memory Stronger!

Disfluency is Not Always Desirable

Imagine reading text using this font. Certainly not easy.

Fortune favors the bold (and the italicized): effects of disfluency on educational outcomes. Cognition, 118, 114–118. doi:10.1016/j.cognition.2010.09.012

Quiz Time!

Learning is...?

- ... what can be retrieved from LTM when needed
- Ways to improve and strengthen access are...?
  - Use Retrieval Practice
- Examples of Retrieval Practice?
  - Testing
  - Spacing

Working Memory is Limited

Current Directions in Psychological Science
19(1) 51-57

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DOI: 10.1177/0963721409359277
http://cdps.sagepub.com
SAGE

The Magical Mystery Four: How Is Working Memory Capacity Limited, and Why?

Nelson Cowan
University of Missouri

Abstract
Working memory storage capacity is important because cognitive tasks can be completed only with sufficient ability to hold information as it is processed. The ability to repeat information depends on task demands but can be distinguished from a more constant, underlying mechanism: a central memory store limited to 3 to 5 meaningful items for young adults. I discuss why this central limit is important, how it can be observed, how it differs among individuals, and why it may exist.

Keywords
working memory capacity limits, central storage capacity limits, chunking, grouping, core capacity

Handling Working Memory Limits

Mental Effort...

Cognitive
Load
Theory (CLT)

Reserve for
encoding/chunking

Cognitive Load is...

the load imposed on an individual's working memory by a particular learning task

Cognitive Load Theory

Novices need to use thinking skills

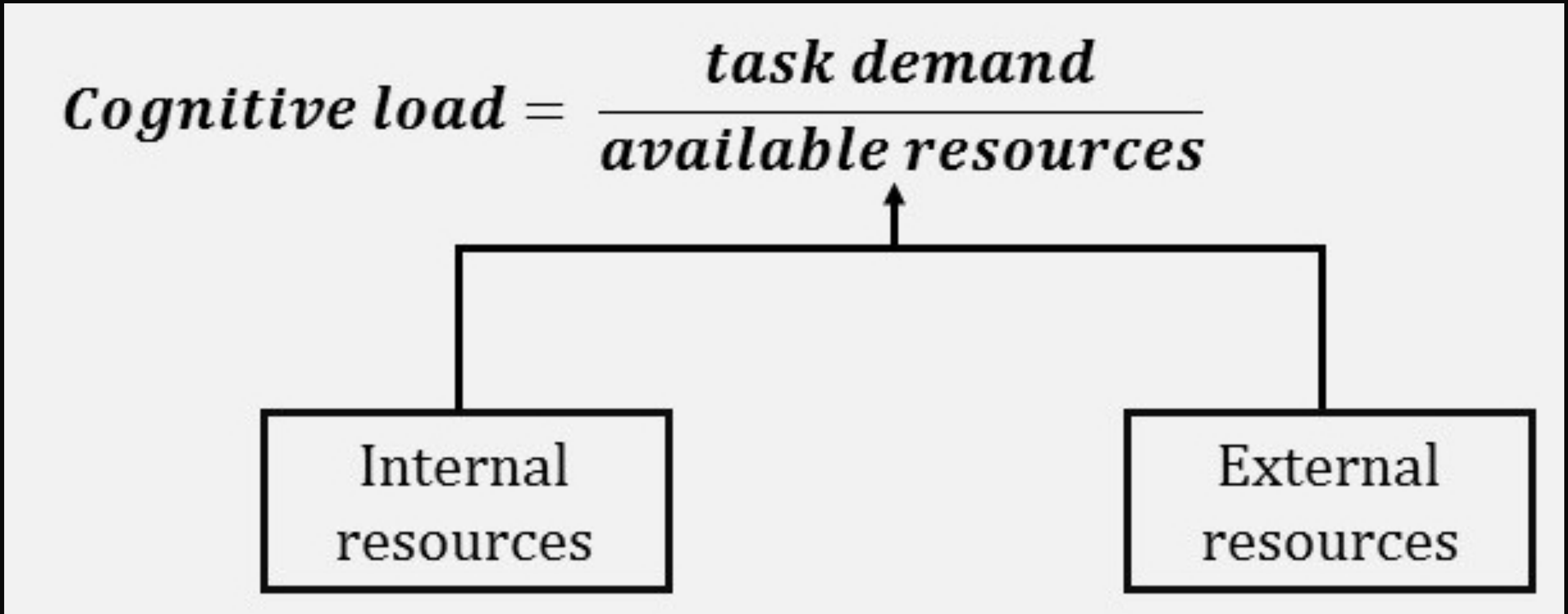
Experts use knowledge

- Sweller, et al, Cognitive Load Theory (2011)

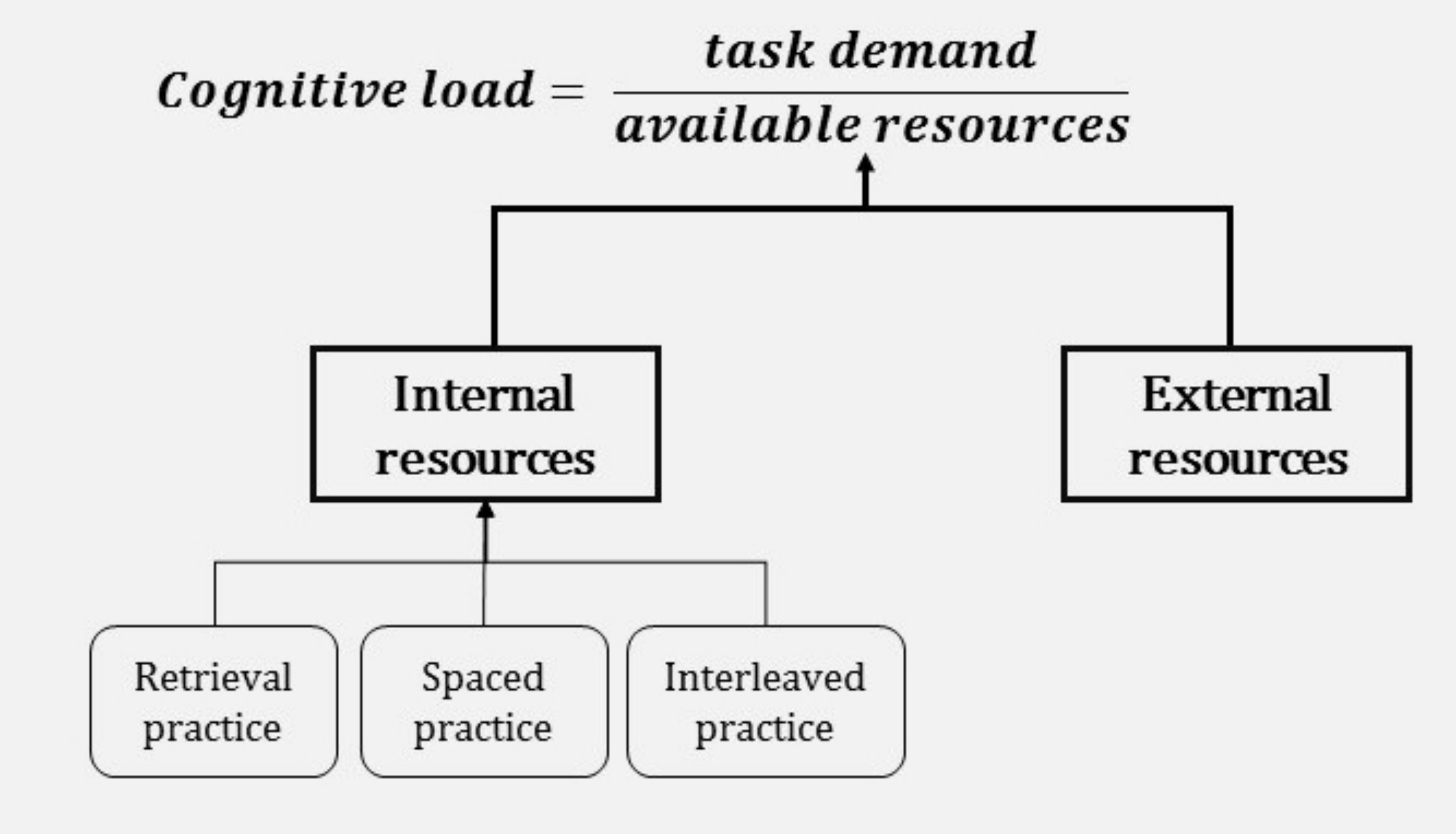
Cognitive Load Theory

$$\text{Cognitive load} = \frac{\text{task demand}}{\text{available resources}}$$

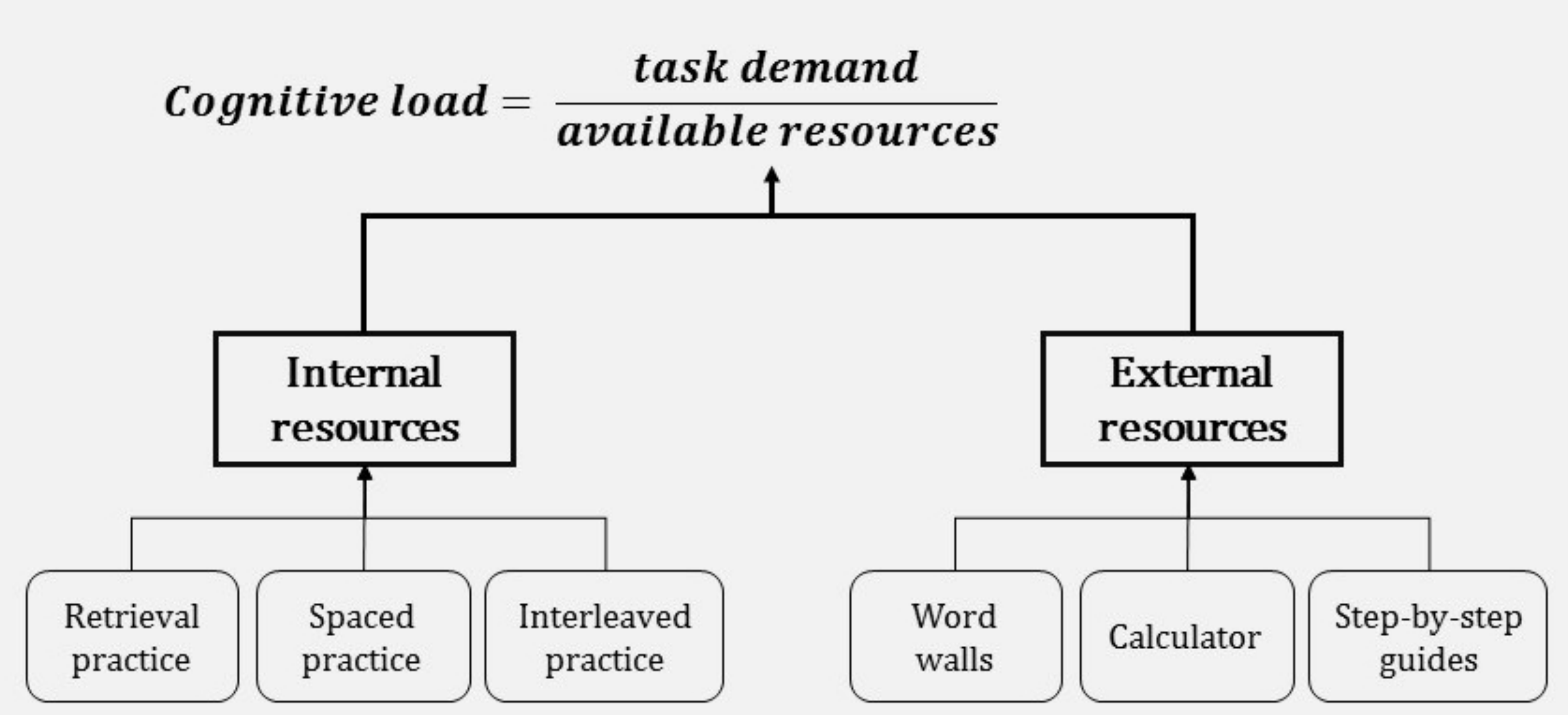
Cognitive Load Theory



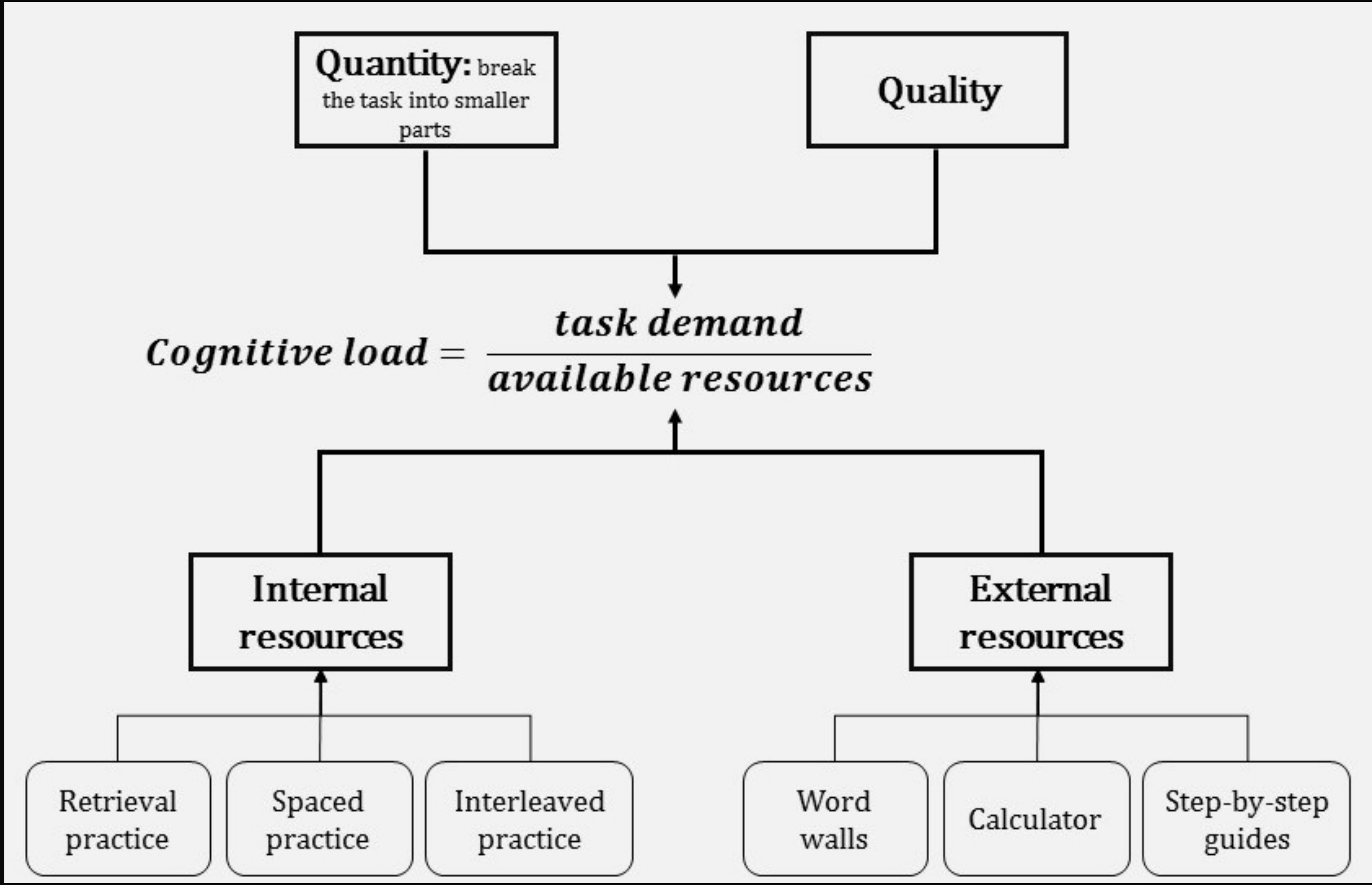
Cognitive Load Theory



Cognitive Load Theory



Cognitive Load Theory



Applying Learning Principles

Do Use: Worked Examples

- Provides guidance
- Scaffolds learning
- We learn from examples
- Curate/create carefully

Worked Example

JavaBean

A JavaBean is a Java class that has named *properties*, defined by getters and setters that follow a naming convention. The following example is a class that has a `String` property named `Description`:

```
public class Product {
  private String description;

  public String getDescription() {
    return description;
  }

  public void setDescription(String description) {
    this.description = description;
  }
}
```

You can also have **numeric** properties, which follow the same naming pattern. For example:

```
public class Product {
  private int count;

  public int getCount() {
    return count;
  }

  public void setCount(int count) {
    this.count = count;
  }
}
```

(from http://WellTestedLearning.com)

Worked Example

Example 1	Example 2	Example 3	Example 4
$\frac{21ab+42b}{15}$	$\frac{21ab+42b}{7}$	$\frac{21ab+35b}{7}$	$\frac{7ab+35b}{7}$
$\div 3$	$\div 7$	$\div 7$	$\div 7$

Negative Example

Example 5	Example 6	Example 7	Example 8
$\frac{21ab+42b}{4}$	$\frac{21ab+42b}{8}$	$\frac{21ab+35b}{8}$	$\frac{7ab+35b}{3}$

Watch Out for Prior Knowledge

- Not runnable
- What's curl?
  - what's --user?
  - what's -F?
- Why 2 "to" entries?
- What's MIME?
- Log entries?

Send via API

Run this:

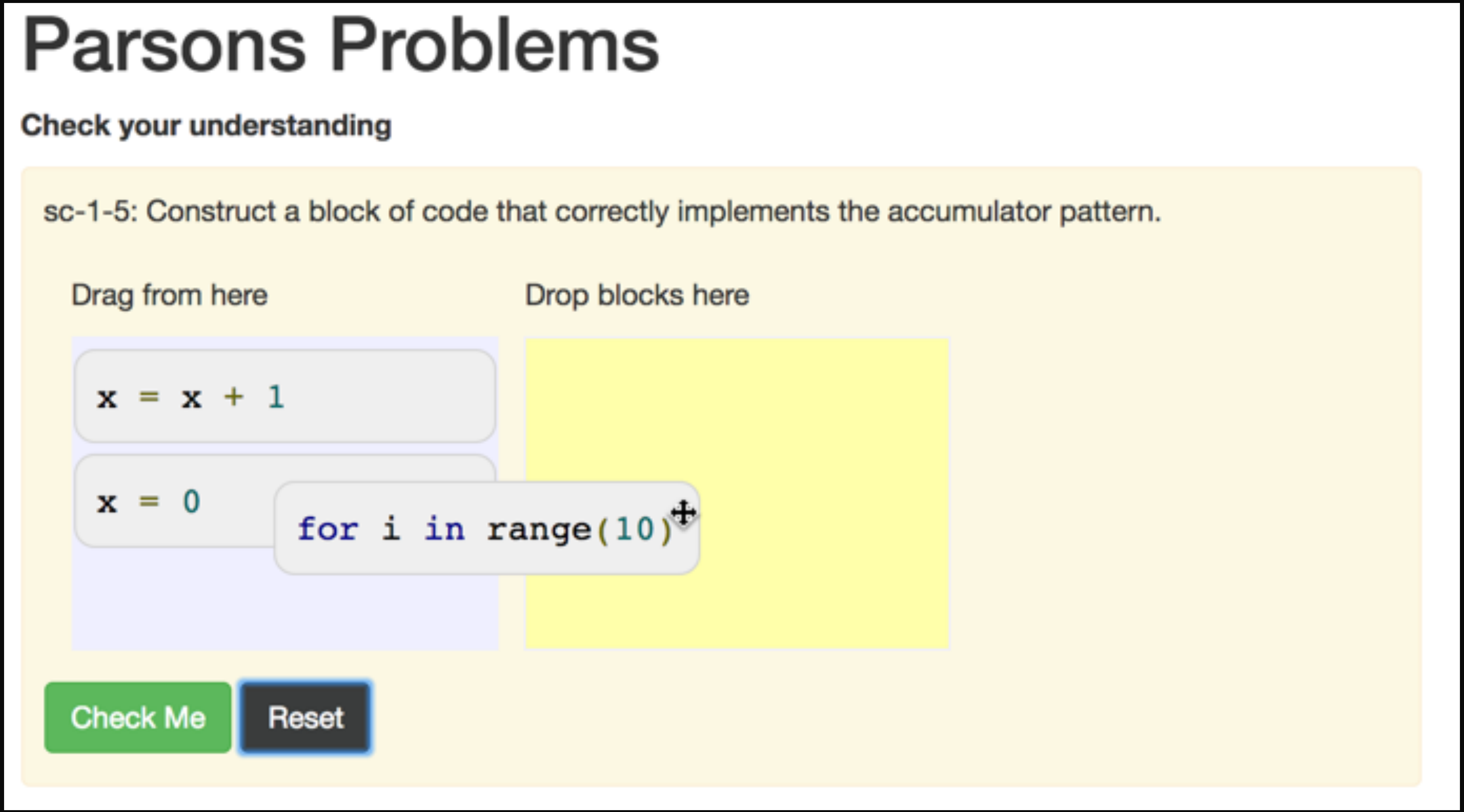
```
curl -s --user 'api:YOUR_API_KEY' \
    https://api.mailgun.net/v3/YOUR_DOMAIN_NAME/messages \
    -F from='Excited User <mailgun@YOUR_DOMAIN_NAME>' \
    -F to=YOU@YOUR_DOMAIN_NAME \
    -F to=bar@example.com \
    -F subject='Hello' \
    -F text='Testing some Mailgun awesomeness!'
```

What actually happened:

- Mailgun assembled a MIME message.
- Added the log entries to our full text search index.
- Delivered the email.

You can find your private API key on your dashboard.

Do Use: Parsons Problems



Example of js-parsons turtle graphics assignment

Construct a program by drag&dropping and reordering lines from the top to the bottom. The constructed program should draw a triangle like shown below. Click ?? to select the correct value for that position.

Drag from here

```
left(120)
```

```
forward(100)
```

```
ENDREPEAT
```

```
REPEAT ?? TIMES
```

Model Drawing

Construct your solution here

Your Code Drawing

Reset

Feedback

Example of js-parsons turtle graphics assignment

Construct a program by drag&dropping and reordering lines from the top to the bottom. The constructed program should draw a triangle like shown below. Click ?? to select the correct value for that position.

Drag from here

```
ENDREPEAT
```

```
REPEAT ?? TIMES
```

Model Drawing

Construct your solution here

```
forward(100)
```

```
left(120)
```

Your Code Drawing

Reset

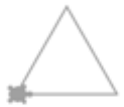
Feedback

Example of js-parsons turtle graphics assignment

Construct a program by drag&dropping and reordering lines from the top to the bottom. The constructed program should draw a triangle like shown below. Click ?? to select the correct value for that position.

Drag from here

Model Drawing



Construct your solution here

```
REPEAT ?? TIMES
forward(100)
left(120)
    ENDREPEAT
```

Your Code Drawing

Reset

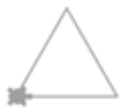
Feedback

Example of js-parsons turtle graphics assignment

Construct a program by drag&dropping and reordering lines from the top to the bottom. The constructed program should draw a triangle like shown below. Click ?? to select the correct value for that position.

Drag from here

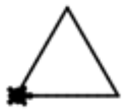
Model Drawing



Construct your solution here

```
REPEAT 3 TIMES
    forward(100)
    left(120)
ENDREPEAT
```

Your Code Drawing



Reset

Feedback

Do Use: Labeling of Sub-Goals

1. Click on "My Blocks" to see the blocks fo
2. Click on "clap"
3. Drag out a *when clap.Touched* block
4. Click on "clapSound"
5. Drag out a *call clapSound.Play*
6. Connect it after the *when clap.Touched*
7. Click on "My Blocks" and then on "Accele
8. Drag out *when AccelerometerSensor1.Acc*

Handle Events from My Blocks

1. Click on "My Blocks" to see the blocks for components you created.
2. Click on "clap"
3. Drag out a *when clap.Touched* block

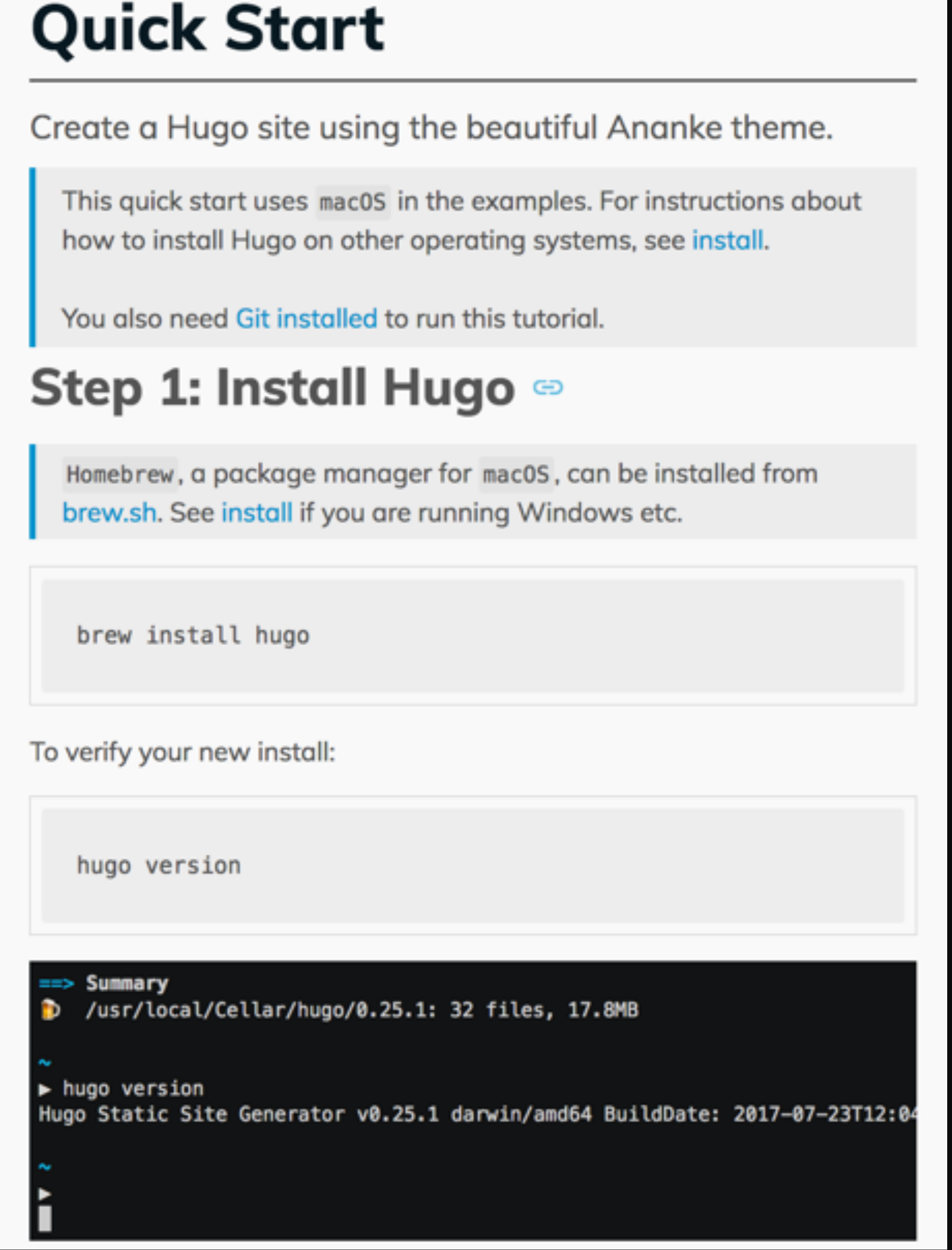
Set Output from My Blocks

4. Click on "clapSound"
5. Drag out a *call clapSound.Play*
6. Connect it after the *when clap.Touched*

Handle Events from My Blocks

7. Click on "My Blocks" and then on "AccelerometerSensor1"
8. Drag out *when AccelerometerSensor1.AccelerationChanged*.

Do Use: Hypermedia!



Quick Start

Create a Hugo site using the beautiful Ananke theme.

> This quick start uses `macOS` in the examples. For instructions about how to install Hugo on other operating systems, see install.
>
> You also need Git installed to run this tutorial.

Step 1: Install Hugo

> `Homebrew`, a package manager for `macOS`, can be installed from brew.sh. See install if you are running Windows etc.

```
brew install hugo
```

To verify your new install:

```
hugo version
```

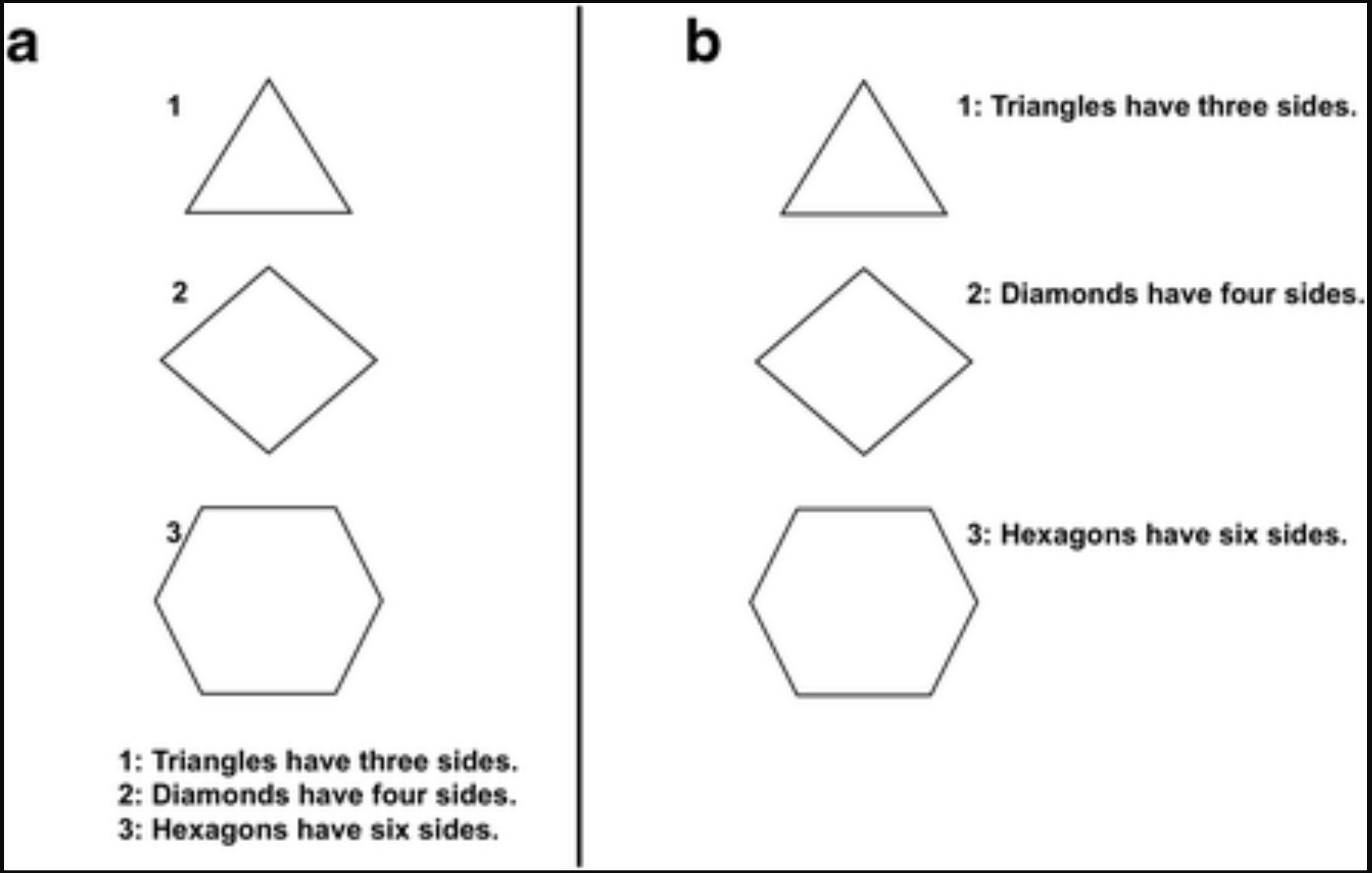
```
==> Summary
🍺  /usr/local/Cellar/hugo/0.25.1: 32 files, 17.8MB

~
▶ hugo version
Hugo Static Site Generator v0.25.1 darwin/amd64 BuildDate: 2017-07-23T12:04

~
▶
```

Avoid: Split-Attention Effect

Don't separate related information



```java
@RestController
public class MealOrderApiController {

  @PostMapping(value = "/api/mealorder")
  public MealOrderResponse mealOrder(@RequestBody MealOrderRequest mealOrderRequest) {

    String burger = mealOrderRequest.getBurger();

    MealBuilder mealBuilder = new MealBuilder();
    mealBuilder.addBurgerString(burger);
    MealOrder mealOrder = mealBuilder.build();

    int price = mealOrder.price();

    MealOrderResponse mealOrderResponse = new MealOrderResponse();
    mealOrderResponse.setPrice(price);

    return mealOrderResponse;
  }
```

MealOrderApiController › mealOrder()

shboard: MealKioskApplication

Console | Debugger | Endpoints | Java Visualizer

Frames

"http-nio-8080-exe...

- mealOrder:27, MealOrderApiController (com.
- invoke0:-1, NativeMethodAccessorImpl (sun.
- invoke:62, NativeMethodAccessorImpl (sun.r
- invoke:43, DelegatingMethodAccessorImpl (
- invoke:498, Method (java.lang.reflect)
- doInvoke:205, InvocableHandlerMethod (org

Variables

- this = {MealOrderApiController@5666}
- mealOrderRequest = {MealOrderRequest@5668} "MealOrderRequest:burger='bacon', drink='large'"
- burger = "bacon"
- mealBuilder = {MealBuilder@5670}
- mealOrder = {MealOrder@5671} "MealOrder: ->Burger {burgerToppings=Toppings{toppings=[BACON]}}, $7"
- price = 7
- mealOrderResponse = {MealOrderResponse@5672}

```
@RestController
public class MealOrderApiController {

  @PostMapping(value = "/api/mealorder")
  public MealOrderResponse mealOrder(@RequestBody MealOrderRequest mealOrderRequest) {  mealOrderRequest: "MealOrderRequest:burger='bacon',

    String burger = mealOrderRequest.getBurger();  burger: "bacon"  mealOrderRequest: "MealOrderRequest:burger='bacon', drink='large'"

    MealBuilder mealBuilder = new MealBuilder();  mealBuilder: MealBuilder@5675
    mealBuilder.addBurgerString(burger);  burger: "bacon"
    MealOrder mealOrder = mealBuilder.build();  mealOrder: "MealOrder: ->Burger {burgerToppings=Toppings{toppings=[BACON]}}, $7"  mealBuild

    int price = mealOrder.price();  price: 7  mealOrder: "MealOrder: ->Burger {burgerToppings=Toppings{toppings=[BACON]}}, $7"

    MealOrderResponse mealOrderResponse = new MealOrderResponse();  mealOrderResponse: MealOrderResponse@5677
    mealOrderResponse.setPrice(price);  price: 7

    return mealOrderResponse;  mealOrderResponse: MealOrderResponse@5677
  }
```

MealOrderApiController › mealOrder()

hboard: MealKioskApplication

Console | Debugger | Endpoints | Java Visualizer

Frames

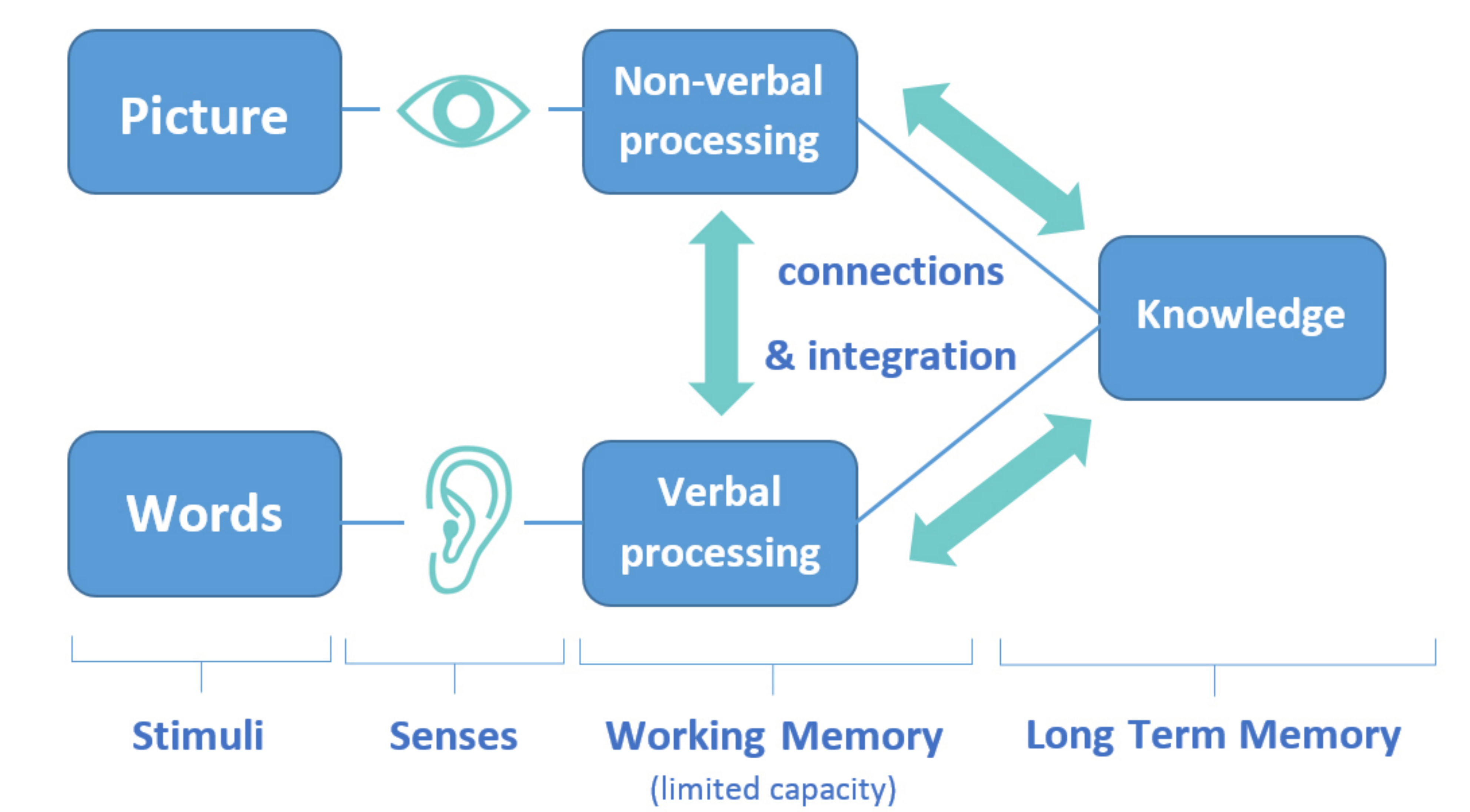
"http-nio-8080-exe...

mealOrder:27, MealOrderApiController (com.
invoke0:-1, NativeMethodAccessorImpl (sun.
invoke:62, NativeMethodAccessorImpl (sun.r
invoke:43, DelegatingMethodAccessorImpl (
invoke:498, Method (java.lang.reflect)
doInvoke:205, InvocableHandlerMethod (org

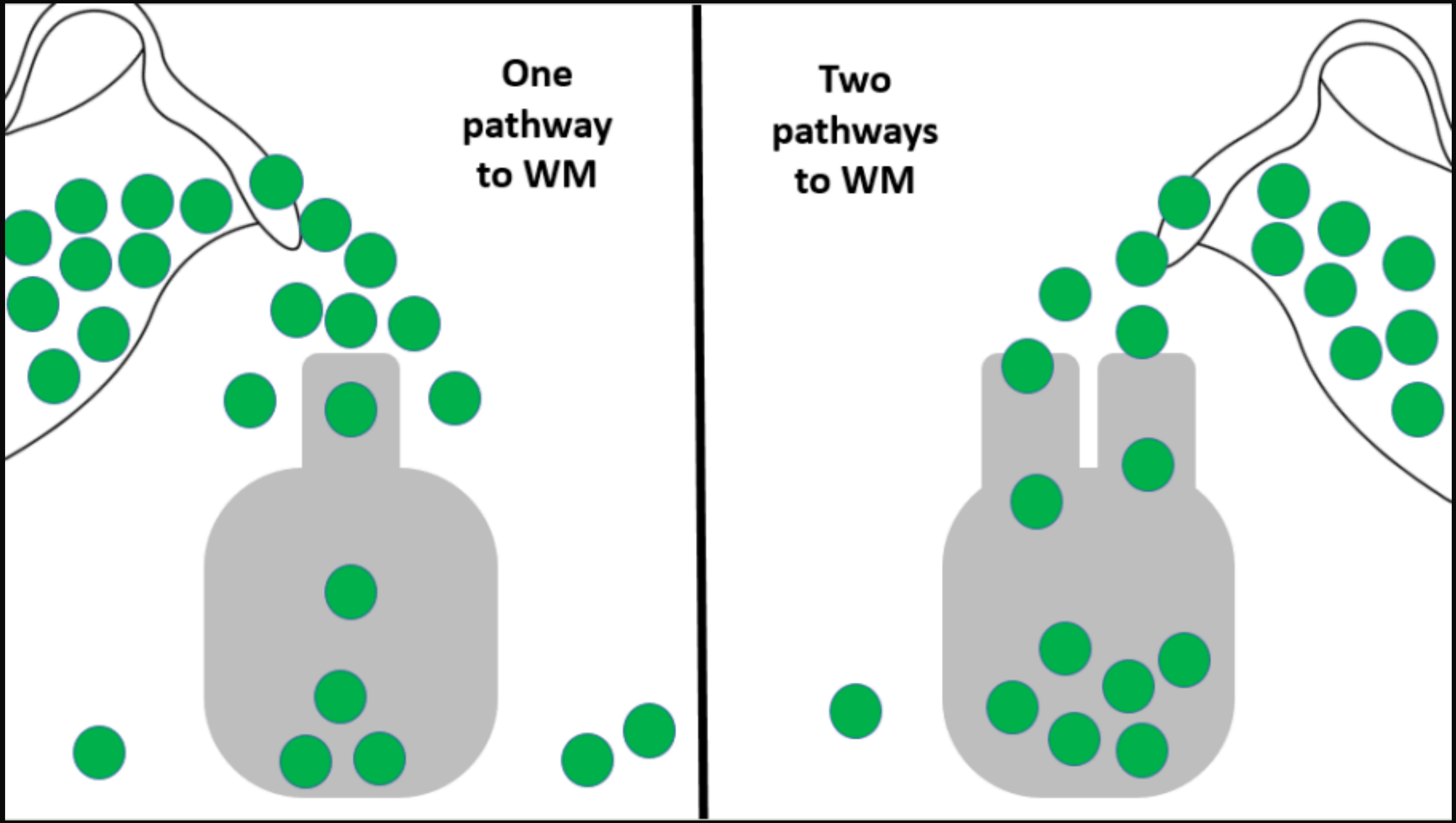
Variables

- this = {MealOrderApiController@5667}
- mealOrderRequest = {MealOrderRequest@5673} "MealOrderRequest:burger='bacon', drink='large'"
- burger = "bacon"
- mealBuilder = {MealBuilder@5675}
- mealOrder = {MealOrder@5676} "MealOrder: ->Burger {burgerToppings=Toppings{toppings=[BACON]}}, $7"
- price = 7
- mealOrderResponse = {MealOrderResponse@5677}

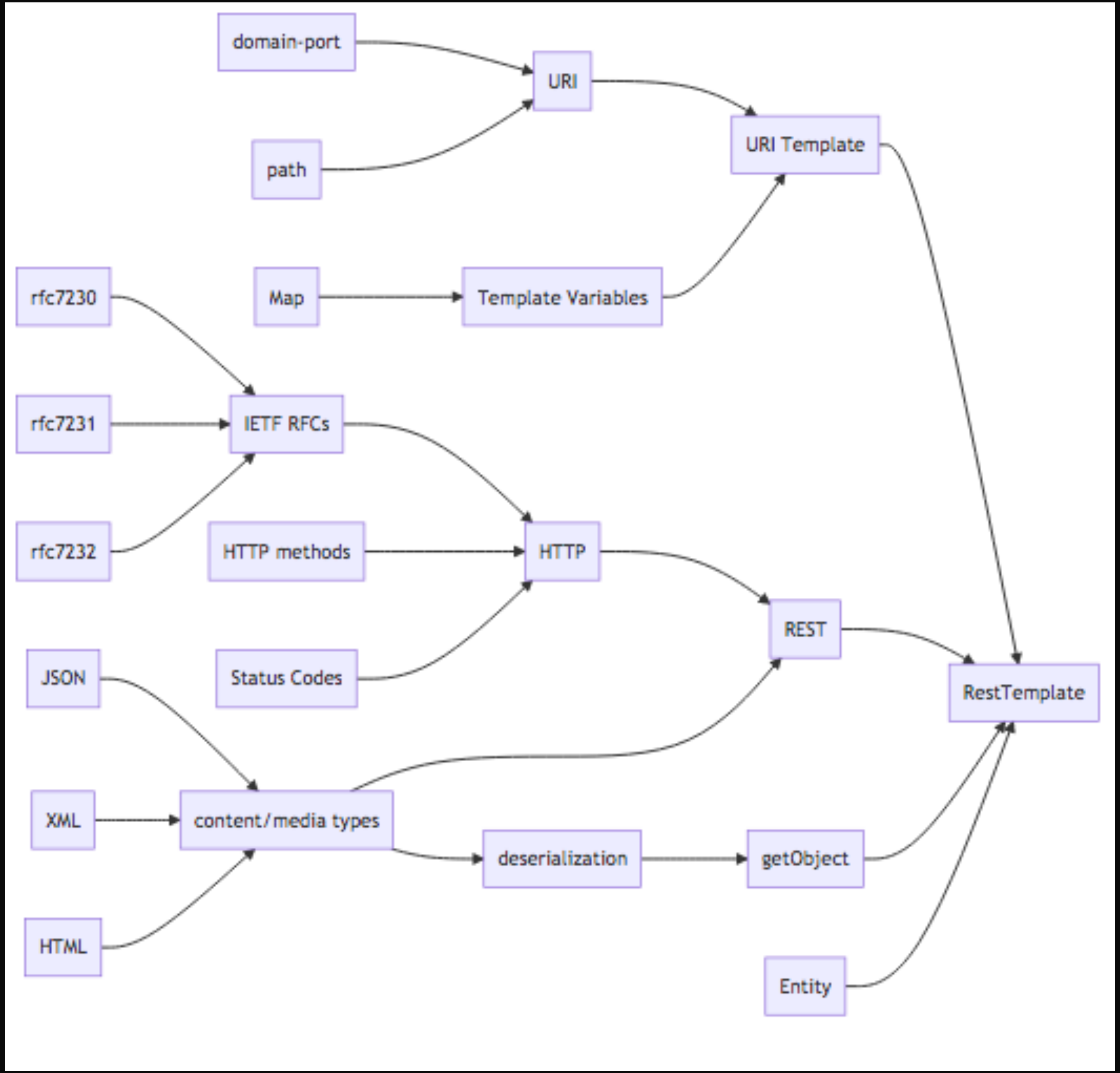
Leverage Dual-Coding



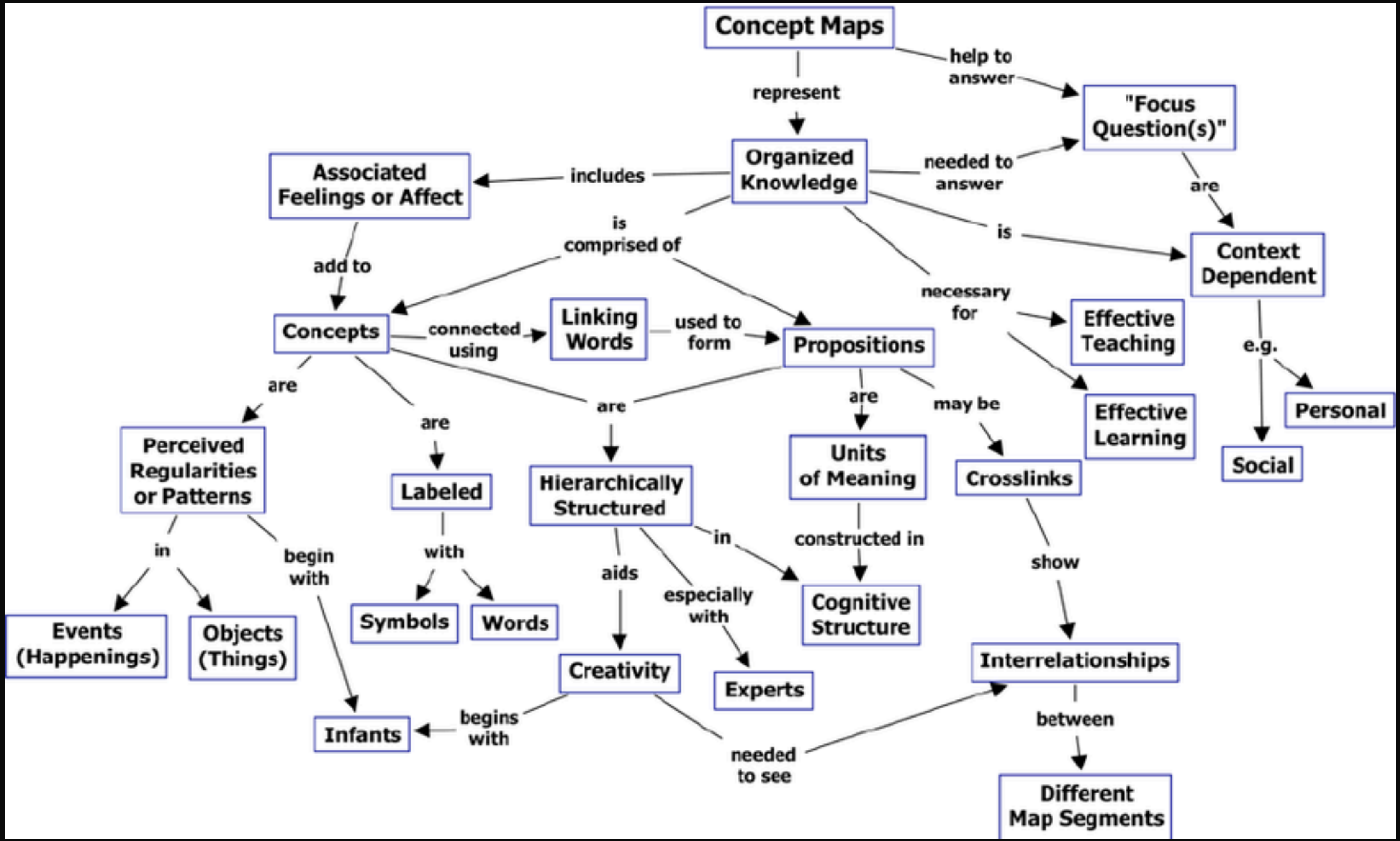
Using Both Pathways



Concept Maps: Battling the Curse

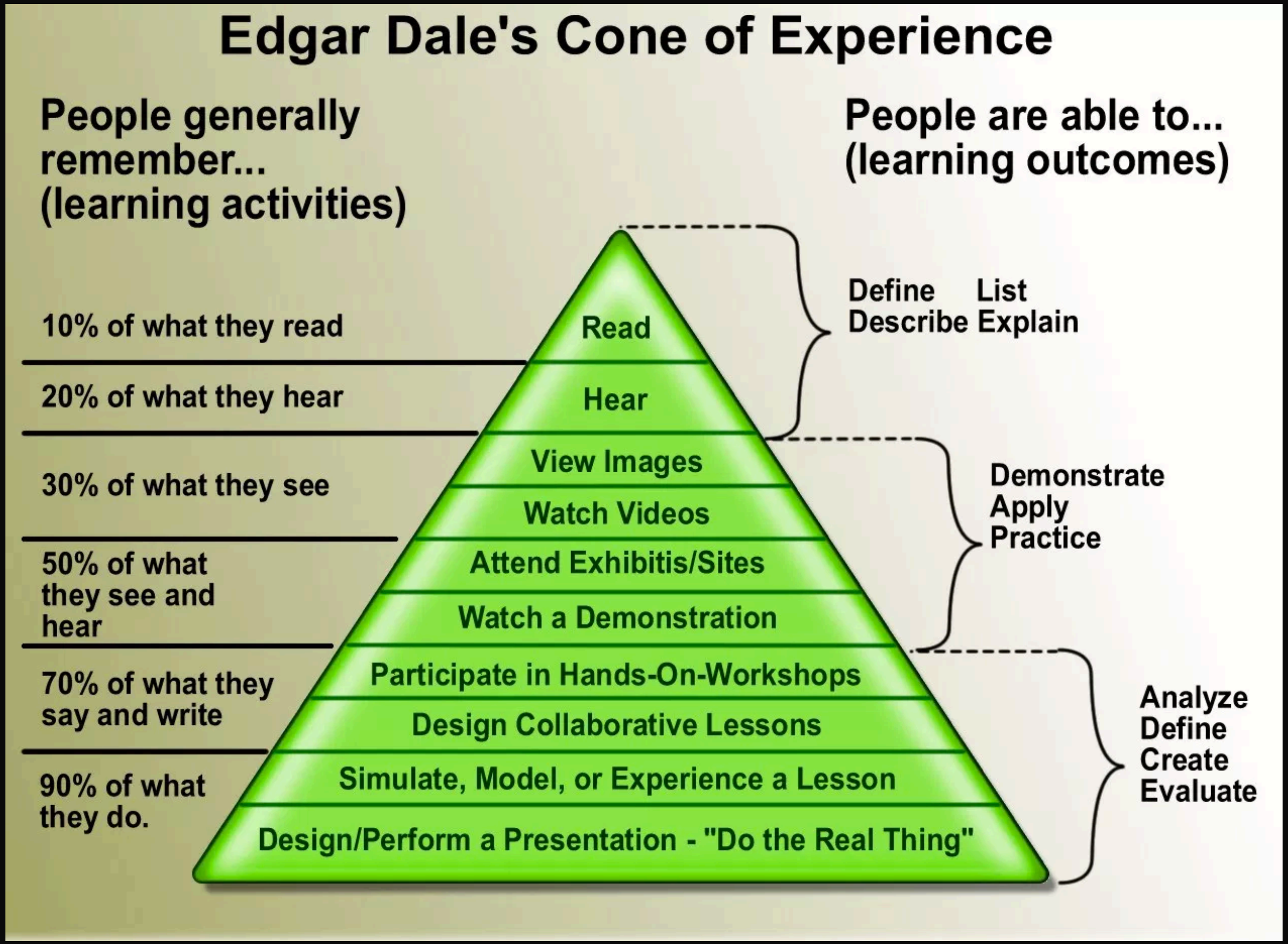


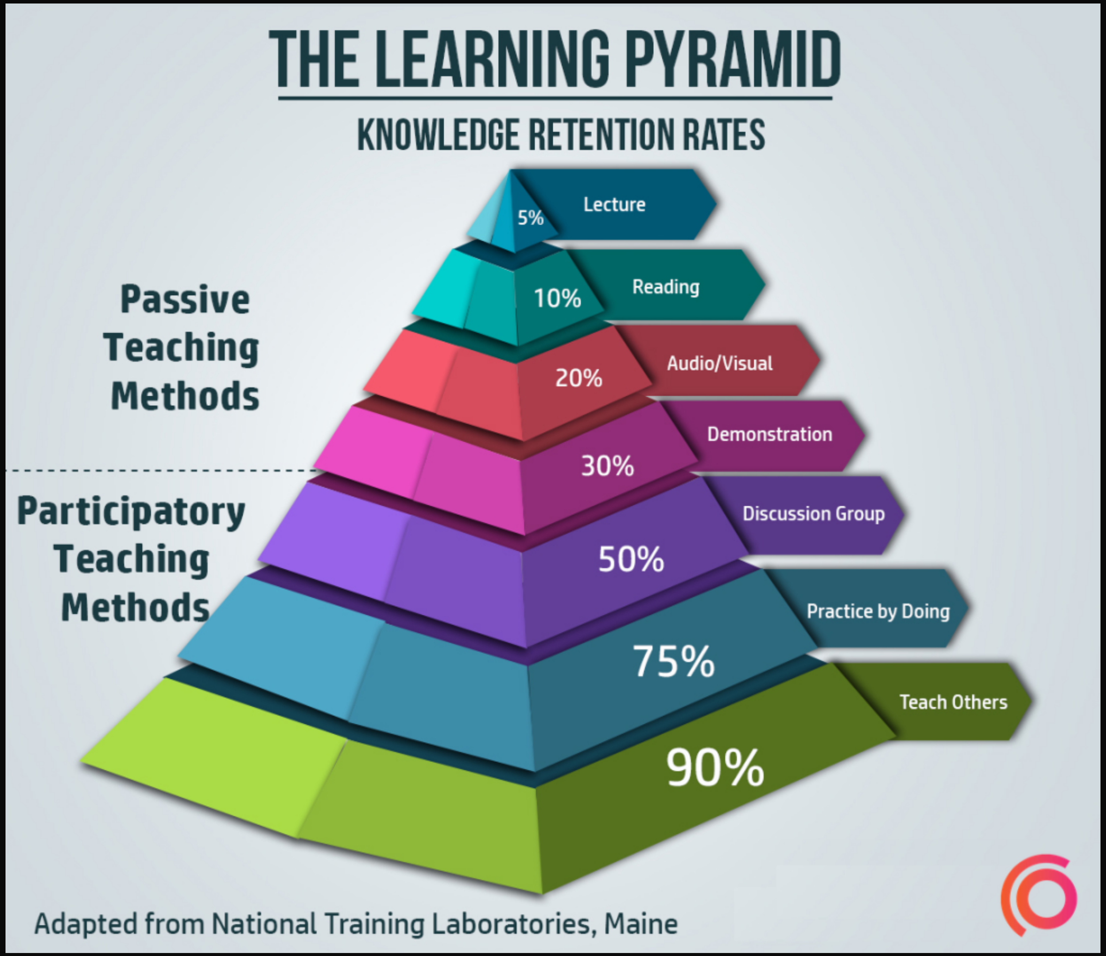
A Meta Concept Map



Learning Myths

(Myth) Dale's Cone





(Myth) Learning Styles

Idea

People differ in effective *mode* of instruction

Modes

- Visual (seeing)
- Aural/Auditory (listening)
- Read/write (words)
- Kinesthetic (experience)

(Myth) Learning Styles

Nope

The "data do not provide support for the learning-styles hypothesis"

"Psychological research has not found that people learn differently, at least not in the ways learning-styles proponents claim."

https://doi.org/10.1111/j.1539-6053.2009.01038.x (2009)

More Retrieval Practice

Working Memory?

- Theory that Working Memory is small: CLT = ?
  - Cognitive Load Theory
- Guide, don't distract learner, such as with...?
  - Split-Attention
  - Extraneous material
- Some examples of examples would be...?
  - Worked Examples
  - Parsons Problems
  - Concrete Examples

Don't Waste Time on Learning Myths, such as...?

- Dale's Cone: 10%, 20%, etc.
- Learning Styles

Human Learning

Thanks!

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