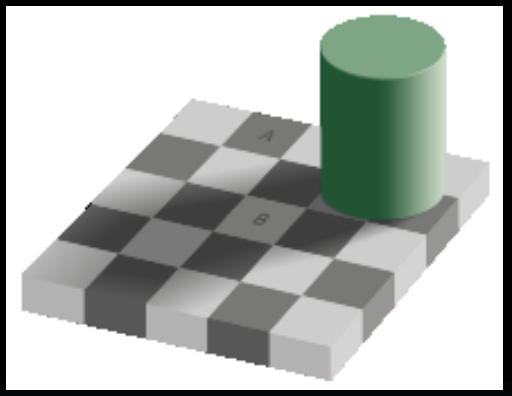
The Science (or Illusions) of Learning

Curricular Implications for Medical Student & Residency Training



Lawrence Loo, MD, MACP

Vice-Chair for Education & Faculty Development - Department of Medicine

Associate Dean for Educational Outcomes and Quality

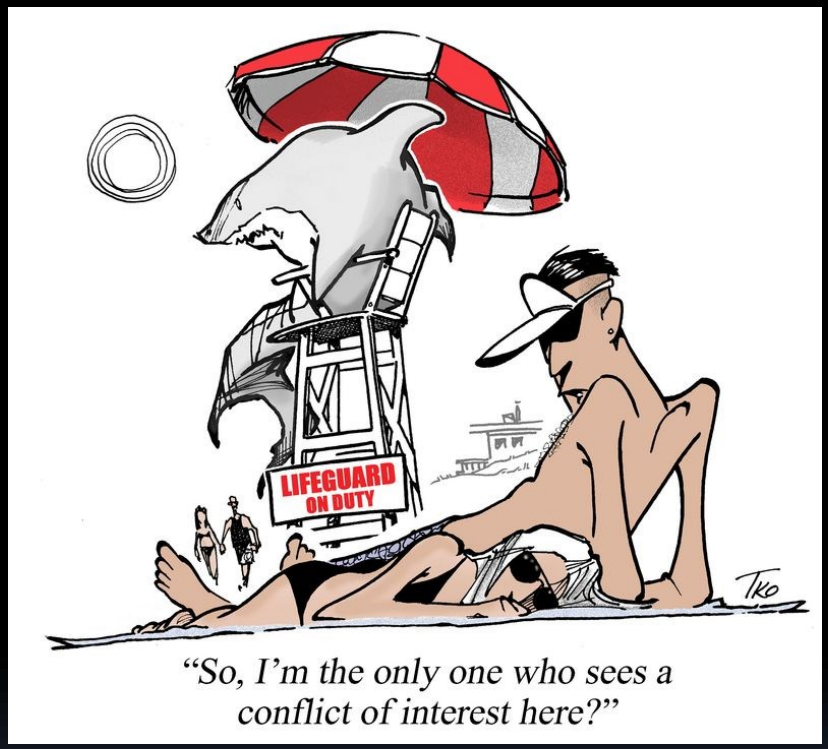
Chauncey L. Smith Professor of Medicine - Loma Linda University School of Medicine

Wednesday – February 7, 2018

CME - Conflict of Interest Disclosure

"All Relevant Financial Relationships"

NONE



"Commercial Interest" is defined by the ACCME (www.accme.org) as "any entity producing, marketing, re-selling or distributing health care goods or services consumed by or used on patients."

Learning Objectives:

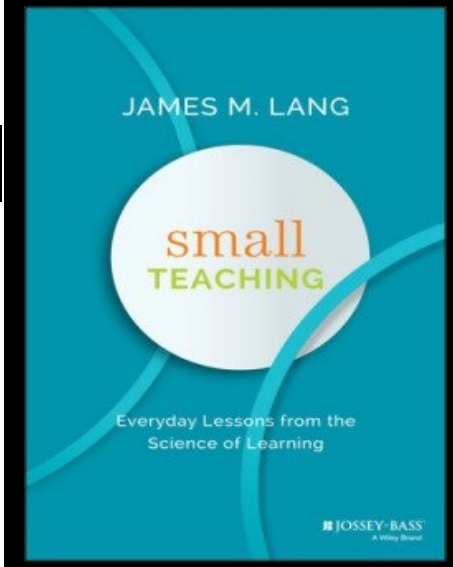
At the end of this session, attendees will be able to

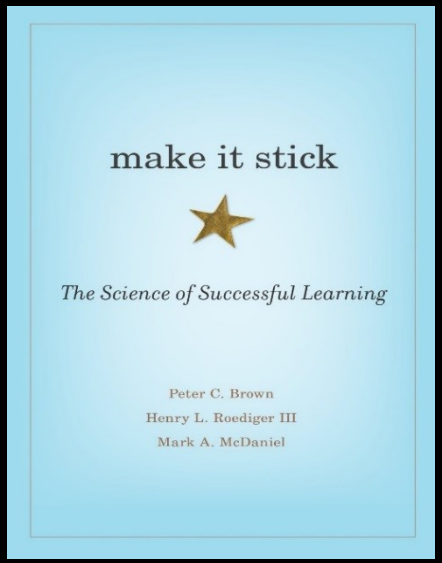
(1) **Bridge the gap** between real world learning in the medical setting and recent research from the fields of general education, neurosciences, and cognitive and educational psychology.

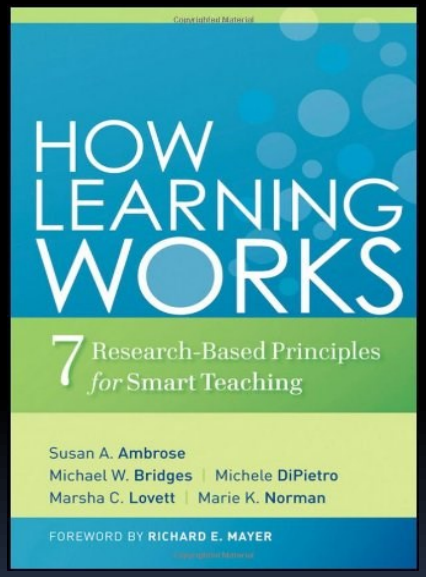
(2) Implement practical **methods of instructions** for long-term learning from the science of learning.

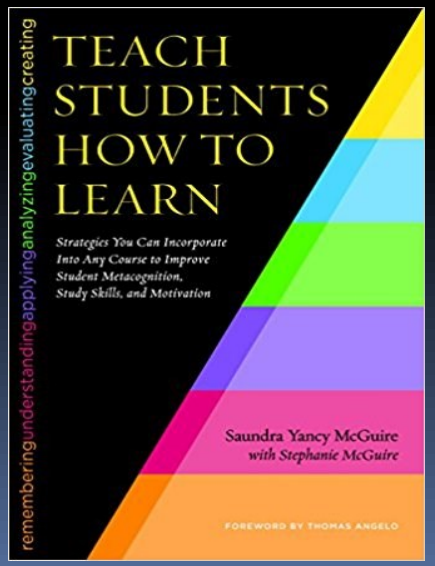
(3) **Avoid illusions** and myths of learning for the long-term.

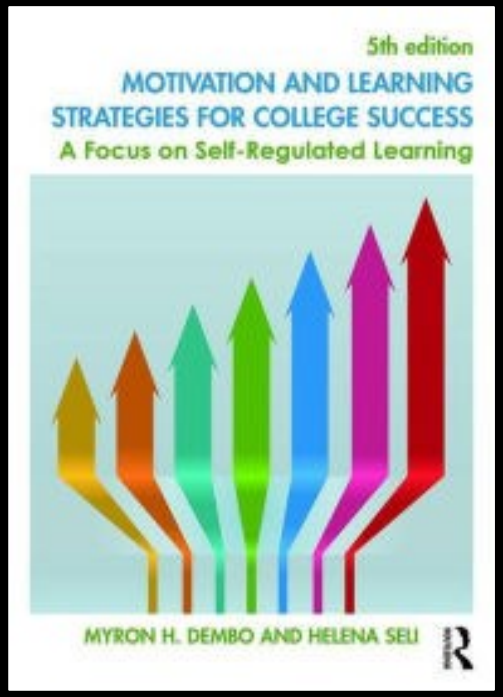
Cognitive Information Processing Theory & Long-term Memory Retention



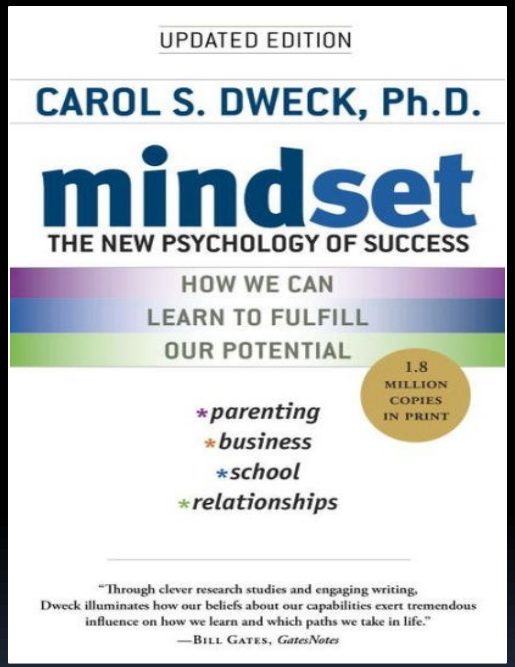




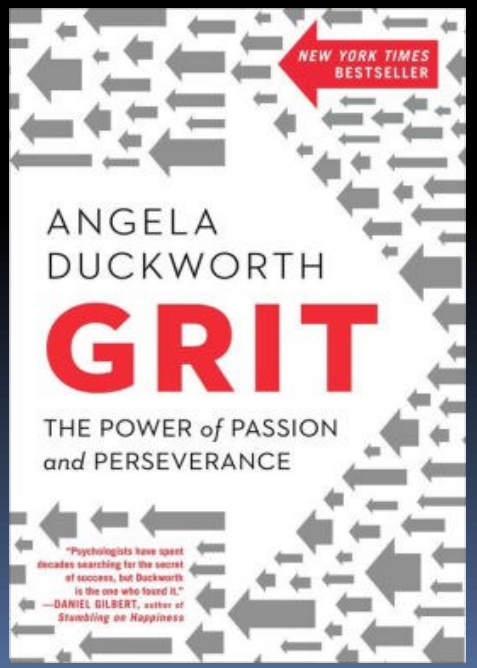




Theory of Self-Regulation

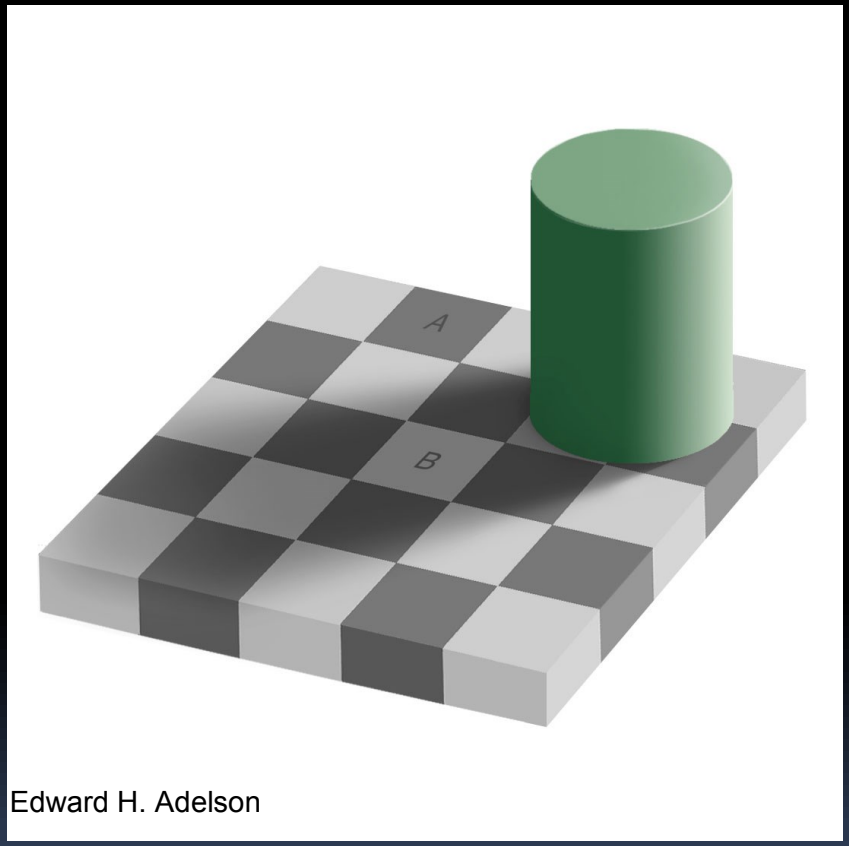


Growth Mindset



Grit

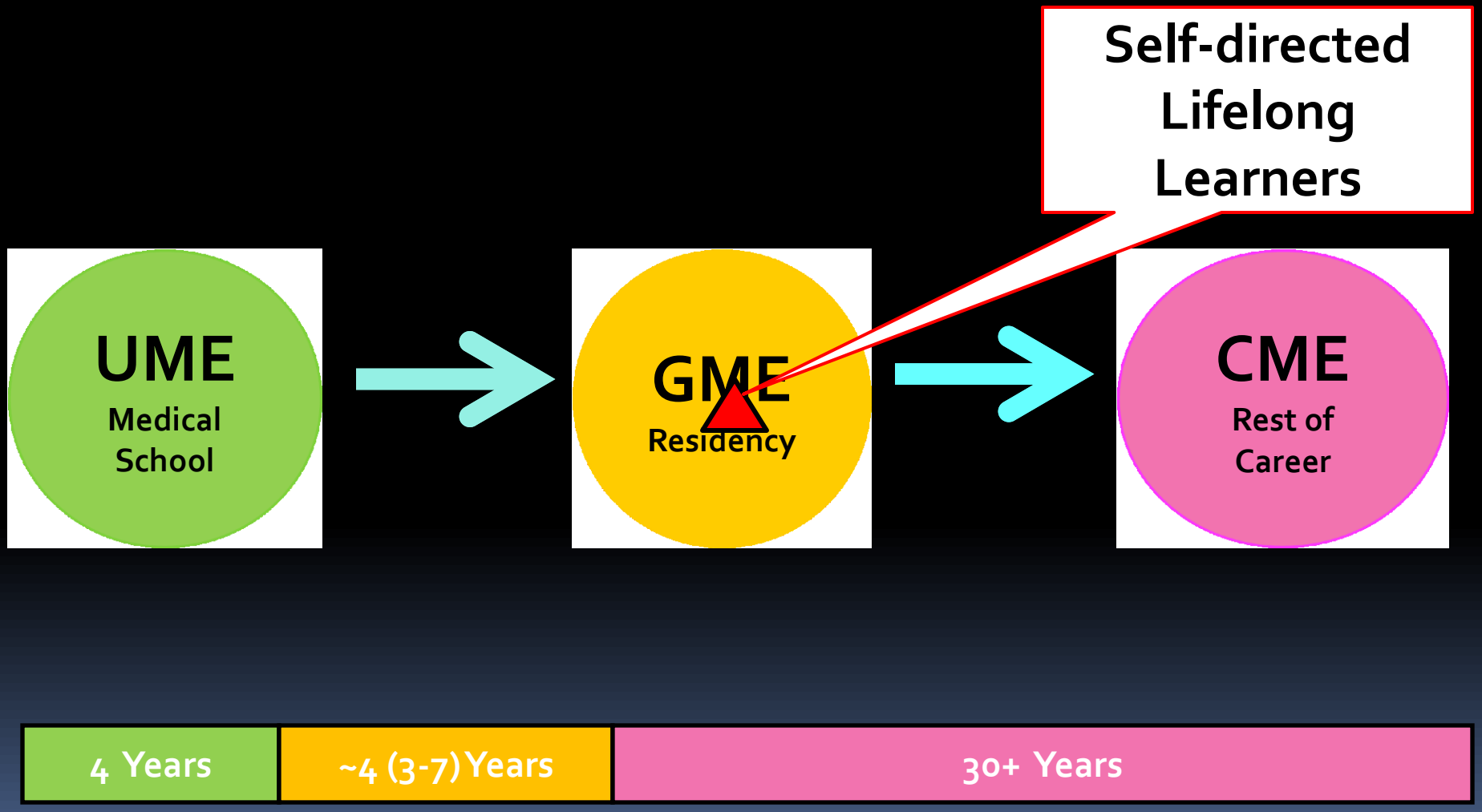
Which box is darker: A, B, or C-the same?



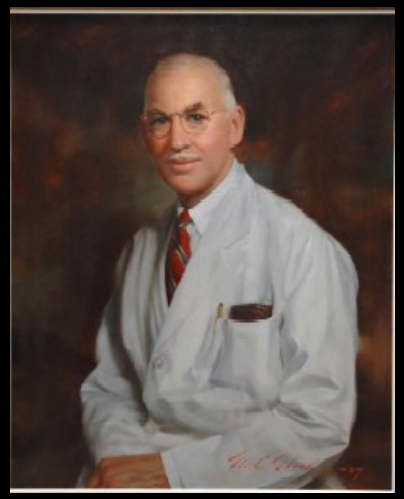
Edward H. Adelson

? Science or Illusion ?

The Continuum of Medical Education

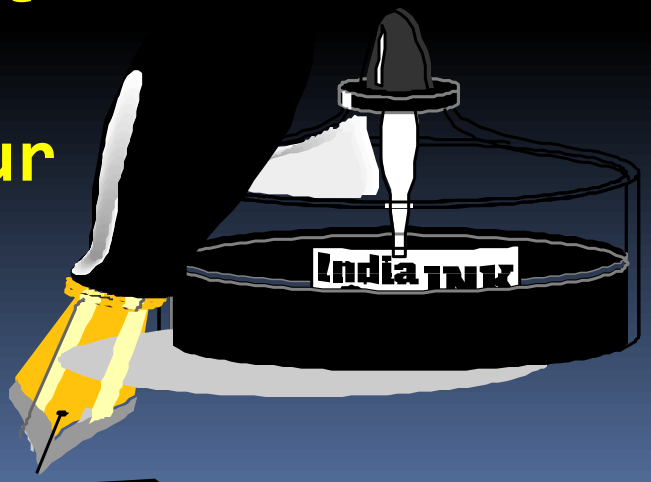


"Don't bother to take notes. Half of what you are taught as medical students will in five years have been shown to be either wrong or out of date.



The trouble is, none of your teachers knows which half.

So the most important thing to learn is 'how to learn on your own.'"



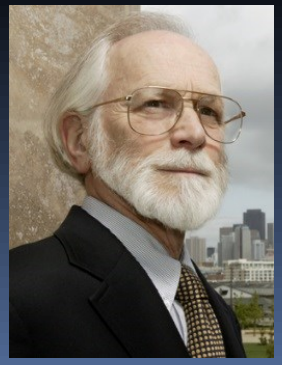
Oliver Cope/Sydney Burwell
(BMJ 1956:2:113-6)

"What are the purposes and priorities of teaching?

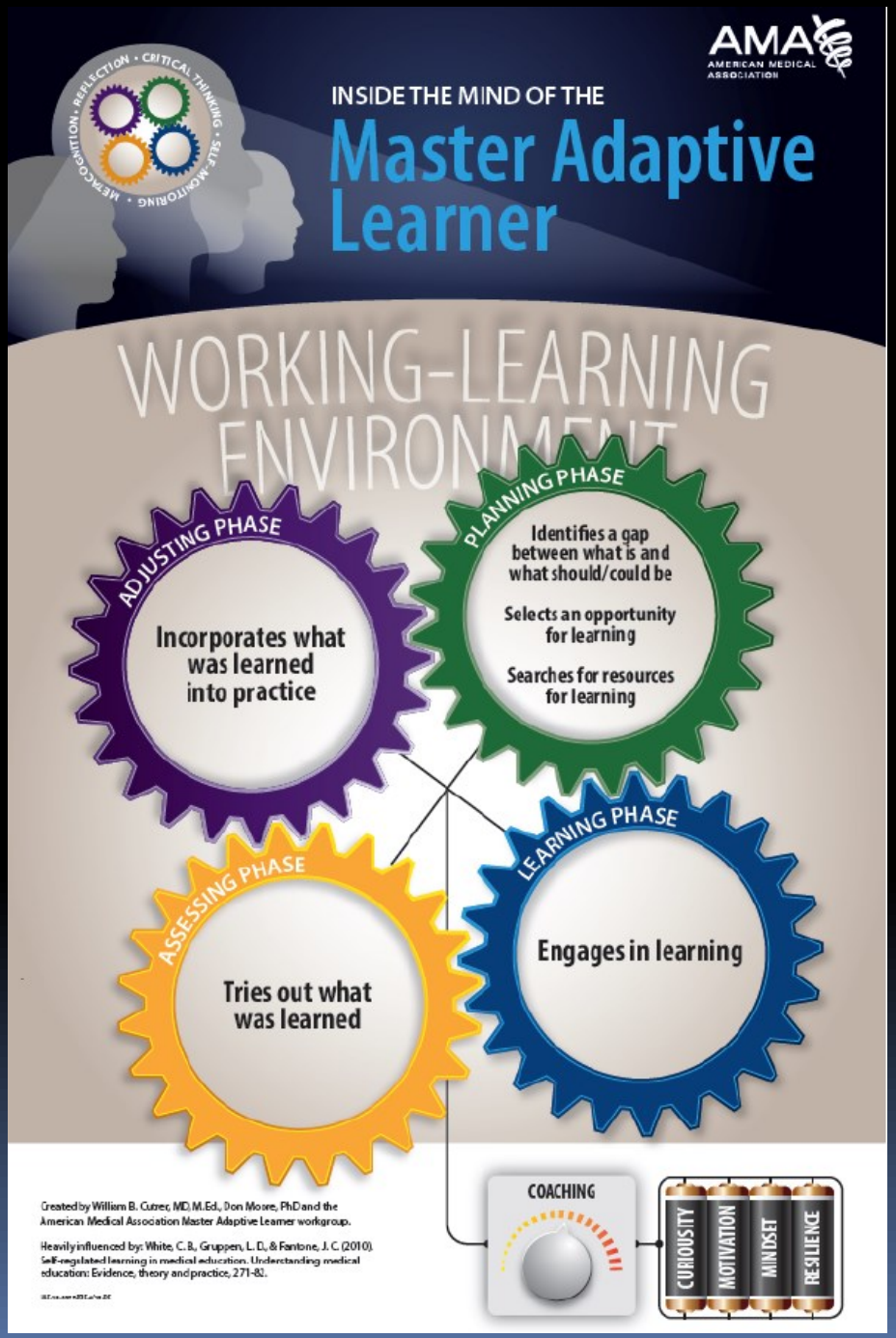
First, to inspire.
Second, to challenge.
Third and *only* third, to impart facts."

J. Michael Bishop, M.D.

(Nobel Prize Laureate Medicine 1989;
Chancellor, UCSF School of Medicine 1998 - 2009)



Developing the
Master Learner:
Applying Learning Theory to the Learner, the Teacher, and the Learning Environment.
(Schumacher DJ, et al. Academic Medicine 88[11]:1635, Nov 2013)



Learning-oriented Teaching (LOT) Model

(TenCate O, et. al.: Acad Med 2004;79:219-28 & Acad Med 2012; 87:735-43)

How to get a "LOT" out of your conferences: Demonstration of the LOT Model

Learning Process Component	Learner's Concerns	Teachers' Concerns and Issues
Cognitive Level	Study **what**?	Presenting (facilitating the provision of relevant information
Affective Level	**Why** Study?	Motivating (stimulating students to invest in studying)
Metacognitive Level	**How** to learn?	Instructing (helping students to go about studying)

Table Adapted from: TenCate, O., Snell, L., Mann, K. & Vermunt, J. (2004). Orienting teaching toward the learning process. *Academic Medicine, 79(3), 219-228. Clinical implications for medical education of LOT model:* Kusurkar RA, et al.: Have motivation theories guided the development and reform of medical education curricula? a review of the Literature. *Acad Med 2012;87:735-43.*

T. Shankel, L. Daniel-Underwood, M. Lewis, L. Loo, T. Thomas, L. Werner

- Learning for the Long Term
- Time Management
- Understanding
- Memorizing
- Integration
- Professionalism
- Learning Style Inventory

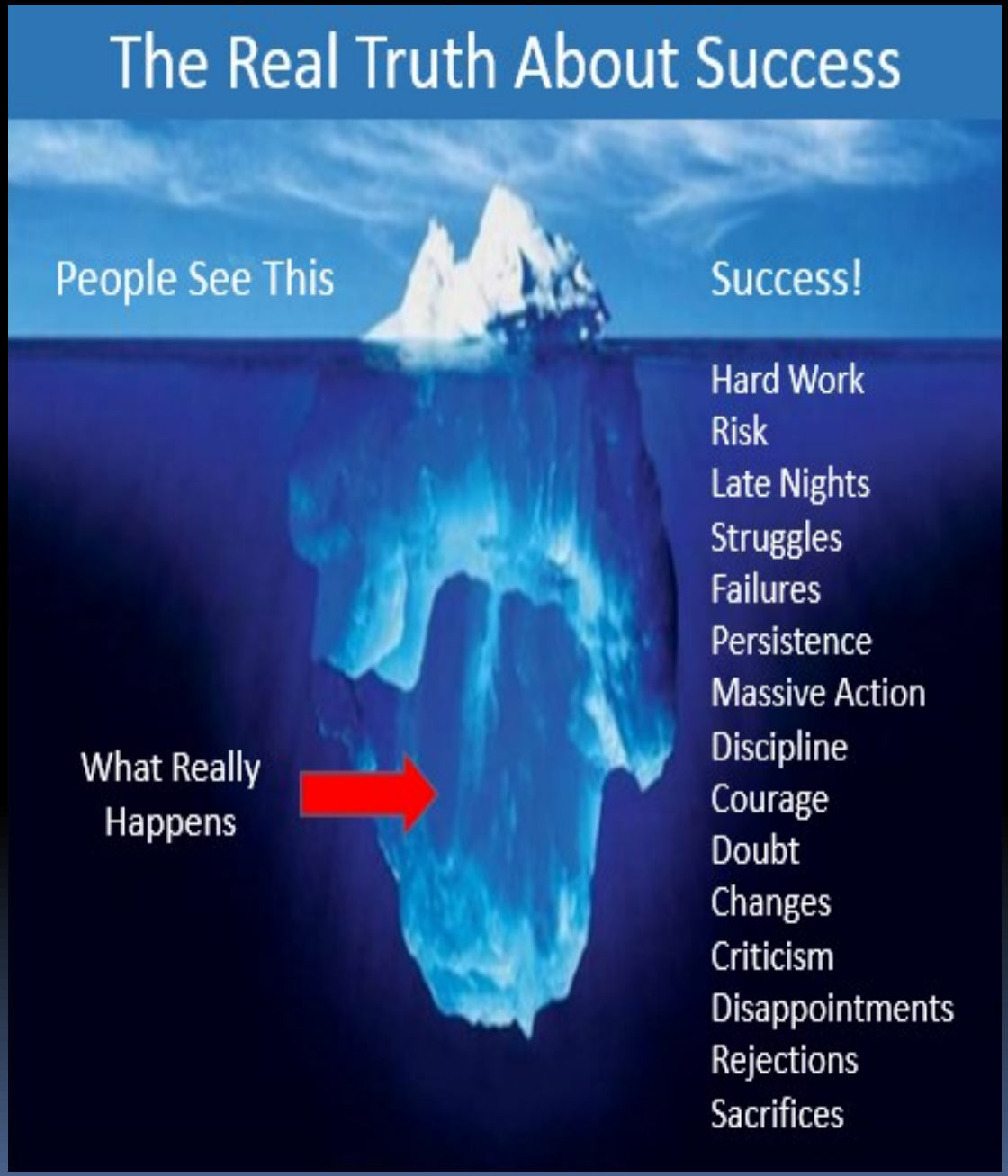
Metacognitive Learning Strategies:

Evidence-based Education and the Science of Learning

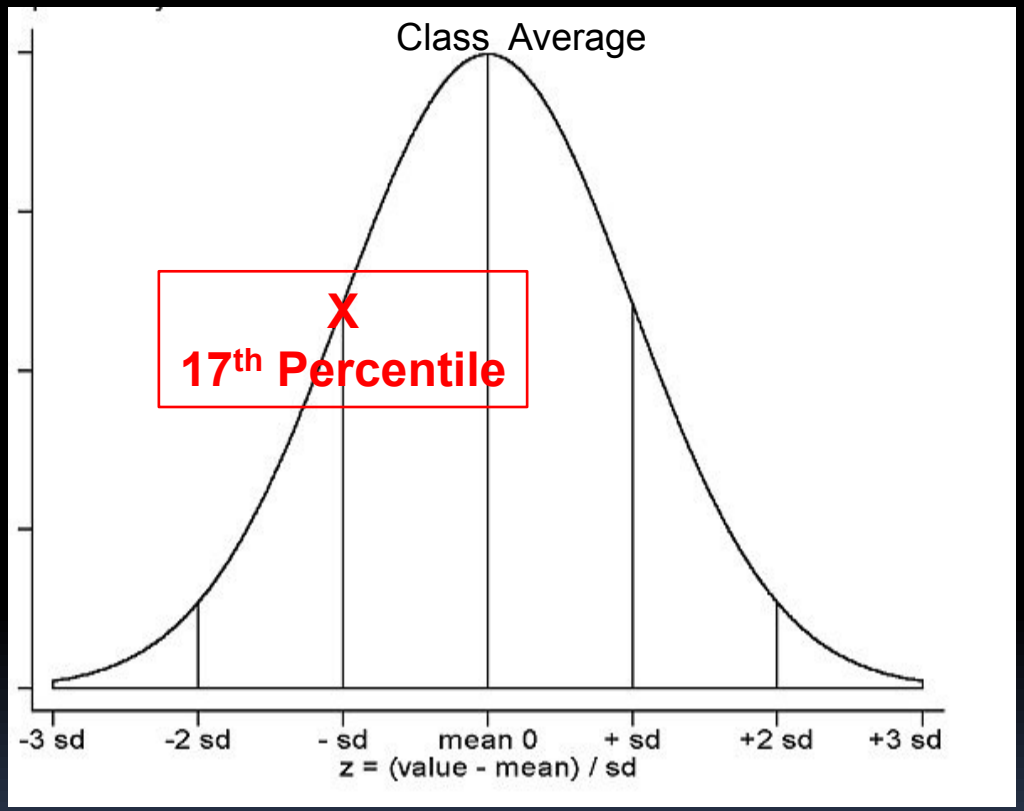
What is "success"?

(The Iceberg Perspective)

And *how* will you achieve this?



What would be your reaction to seeing the results of your first medical school exam results?



Kahoot.it

A. OMG - I'm not smart enough!?!

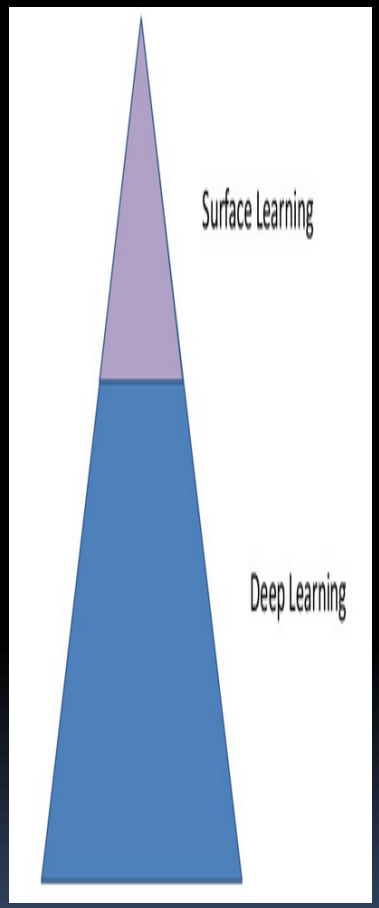
B. OMG - College didn't prepare me well enough!?!

C. OMG - I'll have to work harder !?!

D. OMG - I'll have to try something different !?!

E. **?*#!X &?@ ^ %!!!**

What would be your reaction to seeing the results of your first medical school exam results?



Performance & Ability Orientation

Effort & Growth Orientation

Relax and take a sedative

A. OMG - I'm not smart enough!?!

B. OMG - College didn't prepare me well enough!?!

C. OMG - I'll have to work harder !?!

D. OMG - I'll have to try something different !?!

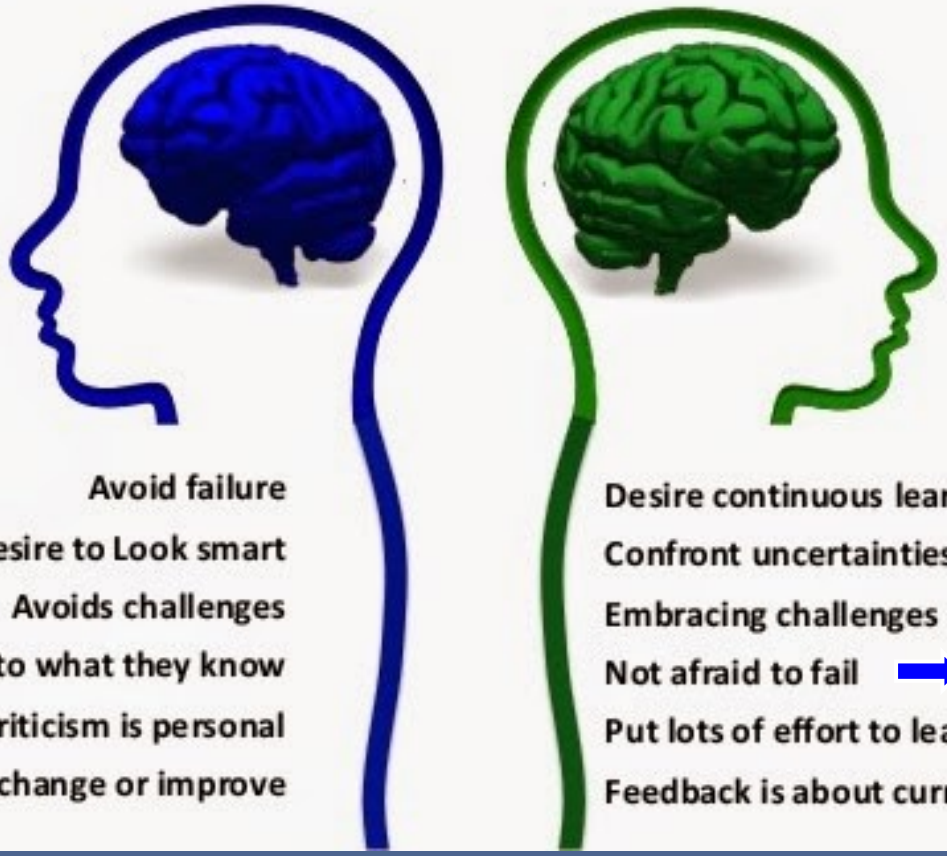
E. **?*#!X &?@ ^ %!!!**

Fixed Mindset vs. Growth Mindset

Based on the work of Dr. Carol Dweck

I believe that my **[Intelligence, Personality, Character]** is inherent and static. Locked-down or fixed. My potential is determined at birth. It doesn't change.

I believe that my **[Intelligence, Personality, Character]** can be continuously developed. My true potential is unknown and unknowable.



Fixed Mindset

Failure

Challenges

Feedback

Effort

- Avoid failure
- Desire to Look smart
- Avoids challenges
- Stick to what they know
- Feedback and criticism is personal
- They don't change or improve

Growth Mindset

- Desire continuous learning
- Confront uncertainties.
- Embracing challenges
- Not afraid to fail → **Perseverance & Resiliency**
- Put lots of effort to learn
- Feedback is about current capabilities

Failure- Who's to Blame?

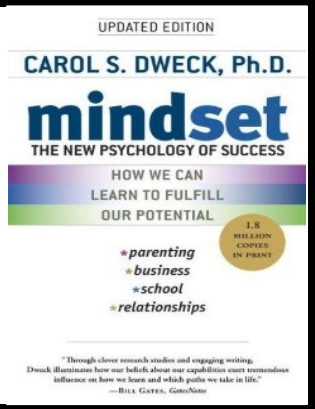
Fixed Mindset

Fixed personal factors

External **uncontrollable** factors

Growth Mindset

Processes & Effort (that **I** used)



"Believing that people (and oneself) can develop their abilities"

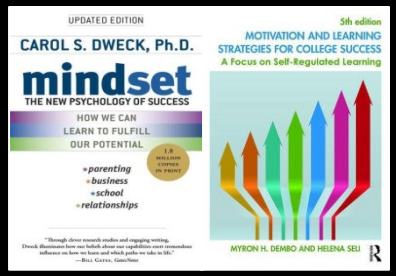
PROCESS

(1) Hard work
(2) Trying new strategies
(3) Seeking input (help) from others
(4) Tied to outcomes

Education
Business
Sports
Relationships
- Stereotypes
- Bias

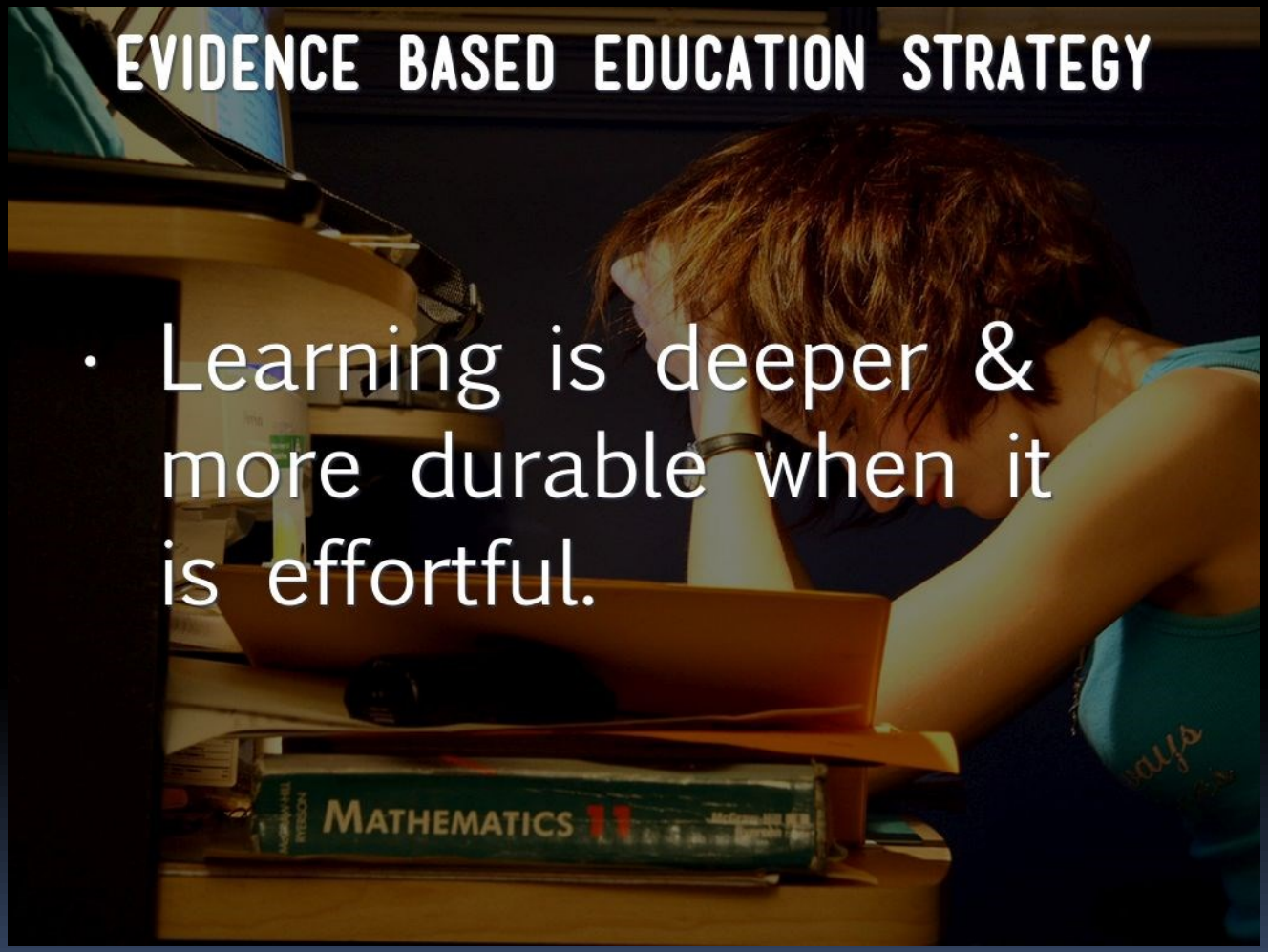
Self Regulated Learners

(Sandars J, Cleary TJ: Self-regulation theory: Applications to medical education. Med Teach 2011; 33:875-886)



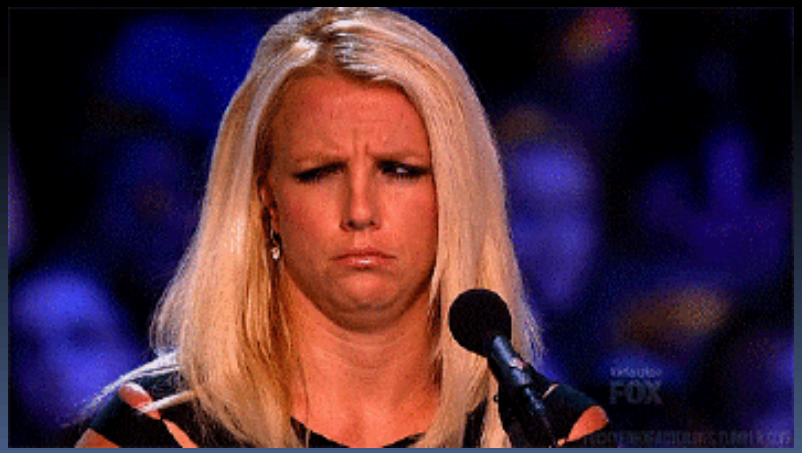
Learning is viewed proactively as something students ***do***, **not** something that happens ***to*** them or ***for*** them.

Fixed Mindset

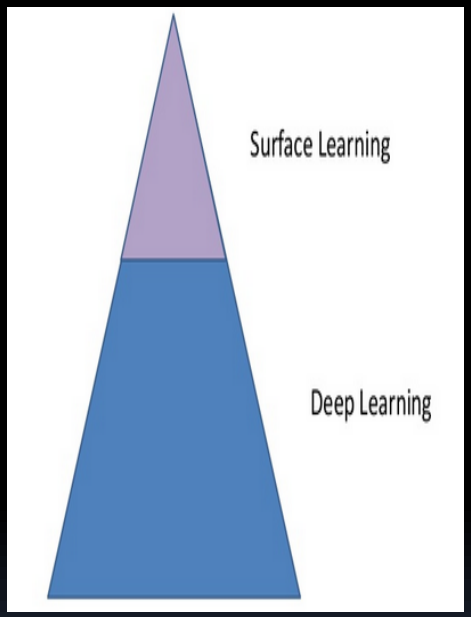

EVIDENCE BASED EDUCATION STRATEGY
Learning is deeper & more durable when it is effortful.
MATHEMATICS 11

Curriculum Implication & Recommendation

- Illusion: Handouts should be complete
- Science: Handouts & classrooms should have opportunities for ***generation***, ***elaboration*** & ***reflection.***



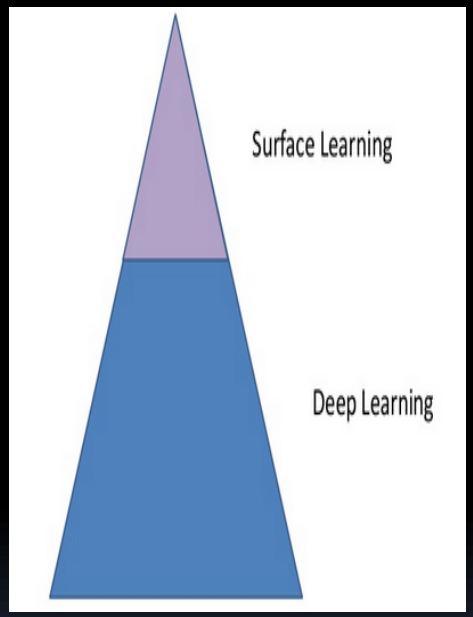
CREATING
STICKY LEARNING
Photo by DrWurm - Creative Commons Attribution-NonCommercial-ShareAlike License https://www.flickr.com/photos/34198377@N07
Created with Haiku Deck



		Disease	
		Yes	No
Test Result	Yes	(A) True +	(B) False +
	No	(C) False –	(D) True –

:

Surface Learning (promoted by "complete" handouts)	**Deep Learning** (promoted by generation & elaboration)
Sensitivity = TP / (TP + FN)	Sensitivity =
Specificity = TN / (TN + FP)	Specificity =
PPV = TP / (TP + FP)	PPV =
NPV = TN / (TN + FN)	NPV =
+ Likelihood Ratio = Sensitivity / (1 - Specificity)	+ Likelihood Ratio =
- Likelihood Ratio = Specificity / (1 – Sensitivity)	- Likelihood Ratio =
TP = True Positives TN = True Negatives **FP** = False Positive FN = False Negatives **PPV** = Positive Predictive Value **NPV** = Negative Predictive Value	Explain to a neighbor what each of the terms above means ***in words*** (not just writing the formulae).



		Disease	
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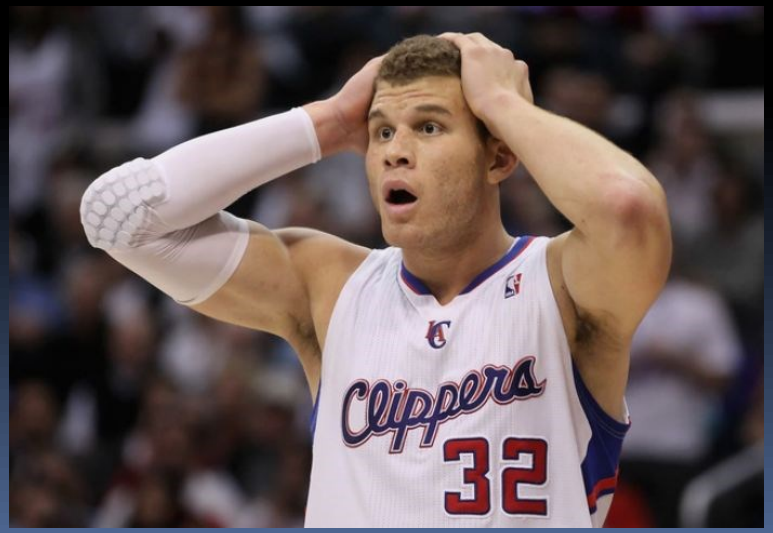
:

Surface Learning (promoted by "complete" handouts)	**Deep Learning** (promoted by generation & elaboration)
Sensitivity = TP/(TP + FN)	Sensitivity = TP / (___ + FN)
Specificity = TN/(TN + FP)	Specificity = ___ / (TN + FP)
PPV = TP / (TP + FP)	PPV = ___ / (TP + ___)
NPV = TN / (TN + FN)	____ = TN / (TN + FN)
+ Likelihood Ratio = Sensitivity / (1 - Specificity)	+ Likelihood Ratio = Sen_iti_vity / (1 – Sp_c_ficity)
- Likelihood Ratio = Specificity / (1 – Sensitivity)	- L_k_l_hood R_tio = Specificity / (1 – Sensitivity)
TP = True Positives TN = True Negatives **FP** = False Positive FN = False Negatives **PPV** = Positive Predictive Value **NPV** = Negative Predictive Value	Turn to a neighbor and **explain how** prevalence will affect (if at all) all of the above terms.

Curriculum Implication & Recommendation

- Illusion: Handouts should be complete
- Science: Handouts & classrooms should have opportunities for ***generation***, ***elaboration*** & ***reflection.***

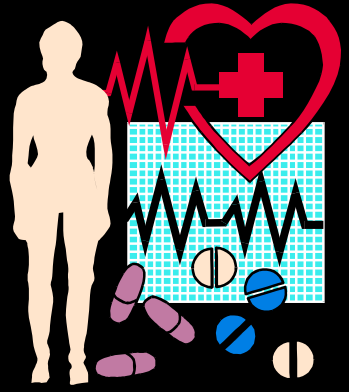


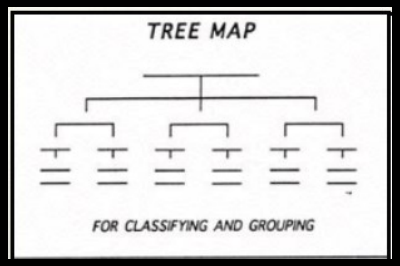
RM Epstein: "Assessment in Medical Education"

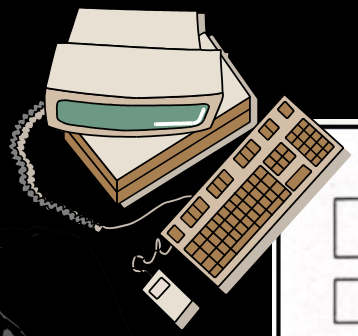
(N Engl J Med 2007;356:387-396)

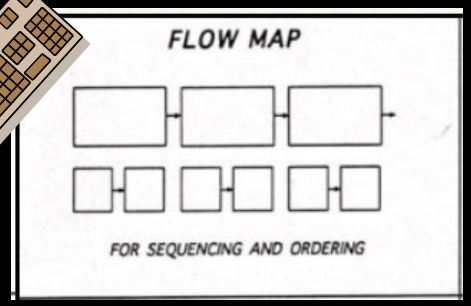
- "Competence is not an achievement but rather a ***habit*** of lifelong learning."

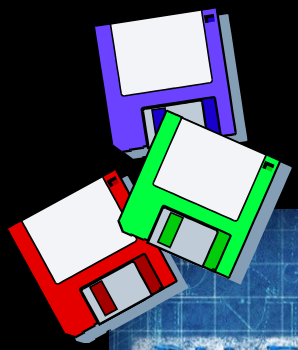
Expanding Your Learning Tool Kit

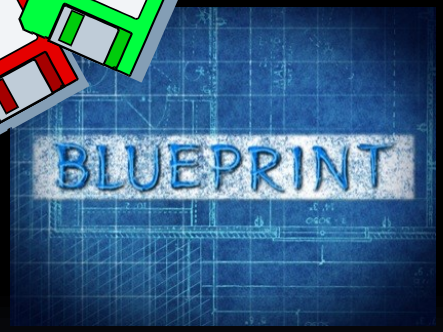


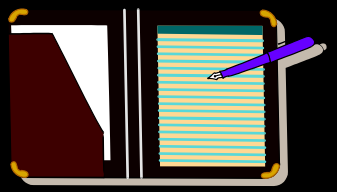


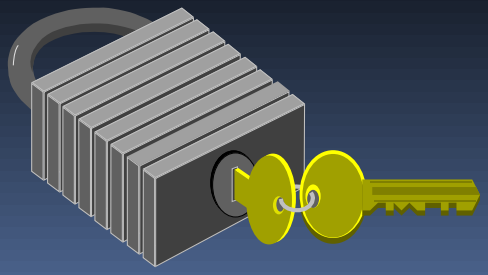












The Science of Learning:

Test Your Knowledge: Science or Illusion

Certain **Learning Styles** (e.g. visual, auditory, kinesthetic, etc.) have been demonstrated to correlate with better academic performance.

Fact

Fallacy

The Science of Learning:

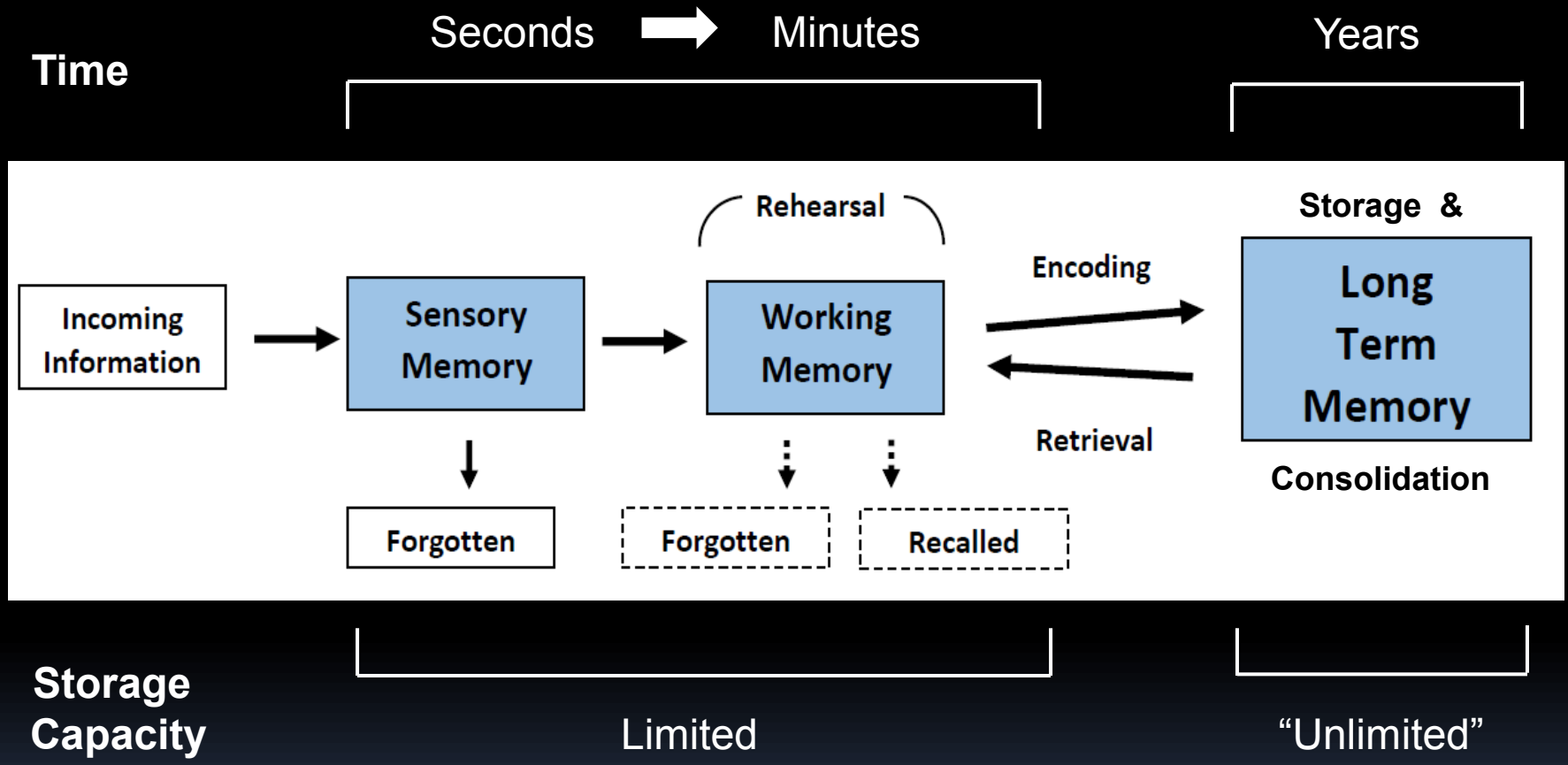
Test Your Knowledge: Science or Illusion

Long-term learning is improved when the teacher **matches** the student's particular learning style (e.g. visual, auditory, kinesthetic).

Fact

Fallacy

Cognitive Information Processing Theory



Mayer RE: Applying the science of learning to medical education. Med Educ 2010;44:543-9.
Van Merrienboer JJG: Cognitive load theory in health professional education. Med Educ 2010;44:85-93.

The Science of Learning:

Test Your Knowledge: Science or Illusion

Today's millennial learners can multi-task better than their parents' generation.

Fact

Fallacy

Multi-tasking & Learning: Exercise #1

Rub your belly –
nice full circular motion

AND

Pat your head –
raise your hand at least 6 inches above between pats

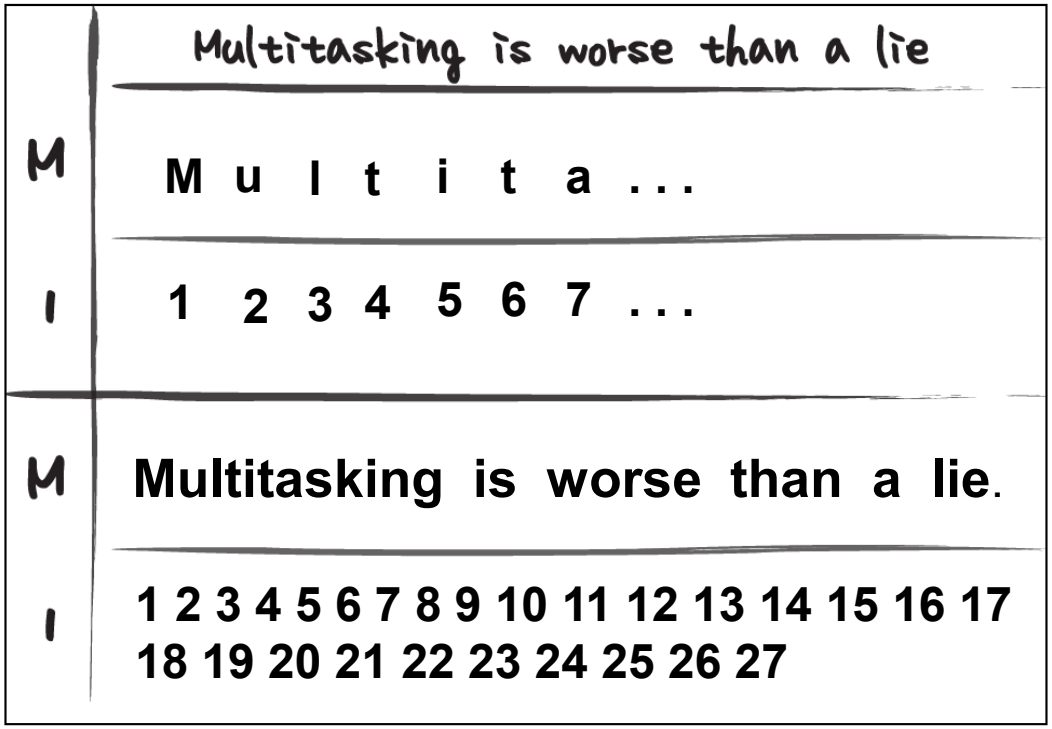
If you're already good at this (because you've practiced), try this instead:
Pat your belly AND rub the top of your head

The Myth of Multitasking Exercise #2

THE Myth OF Multitasking

EXERCISE

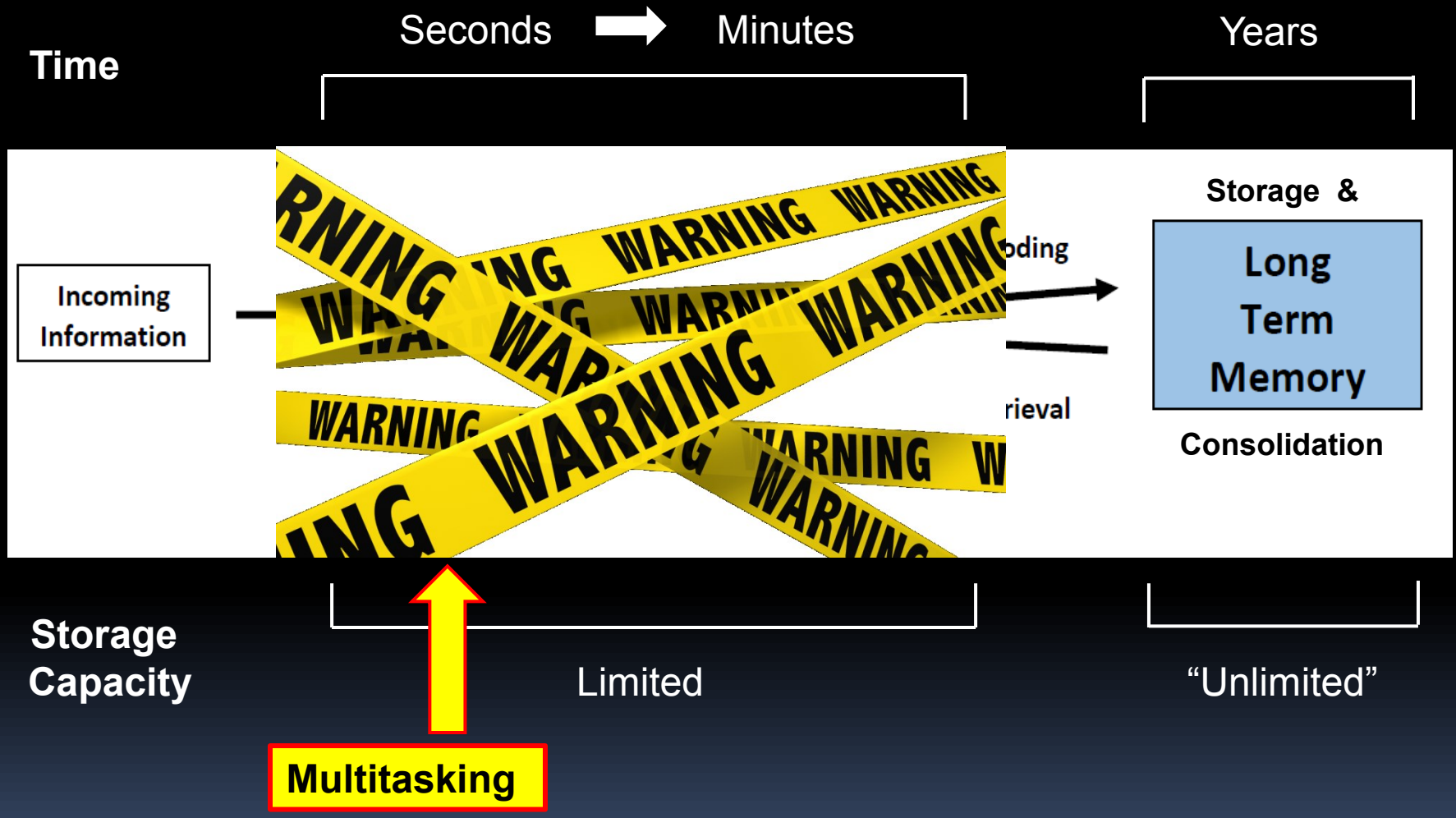
Are you really multitasking … or are you switchtasking? The following exercise will help you quickly understand the negative impact in efficiency caused by switchtasking.



The Myth of Multitasking

Interfering with **Sensory & Working Memory**

Cognitive Information Processing Theory



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Van Merrienboer JJG: Cognitive load theory in health professional education. Med Educ 2010;44:85-93.

Curriculum Implication & Recommendation

- Turn **off** the wi-fi in classrooms & lecture halls where learners are attempting to encode information into their working memories.

The Science of Learning:

Test Your Knowledge: Science or Illusion

Which of the following study "methods" is the ***least*** effective for long-term memory retention and recall?

A. Reading (and re-reading)

FACT

C. Word or picture mnemonics

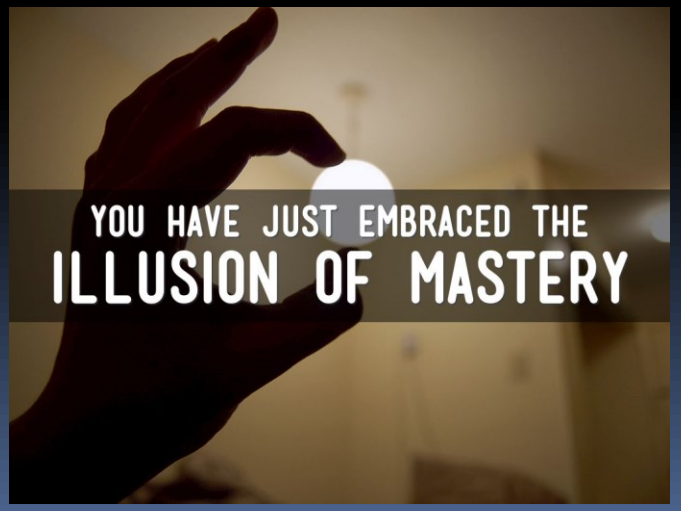
B. Underlining and highlighting

D. Sleeping

Familiarity Trap

("Make It Stick: the Science of Successful Learning" 2014 - Chapter 3)

- Rereading something over and over again will "burn" it into my memory but **familiarity** with the words and syntax is <u>not</u> the same as understanding the underlying principles and concepts.



The Science of Learning:

Test Your Knowledge: Science or Illusion

Which of the following study "methods" is the ***most*** effective for long-term memory retention and recall?

A. Reading (and re-reading)

B. Underlining and highligting

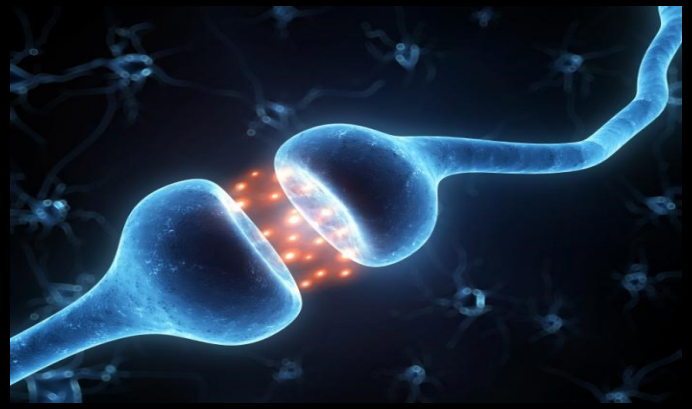
FACT

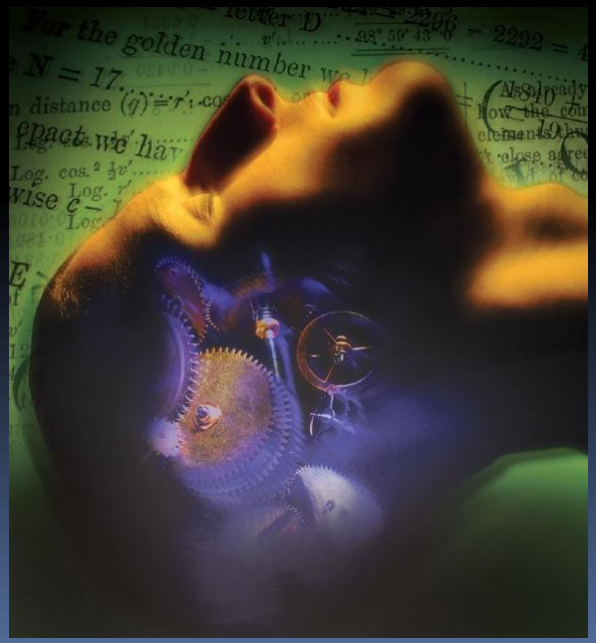
C. Word or picture mnemonics

D. Sleeping

The Science of Learning:

Test Your Knowledge: Science or Illusion





The Myth of Multitasking

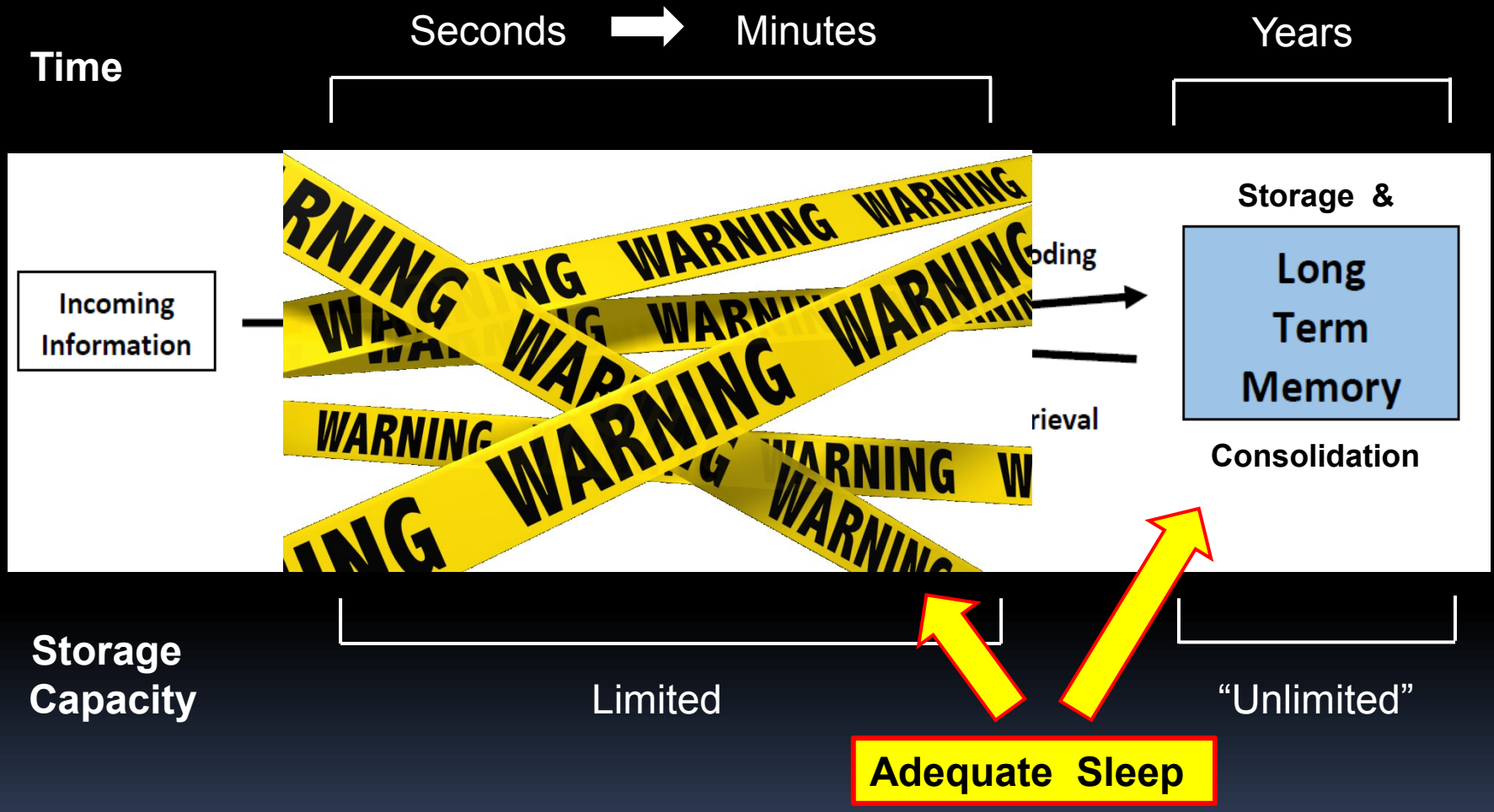
Promotes

Consolidation & Long Term Memory

Interfering with

Sensory & Working Memory

Cognitive Information Processing Theory



Mayer RE: Applying the science of learning to medical education. Med Educ 2010;44:543-9.
Van Merrienboer JJG: Cognitive load theory in health professional education. Med Educ 2010;44:85-93.

Small Group Exercise #3

The Science of Learning:

Test Your Knowledge: Science or Illusion

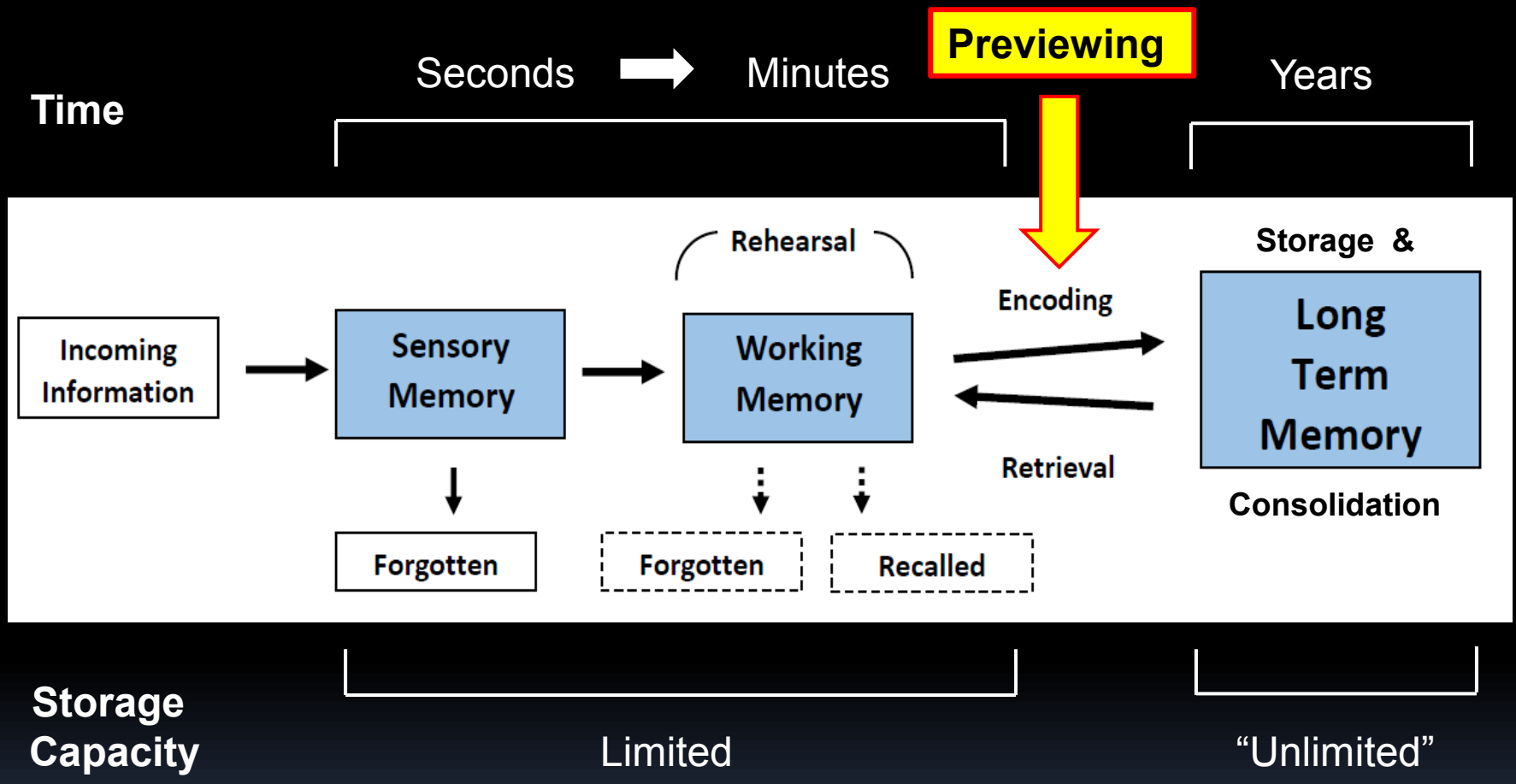
Did you use **Previewing** as a regular study strategy during college?

Yes

NO

No

Cognitive Information Processing Theory



Mayer RE: Applying the science of learning to medical education. Med Educ 2010;44:543-9.
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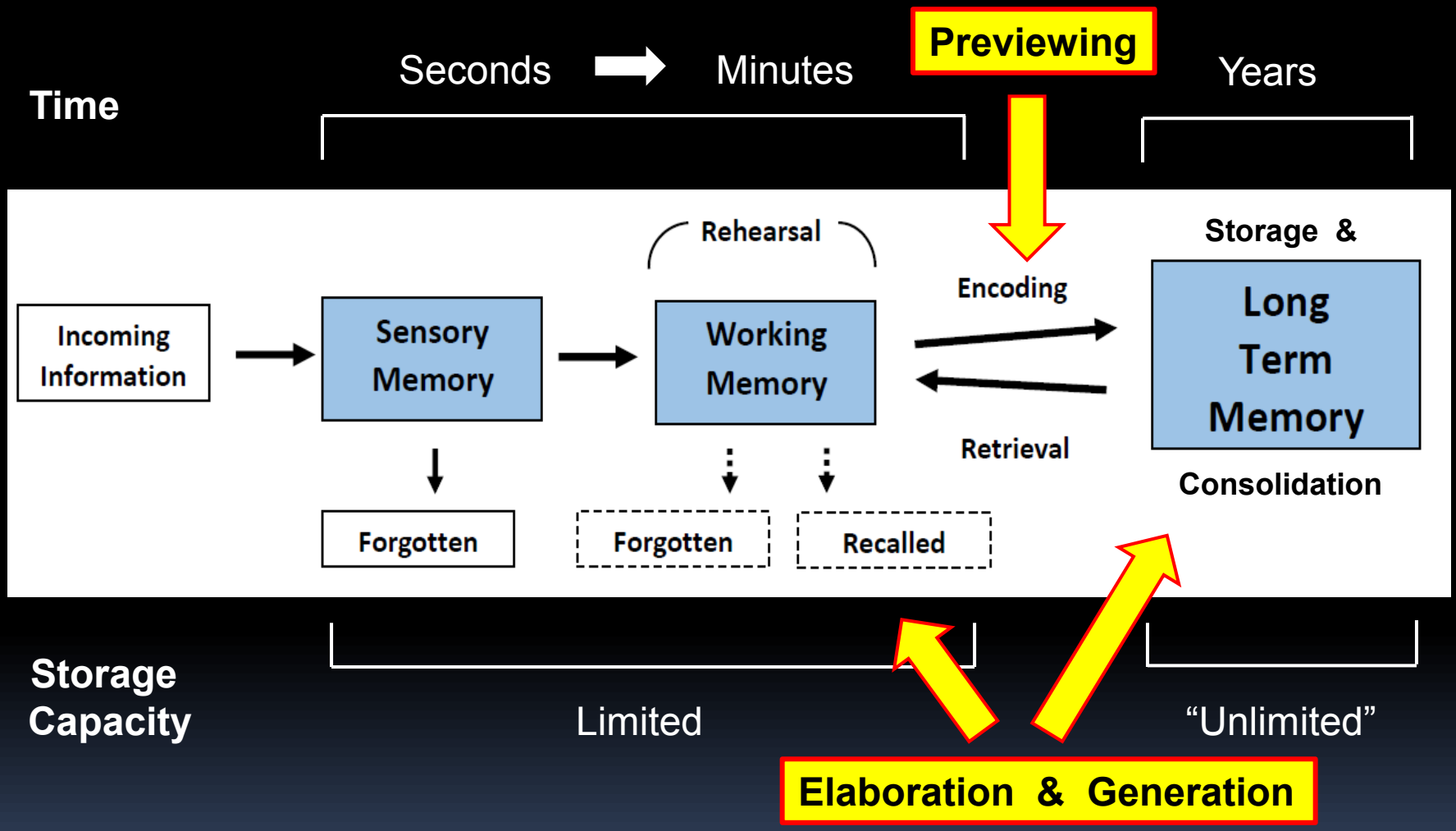
Individual Exercise #4

Cognitive Information Processing Theory



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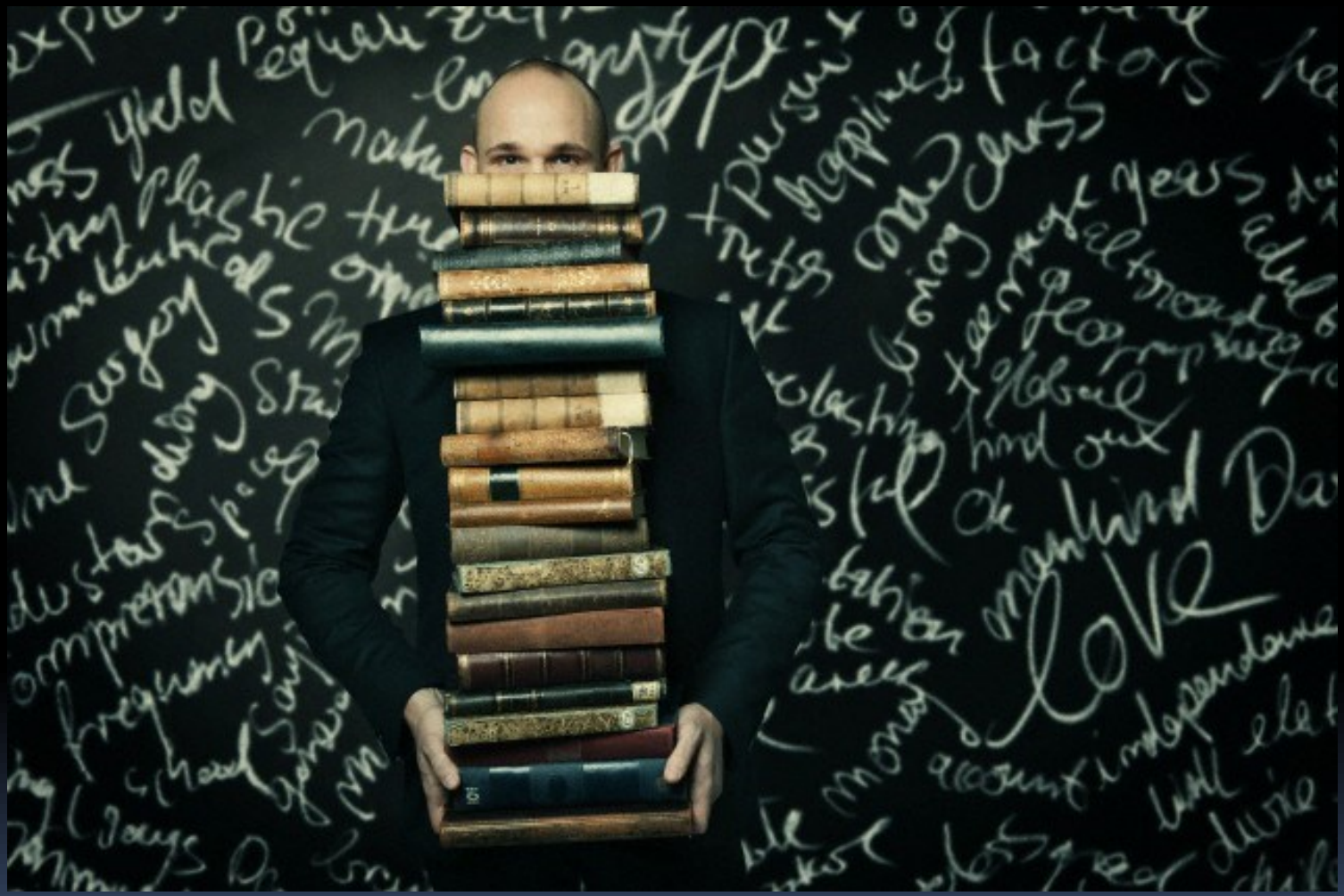
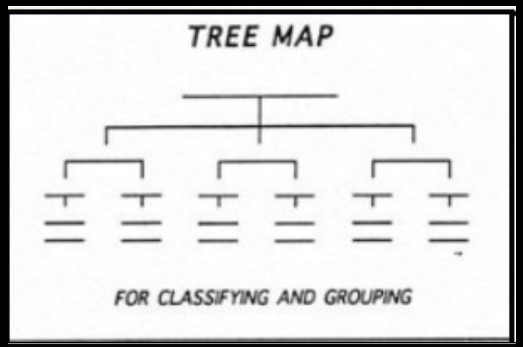
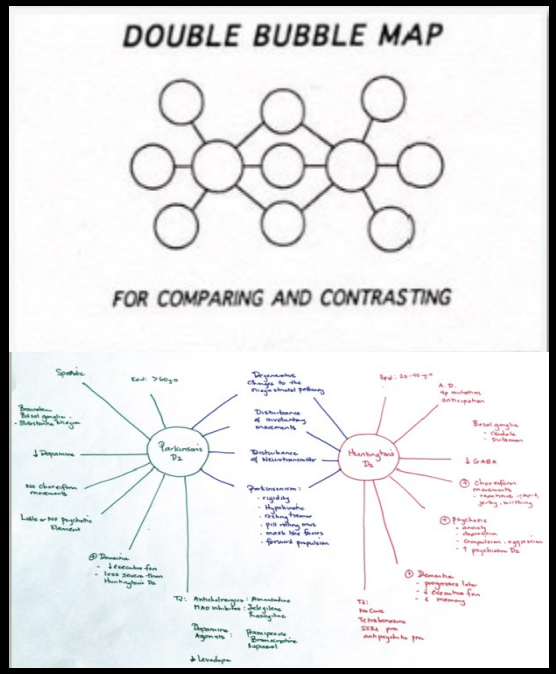
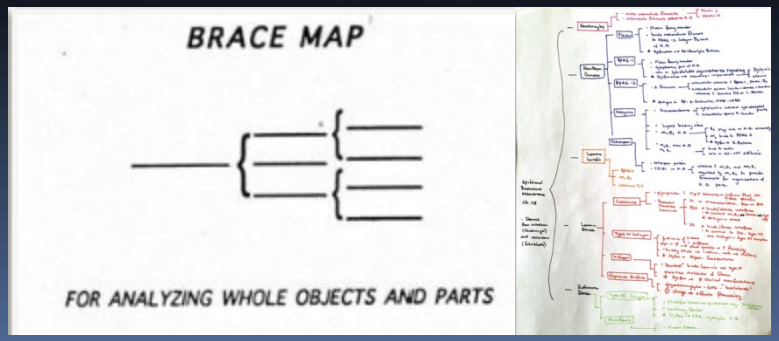

Love

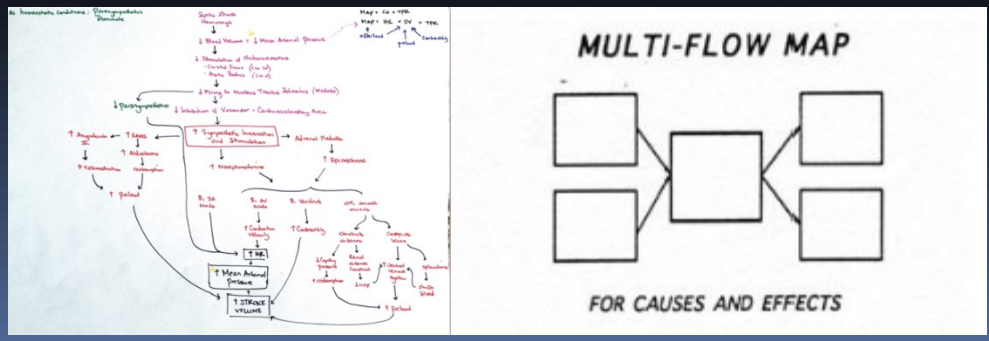
Expanding Your Learning Tool Kit

Organization Frameworks - Thinking Maps®

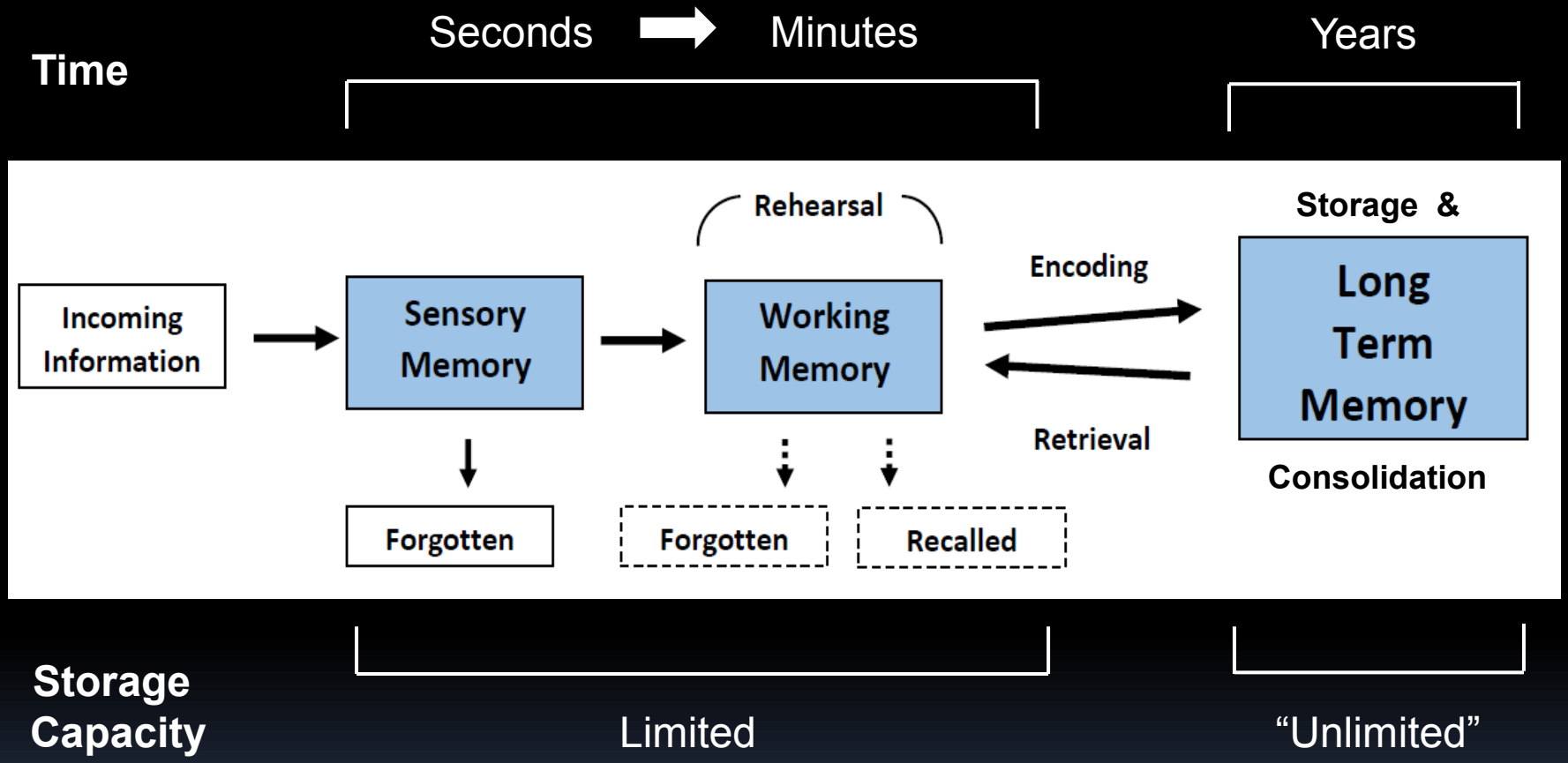








Cognitive Information Processing Theory



Retrieval of Encoded Information

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Proven Methods for Long Term Memory

(Adv Health Sci Educ Theory Pract 2012;17:225-40. and US Department of Education – Institute of Education Sciences: Organizing Instruction and Study to Improve Student Learning)

Retrieval of Encoded & Stored Information

- Testing Effect
- Spacing Effect
- Interleaving Effect

The Science of Learning:

Test Your Knowledge: Science or Illusion

When using practice test questions, long-term memory retention is better with a "recognition" approach or a "recall" approach?

Recognition

Recall

Practice Test Question: **Recognition** Approach

A 34-year old woman has had severe watery diarrhea for the past four days. Two months earlier she had infectious mononucleosis. She abuses drugs intravenously and has antibodies to HIV in her blood. Physical examination shows dehydration and marked muscle weakness.

Laboratory studies are most likely to show:

a) decrease serum K^+ concentration
b) decrease serum Ca^{2+} concentration
c) increase serum HCO_3^- concentration
d) increase serum Na^+ concentration
e) increase serum pH

Practice Test Question: **Recall** Approach

A 34-year old woman has had severe watery diarrhea for the past four days. Two months earlier she had infectious mononucleosis. She abuses drugs intravenously and has antibodies to HIV in her blood. Physical examination shows dehydration and marked muscle weakness.

Laboratory studies are most likely to show:

The Science of Learning:

Test Your Knowledge: Science or Illusion

When using practice test questions, long-term memory retention is better with a “recognition” approach or a “recall” approach?

Recognition

Fact

Recall

Proven Methods for Long Term Memory

(Adv Health Sci Educ Theory Pract 2012;17:225-40. and US Department of Education – Institute of Education Sciences: Organizing Instruction and Study to Improve Student Learning)

Retrieval of Encoded Information

- **Testing Effect**: When studying material *previously learned*, repeated testing of information produces superior retention relative to repeated studying (or rereading).
  - - **Effort Retrieval**: Information is retained longer depending on the ***effort*** required to answer the question.

Proven Methods for Long Term Memory

(Adv Health Sci Educ Theory Pract 2012;17:225-40. and US Department of Education – Institute of Education Sciences: Organizing Instruction and Study to Improve Student Learning)

Retrieval of Encoded Information

- **Testing Effect - Effort Retrieval**: Multiple methods including
  - - Write down everything one thinks they know about a particular topic
  - - Verbal questions from colleague(s)
  - - Flash cards (but **write your own**, <u>not</u> use others)
  - - **Write your own** test questions

Proven Methods for Long Term Memory

(Adv Health Sci Educ Theory Pract 2012;17:225-40. and US Department of Education – Institute of Education Sciences: Organizing Instruction and Study to Improve Student Learning)

Retrieval of Encoded Information

- Testing Effect
- Spacing Effect
- Interleaving Effect

The Science of Learning:

Test Your Knowledge: Science or Illusion

When preparing for exams, is it better to do practice test questions periodically (e.g. every 1-2 weeks) or just before the major exam (i.e. as one major review)?

Periodically **Fact** 1 Major Review

Proven Methods for Long Term Memory

(Adv Health Sci Educ Theory Pract 2012;17:225-40. and US Department of Education – Institute of Education Sciences: Organizing Instruction and Study to Improve Student Learning)

Retrieval of Encoded Information

- **Spacing Effect**: Intermittent studying over time confers better *long-term* memory retention than mass-practicing at a single point in time.
  - *Cramming* may produce short-term gains but the *information is quickly loss*.
  - Combine with the testing effect: Test oneself periodically (rather than all at once) to reinforce long term memory

Curriculum Implication & Recommendation

- Use testing effect not only to assess individual performance but as part of curriculum design to enhance long-term learning by:
- Making all exams comprehensive
- Offer weekly exams
- Test higher order thinking (e.g. open-book exams)

The Science of Learning:

Test Your Knowledge: Science or Illusion

If you had 3 days & 6 hours/day left to study for 3 major subjects, is it better to study 6 hours on one subject each day OR two hours a day on 3 different subjects?

1 subject per day

Fact

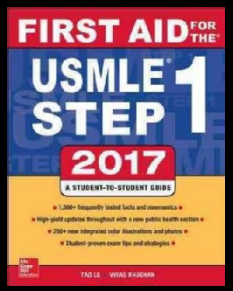
3 subjects per day

Proven Methods for Long Term Memory

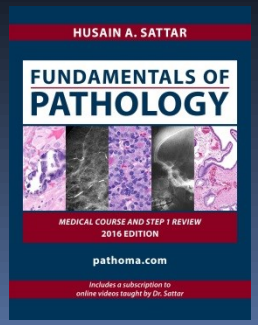
(Adv Health Sci Educ Theory Pract 2012;17:225-40. and US Department of Education – Institute of Education Sciences: Organizing Instruction and Study to Improve Student Learning)

Retrieval of Encoded Information

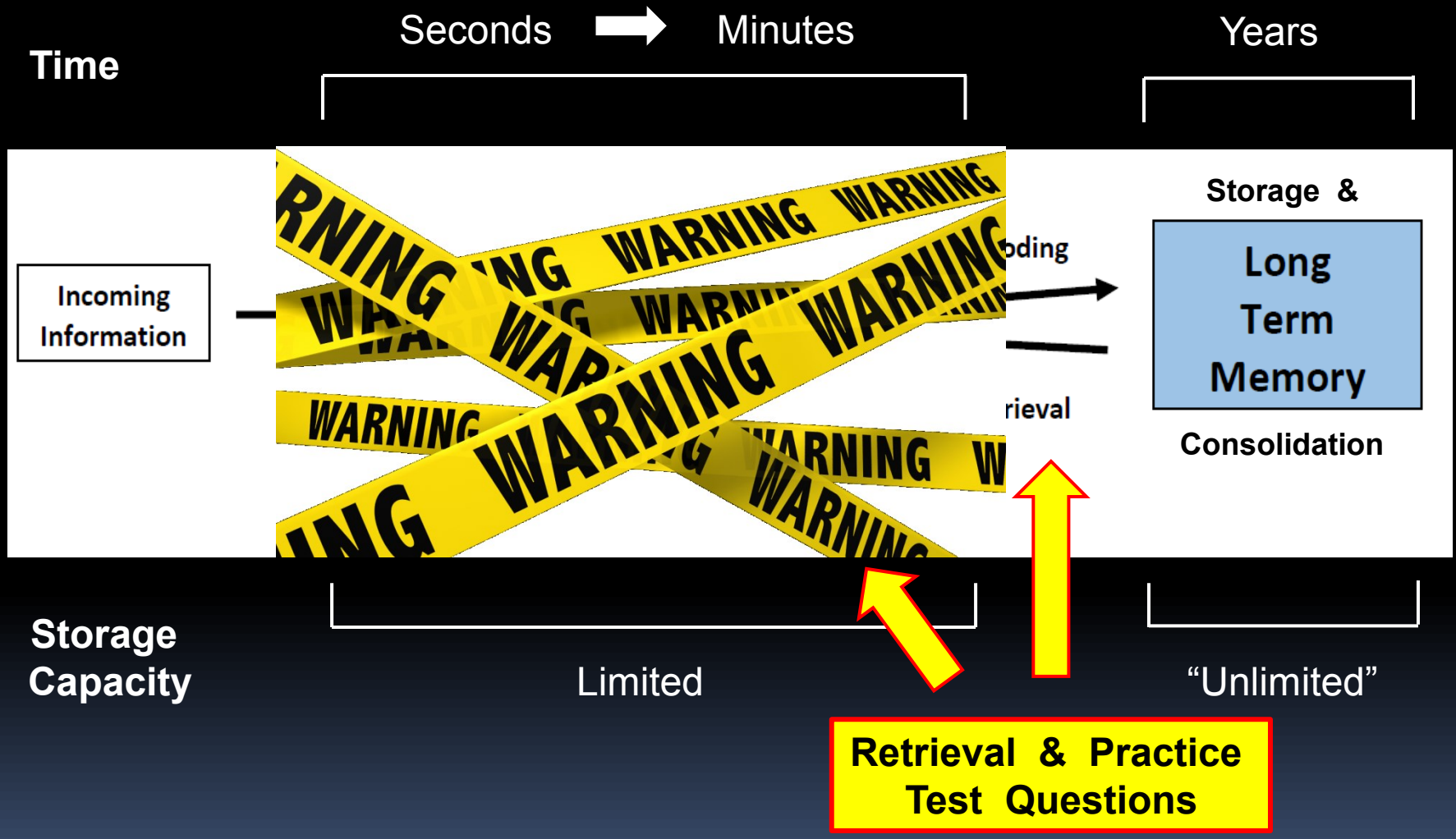
- **Interleaving Effect**: Is it better to study in blocks (one subject at a time until "mastery") or mix subject topics while studying?
  - Surprisingly mixing subjects (or interleaving) reinforces *long term* memory better.
  - Example: If one had 6 hours of study time over 3 days and 3 subjects to study, it is better to study 3 subjects 2 hours per day rather than 1 subject for 6 hours per day.



Testing Effect is for ***retrieval*** of information *already learned*. Testing is ***not*** for ***encoding*** information.



Cognitive Information Processing Theory



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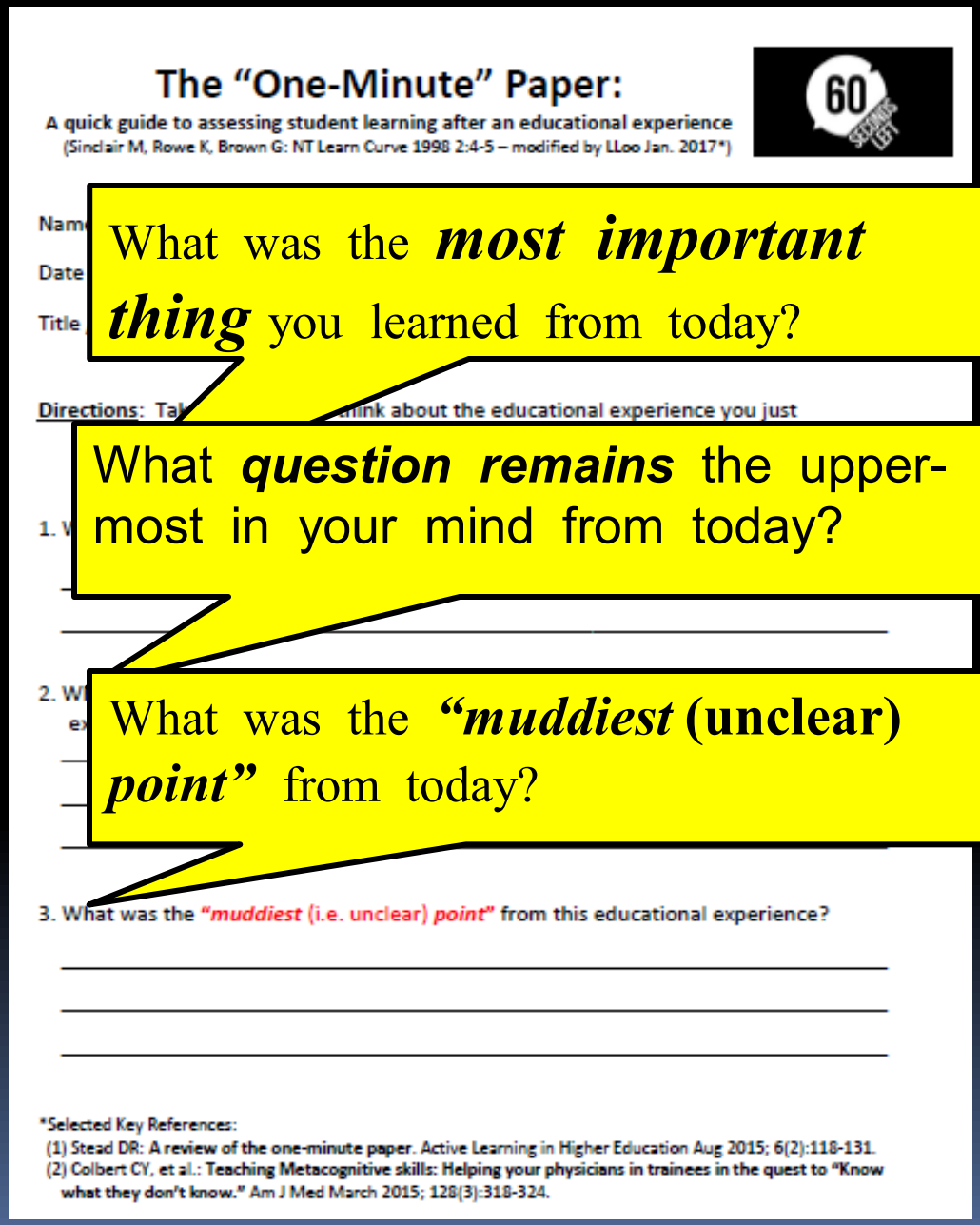
Metacognitive Strategy:

@ end of a course, day, week or month or any educational experience, consider

The One Minute Paper

(Learn Curve 1992:2:4-5)



What was the ***most important thing*** you learned from today?

What ***question remains*** the upper-most in your mind from today?

What was the ***"muddiest* (unclear) *point"*** from today?

Key Points for Long Term Memory Retention

- It is a marathon, not a sprint. Build **habits** of learning.
- Do not confuse **encoding** information with **consolidation** or **recalling** information.
- Very few people (≤ 2%) can actually multi-task well.
- Have a **limited working memory** to encode information into long term memory. Do not multitask / get distracted.
- **Testing reinforces** learning by **recalling** information *already learned*. Test questions do **not** help to encode information.

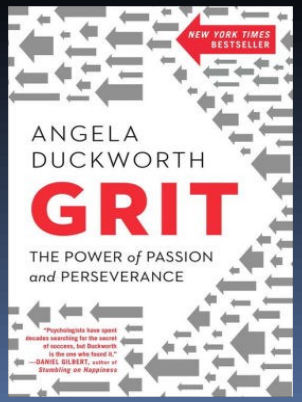
Angela Lee Duckworth (2013): Grit & Growth Mindset

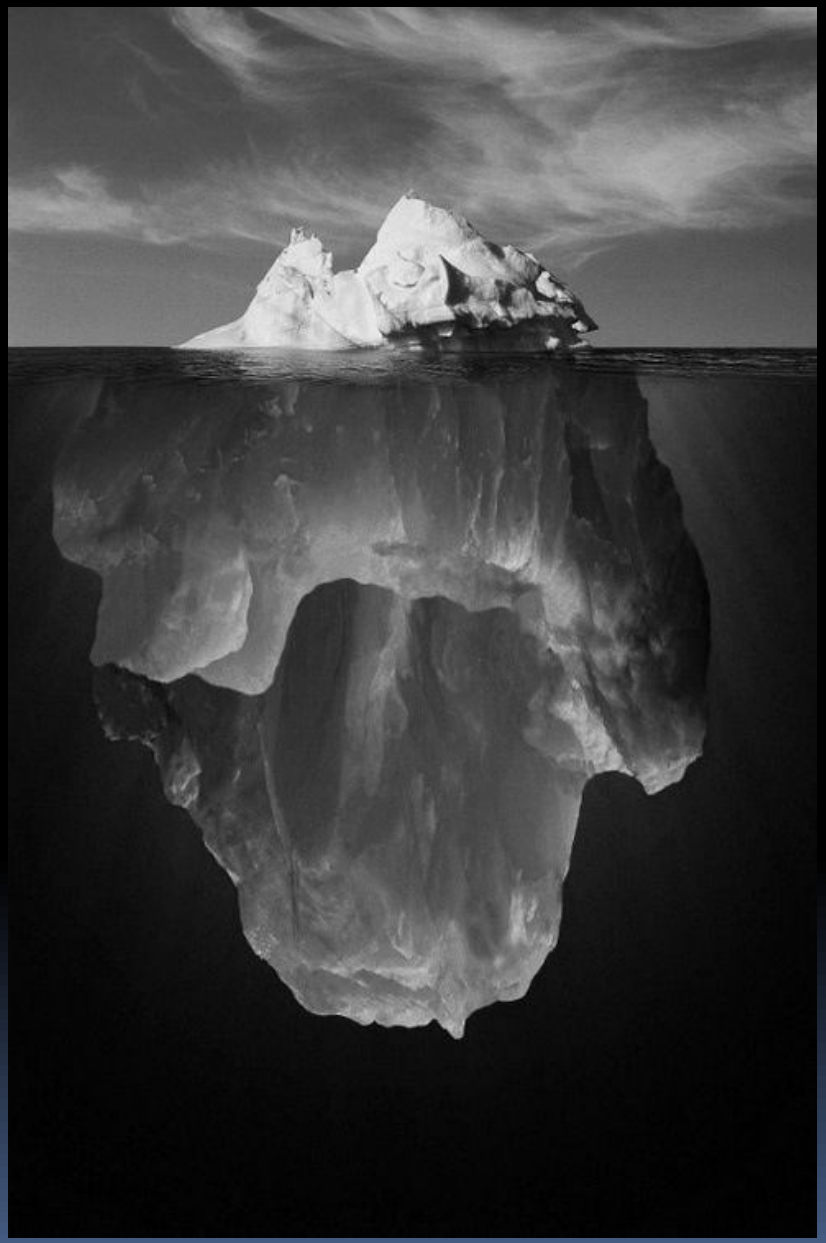
What is "success"?

(The Iceberg Perspective)

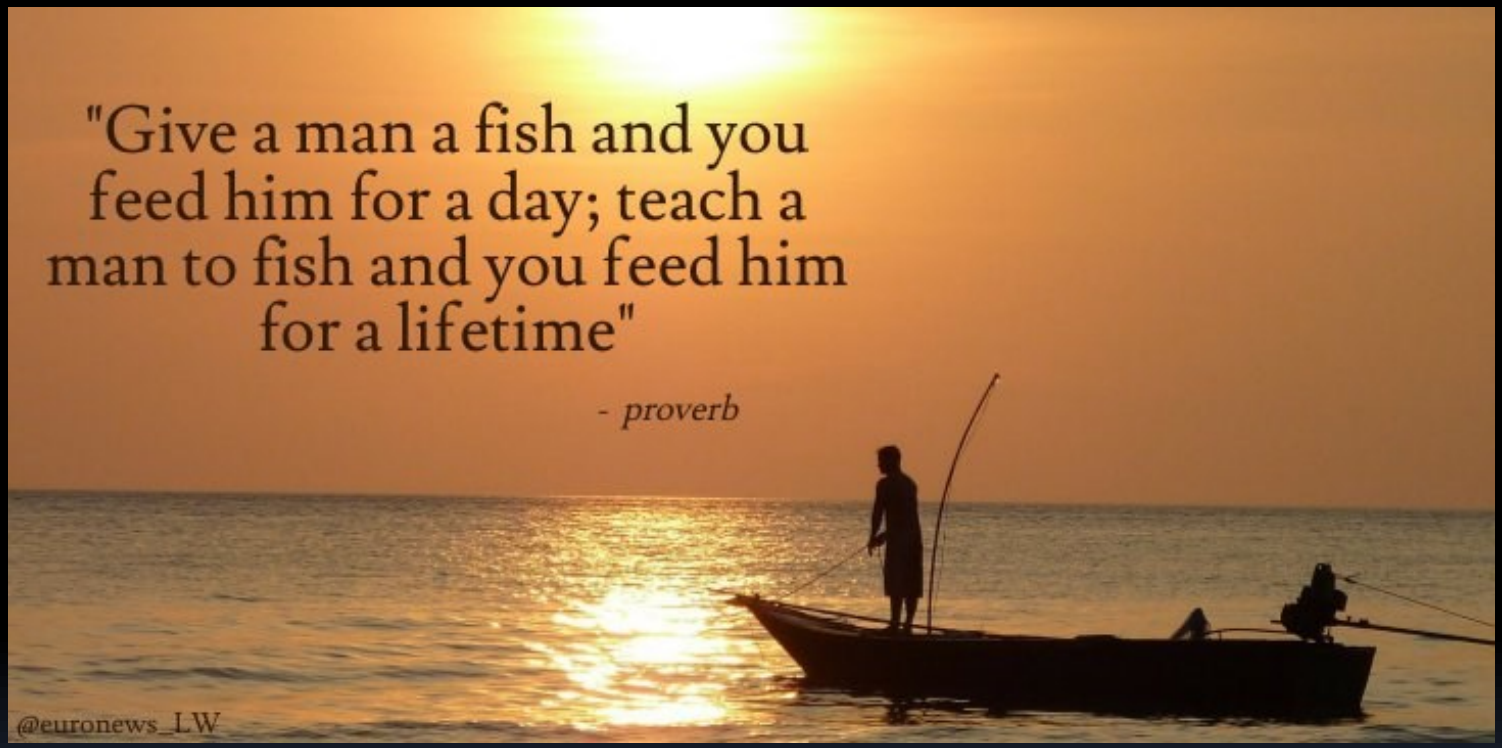
Talent + **Effort** = Skill

Skill + **Effort** = Achievement & Success





LET'S
DO
THIS!


"Give a man a fish and you feed him for a day; teach a man to fish and you feed him for a lifetime"
- proverb
@euronews_LW

! Thank You !