The Science (or Illusions) of Learning
Curricular Implications for Medical Student & Residency Training

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“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.”

“All Relevant Financial Relationships”

NONE

“So, I’m the only one who sees a conflict of interest here?”
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
Growth Mindset

Theory of Self-Regulation

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

? Science or Illusion? 

Edward H. Adelson
The Continuum of Medical Education

UME  Medical School

GME  Residency

CME  Rest of Career

Self-directed Lifelong Learners

4 Years  ~4 (3-7) Years  30+ Years
"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 Half of what you are taught as medical students will in five years have been shown to be either wrong or out of date.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)
## Learning-oriented Teaching (LOT) Model


### How to get a “LOT” out of your conferences:
**Demonstration of the LOT Model**

<table>
<thead>
<tr>
<th>Learning Process Component</th>
<th>Learner’s Concerns</th>
<th>Teachers’ Concerns and Issues</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cognitive Level</td>
<td>Study <strong>what?</strong></td>
<td>Presenting (facilitating the provision of relevant information)</td>
</tr>
<tr>
<td>Affective Level</td>
<td>Why <strong>Study?</strong></td>
<td>Motivating (stimulating students to invest in studying)</td>
</tr>
<tr>
<td>Metacognitive Level</td>
<td>How <strong>to learn?</strong></td>
<td>Instructing (helping students to go about studying)</td>
</tr>
</tbody>
</table>

- 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?

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?

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Performance & Ability Orientation

Effort & Growth Orientation

Relax and take a sedative
Fixed Mindset vs. Growth Mindset

Based on the work of Dr. Carol Dweck

Fixed Mindset

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.

Failure
- Avoid failure
- Desire to Look smart
- Avoids challenges

Challenges
- Desire continuous learning
- Confront uncertainties.
- Embracing challenges
- Not afraid to fail
- Put lots of effort to learn
- Feedback is about current capabilities

Effort
- They don’t change or improve

Growth Mindset

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

Perseverance & Resiliency
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


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

- Learning is deeper & more durable when it is effortful.
Curriculum Implication & Recommendation

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

<table>
<thead>
<tr>
<th>Test Result</th>
<th>Disease Yes</th>
<th>Disease No</th>
</tr>
</thead>
<tbody>
<tr>
<td>True +</td>
<td>(A)</td>
<td>(B)</td>
</tr>
<tr>
<td>False +</td>
<td>(C)</td>
<td>(D)</td>
</tr>
<tr>
<td>False -</td>
<td>(E)</td>
<td>(F)</td>
</tr>
<tr>
<td>True -</td>
<td>(G)</td>
<td>(H)</td>
</tr>
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</table>

**Surface Learning** (promoted by “complete” handouts)

<table>
<thead>
<tr>
<th><strong>Sensitivity</strong> = ( \frac{TP}{TP + FN} ) &amp; <strong>Sensitivity</strong> =</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Specificity</strong> = ( \frac{TN}{TN + FP} ) &amp; <strong>Specificity</strong> =</td>
</tr>
<tr>
<td><strong>PPV</strong> = ( \frac{TP}{TP + FP} ) &amp; <strong>PPV</strong> =</td>
</tr>
<tr>
<td><strong>NPV</strong> = ( \frac{TN}{TN + FN} ) &amp; <strong>NPV</strong> =</td>
</tr>
<tr>
<td>+ <strong>Likelihood Ratio</strong> = ( \frac{Sensitivity}{(1 - Specificity)} ) &amp; + <strong>Likelihood Ratio</strong> =</td>
</tr>
<tr>
<td>- <strong>Likelihood Ratio</strong> = ( \frac{Specificity}{(1 - Sensitivity)} ) &amp; - <strong>Likelihood Ratio</strong> =</td>
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**Deep Learning** (promoted by generation & elaboration)

<table>
<thead>
<tr>
<th><strong>TP</strong> = True Positives</th>
<th><strong>TN</strong> = True Negatives</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>FP</strong> = False Positive</td>
<td><strong>FN</strong> = False Negatives</td>
</tr>
<tr>
<td><strong>PPV</strong> = Positive Predictive Value</td>
<td></td>
</tr>
<tr>
<td><strong>NPV</strong> = Negative Predictive Value</td>
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Explain to a neighbor what each of the terms above means in words (not just writing the formulae).
**Surface Learning**
(promoted by “complete” handouts)

- Sensitivity = \( \frac{TP}{TP + FN} \)
- Specificity = \( \frac{TN}{TN + FP} \)
- PPV = \( \frac{TP}{TP + FP} \)
- NPV = \( \frac{TN}{TN + FN} \)

\[ + \text{ Likelihood Ratio} = \text{Sensitivity} / (1 - \text{Specificity}) \]

\[ - \text{Likelihood Ratio} = \text{Specificity} / (1 - \text{Sensitivity}) \]

**Deep Learning**
(promoted by generation & elaboration)

- Sensitivity = \( \frac{TP}{___ + FN} \)
- Specificity = \( \text{___} / (TN + FP) \)
- PPV = \( \text{___} / (TP + ___) \)
- NPV = \( \text{___} = TN / (TN + FN) \)

\[ + \text{ Likelihood Ratio} = \text{Sen}_\text{iti}_\text{vity} / (1 - \text{Sp_c_ficity}) \]

\[ - \text{Likelihood Ratio} = \text{Specificity} / (1 - \text{Sensitivity}) \]


**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*. 
“Competence is not an achievement but rather a **habit** of lifelong learning.”
Expanding Your Learning Tool Kit
Certain **Learning Styles** (e.g. visual, auditory, kinesthetic, etc.) have been demonstrated to correlate with better academic performance.
Long-term learning is improved when the teacher **matches** the student’s particular learning style (e.g. visual, auditory, kinesthetic).
Today’s millennial learners can multi-task better than their parents’ generation.
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.

<table>
<thead>
<tr>
<th>M</th>
<th>Multitasking is worse than a lie</th>
</tr>
</thead>
<tbody>
<tr>
<td>I</td>
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<tr>
<th>1 2 3 4 5 6 7 ...</th>
</tr>
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<td>1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27</td>
<td></td>
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The Myth of Multitasking

- Following ESPN
- Studying other classes
- Checking Emails
- Texting

Interfering with Sensory & Working Memory
Cognitive Information Processing Theory

Time

Seconds → Minutes

Years

Incoming Information

WARNING

Coding

Storage & Retrieval

Long Term Memory

Consolidation

Storage Capacity

Limited

“Unlimited”

Multitasking

Curriculum Implication & Recommendation

- Turn off the wi-fi in classrooms & lecture halls where learners are attempting to encode information into their working memories.
Which of the following study “methods” is the least effective for long-term memory retention and recall?

A. Reading (and re-reading)

B. Underlining and highlighting

C. Word or picture mnemonics

D. Sleeping

FACT
Familiarity Trap

- Rereading something over and over again will “burn” it into my memory but **familiarity** with the words and syntax is **not** 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?

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C. Word or picture mnemonics

D. Sleeping

**FACT**
The Myth of Multitasking

Promotes

Consolidation & Long Term Memory

Interfering with Sensory & Working Memory

Following ESPN

! Sleeping!

Studying other classes

Checking Emails

Texting
Small Group Exercise #3
Did you use Previewing as a regular study strategy during college?

Yes

NO

No
Cognitive Information Processing Theory

Time
- Seconds
- Minutes
- Years

Incoming Information

Time
- Storage Capacity
  - Limited
  - “Unlimited”

Previewing

Storage & Consolidation
- Long Term Memory

Processing Steps
- Encoding
- Retrieval
- Rehearsal

Memory Stages
- Sensory Memory
- Working Memory

Storage Capacity
- Limited
- “Unlimited”

Individual Exercise #4
Cognitive Information Processing Theory

Time
- Seconds
- Minutes
- Years

Storage Capacity
- Limited
- “Unlimited”

Elaboration & Generation

Previewing

Encoding

Retrieval

Consolidation

Long Term Memory

Storage &

Incoming Information → Sensory Memory → Working Memory

Forgotten

Recalled

Rehearsal

Expanding Your Learning Tool Kit

Organization Frameworks - Thinking Maps®

TREE MAP
FOR CLASSIFYING AND GROUPING

Lung Diseases
Obstructive  Restrictive  Consolidation  PTX  Effusion  Muc.
Chronic Bronchitis  Emphysema  MDA  Dass  Pneumonia  E. coli  Foreign Object  Pigeon Breast

DOUBLE BUBBLE MAP
FOR COMPARING AND CONTRASTING

BRACE MAP
FOR ANALYZING WHOLE OBJECTS AND PARTS

MULTI-FLOW MAP
FOR CAUSES AND EFFECTS
Cognitive Information Processing Theory

Time

- Seconds
- Minutes
- Years

Incoming Information → Sensory Memory → Working Memory

- Forgotten
- Forgotten
- Recalled

Rehearsal

Encoding → Storage & Consolidation

Long Term Memory

Retrieval of Encoded Information

Storage Capacity

- Limited
- “Unlimited”

References:
Proven Methods for Long Term Memory

Retrieval of Encoded & Stored Information

- Testing Effect
- Spacing Effect
- Interleaving Effect
When using practice test questions, long-term memory retention is better with a “recognition” approach or a “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:

a) decrease serum K+ concentration  
b) decrease serum Ca2+ concentration  
c) increase serum HCO3- concentration  
d) increase serum Na+ concentration  
e) increase serum pH
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Recognition

Fact

Recall
Proven Methods for Long Term Memory

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


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, not use others**)
  - Write your own test questions
Proven Methods for Long Term Memory


Retrieval of Encoded Information

- Testing Effect
- Spacing Effect
- Interleaving Effect
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**
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)
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?

Fact: 3 subjects per day
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


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
"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
! Thank You !