The Unified Learning Model

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Acknowledgement

- Based on
  - Shell, D. F., D. W. Brooks, G. Trainin, K. M. Wilson, D. F. Kauffman, and L. M. Herr (2010). *The Unified Learning Model*, Springer.

Introduction

- The ULM is a model of how people learn and a resulting model of teaching and instruction
  - Focuses on the basic processes and components of learning
  - Underlies ALL learning phenomena
- What are the components that underlie all learning phenomena?
  - Working memory
  - Knowledge
  - Motivation

Working Memory

- Centerpiece of ULM
- Where temporary storage and processing of information happen in the brain
  - Example: reciting digits
- The way WM functions dictates
  - How learning happens
  - What instructional methods/techniques facilitate/hinder learning

Knowledge

- Second core component
- Has a two-fold role in ULM
  - Knowledge is the goal of the ULM; purpose or learning is to increase the many facets of our knowledge
  - Knowledge influences how working memory operates; “the prior knowledge effect”: t he more you know about something, the easier it is to learn something new about it
- Knowledge is a process of working memory as well as its product!

Motivation

- Third core component
- One of the most highly researched topics in education
- In ULM
  - Motivation is the impetus for directing working memory to a task; in our case, directing working memory to the task of learning
  - Motivation is an inherent component of WM operation and plays a critical role in effective and efficient allocation of WM to learning

Three Principles of Learning

- ULM is founded on three basic principles of learning
  - Learning is a product of working memory allocation
  - Working memory's capacity for allocation is affected by prior knowledge
  - Working memory allocation is directed by motivation

Three Principles of Learning 2

- The three principles form the foundation for a complete theory of instruction and teaching:
  - Teaching that follows these principles will be effective; teaching that does not will be ineffective

What is Learning?

- Basic answer:
  - Learning is a relatively permanent change in a neuron
- But the biological and chemical processes involved in this change are extremely complex
- Our discussions will skip
  - The Neurobiology of Learning
  - The Operation of the Neuron
  - The Architecture of the Brain

Sidebar

- Nature vs. Nurture – “we can safely say that it is both”
- The macro architecture of the brain is genetic
  - Common to all
- The micro-architecture of the brain is environmental
  - Differences between people are due to differences in micro-architecture
  - The vast majority of these differences in patterns are due to learning

What is Knowledge?

- Is entirely the result of micro-architecture of the brain in the ULM
- Example: mathematics and anatomical region and neural patterns
- The strengthening and weakening of neurons I learning.
  - "Thus, the micro-architecture of the brain and as a result, virtually all of our knowledge is the result of learning."

How Learning Works?

- We receive a tremendous amount of sensory (an internal proprioceptive) input at any one moment
- The knowledge present in a sensory input area is extremely low level
  - E.g., boundary discriminations between light and dark areas
- Sensory areas simply aggregate their specific component pieces into an output that is sent out of the sensory area to the rest of the brain
  - *What is the place called?*

How Learning Works? 2

- What is the place called?
  - The place where this sensory input is sent is *working memory*
- WM
  - Does not have a clearly defined anatomical area;
  - Appears to be a collection of brain regions in the prefrontal cortex along with other structures such as the hippocampus
  - Too much sensory input to deal with at the same time, so a primary function of WM is to choose what of this input will be ignored and what will be processed

How Learning Works? 3

- **Attention**!!
- WM is where, at a given moment in time, we attend to some inputs and not others
  - Sensory input that is attended to in WM is a candidate for being stored in the long-term permanent memory neurons of the brain
  - Transfer: long-term potentiation (maintained over a few hours interval)
  - If the neural pattern does not decay, it activates a neural pattern in the cortical region that produces a permanent memory **trace** of the original input
    - When a trace learning occurs in the cortical neurons, their patterns of connectivity become changed

How Learning Works? 4

- **So what**??
  - Random traces – wouldn't worth much
- When a previously-seen pattern is seen again, WM "recognizes" the pattern as a known and the existing memory is strengthened
  - The pattern matching and activating the neural patterns → retrieval
  - When there are multiple sensory inputs → spreading activation

Regroup

- Learning doesn't happen without WM
- WM has limited capacity
  - We can't attend to all sensory inputs
  - can queue up very few things at once (about four)
  - can attend to only one thing at a time
- WM is the **bottleneck** of learning
- **Centrality** of WM!!

How Learning Works? 5

- **So, what now? Are we stuck with the bottleneck?**
  - **Motivation comes to the rescue!**
- The brain areas associated with WM have substantial connections with the brain areas associated with emotions
  - These emotional inputs can affect attention and how the capacity that WM has is allocated
- Attention requires effort!
  - (Try concentrate on something and only that for 30 seconds …)

How Learning Works? 6

- **Motivation is the psychological construct that is used to describe those things that impel and sustain us in putting forth effort**
- Motivation in WM is derived from emotional inputs as well as from knowledge that has been stored about previous performance, goals, rewards, and ourself
  - These motivational influences determine the effort level that is put into learning

General Rules of Learning

- 1. New learning requires attention
- 2. Learning requires repetition
- 3. Learning is about connections
- Effortless learning: every-day learning
  - like memory for our own day-to-day life: what you ate this morning
- Since school is about deliberately learning specific information and skills, learning in school will be difficult
  - Transferring what you do learn in school to new applications requires even more efforts!

Learning is Learning

- At the level of the neuron, human learning is human learning
- This does not mean that all students learn everything equally
  - Students are certainly motivated by different things and aided by different prior knowledge patterns
  - Instruction an teaching methods may affect learning differently for students
  - No teaching or instructional method produces exactly the same WM allocation or connection to prior knowledge for all students

Discussions

- From agent (meta-)reasoning viewpoint?
- From multiagent-learning viewpoint?