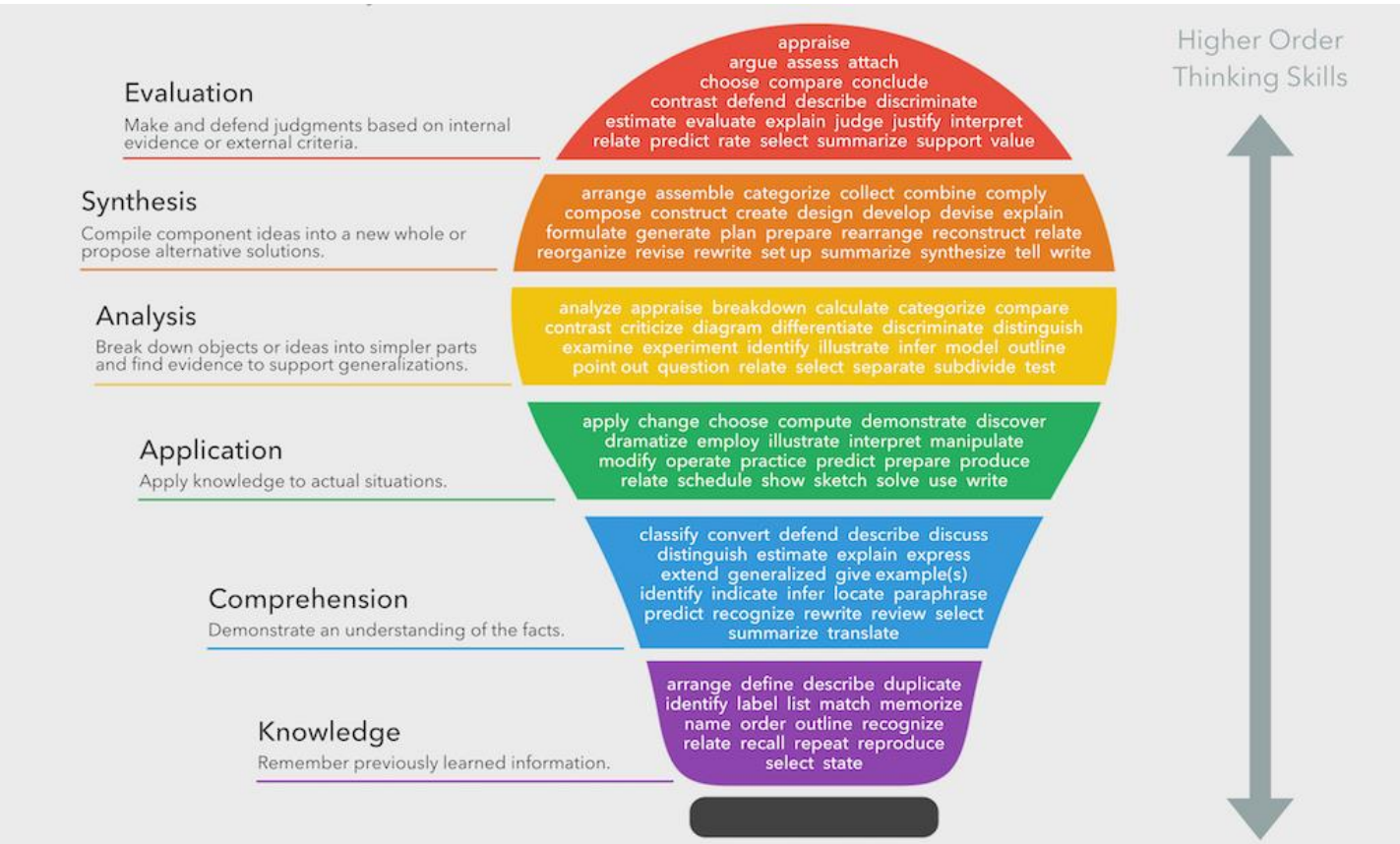
Combined Primers from the 2019 UGA College of Engineering Faculty Learning Community on Theories of Learning

Created and compiled by Dr. John Morelock

Week 1. Bloom's Taxonomy & Kolb's Learning Cycle

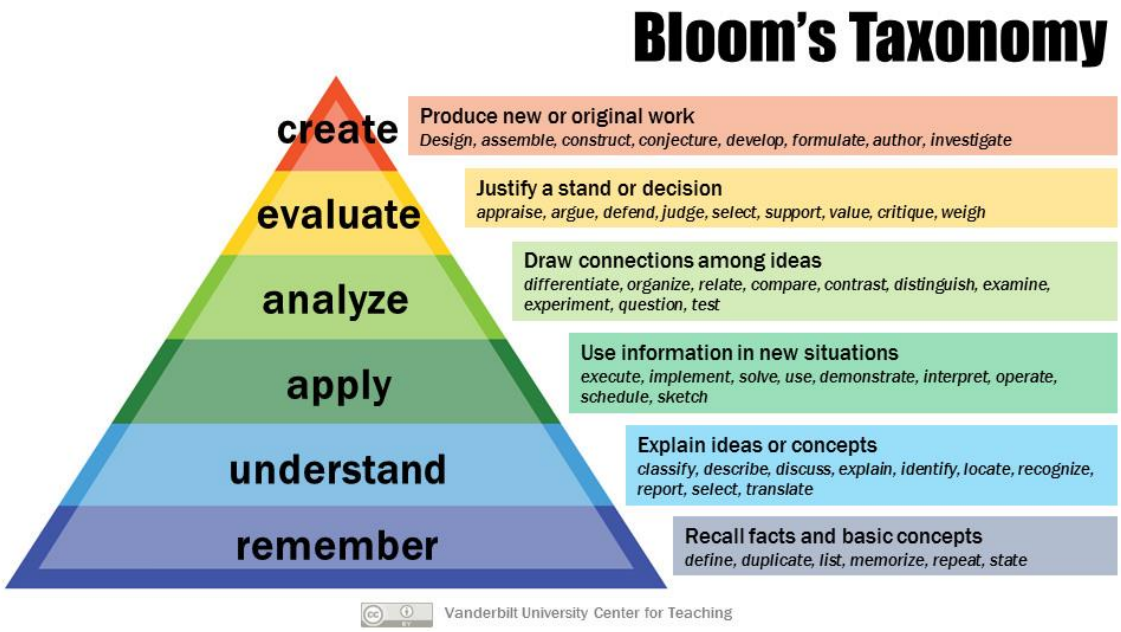
Bloom's Taxonomy

Original Taxonomy. Bloom's taxonomy (created in 1956 by Benjamin Bloom) is a popular and broadly used framework for the design of learning outcomes and related activities. It divides learning outcomes into six "orders," with higher orders representing more advanced levels of learning. If you have ever heard the term "higher order thinking skills," that usually refers to the top three orders of Bloom's Taxonomy. The figure below visually depicts the six orders of Bloom's original taxonomy, including definitions and common "action verbs" used in learning outcomes for each order.



Source: https://www.teachthought.com/learning/what-is-blooms-taxonomy-a-definition-for-teachers/

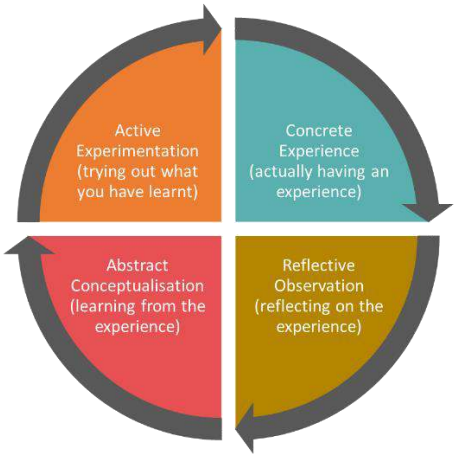
Revised Taxonomy. In 2001, a group of researchers revised bloom's taxonomy to update it for commonly discussed 21st century educational needs. This revised version renames some of the lower-level orders, and replaces the Synthesis order with the Creation order, with Creation being considered above Evaluation as the new top order. The figure below depicts the revised taxonomy. The original taxonomy is still in use, but the revised taxonomy is increasingly becoming more popular.



Source: https://cft.vanderbilt.edu/guides-sub-pages/blooms-taxonomy/

Kolb's Learning Cycle

In 1984, David Kolb created a learning framework that involve two components: An experiential learning cycle that he proposed for how people learn through experience, and a set of four learning styles that articulate which phases of the learning cycle learners prefer to engage. While his learning styles have been controversial among the educational research community, his learning cycle is still commonly used for experiential learning activity design. Using Kolb's Learning Cycle, educational designers propose that experiential learning activities should have four phases: (1) a concrete experience related to the desired concept of interest, (2) a reflection on that experience, (3) a conceptual abstraction of that experience to infer general principles about the concept of interest, and (4) active experimentation to test if that abstraction holds true. While you can feasibly start an activity in any of the four phases, all phases would be included in the appropriate order. The figure below visually illustrates Kolb's Learning Cycle.



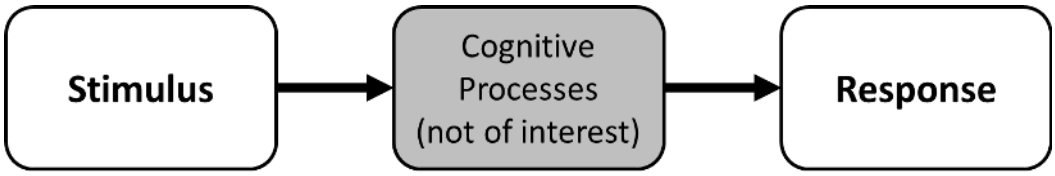
Kolb's Learning Cycle (1984)

Source: https://www.inspiring.uk.com/how-to-create-effective-learning-within-your-organisation/kolbs-learning-cycle/

Week 2. Overview of Learning Paradigms

Behaviorism

Behaviorism is one of the oldest learning theories, originally pioneered by Ivan Pavlov at the turn of the 20th century and advanced by several researchers throughout the 1900's, most prominently B. F. Skinner. It posits that learning occurs through associating a particular stimulus with a particular response. This association often comes from repeated exposure to a particular stimulus, with rewards or punishments administered for particular responses. In behaviorism, what goes on in the learner's head to translate the stimulus into a response is a black box that is largely irrelevant; the stimulus and response themselves are what matter. The figure below depicts behaviorist learning theory in a nutshell.



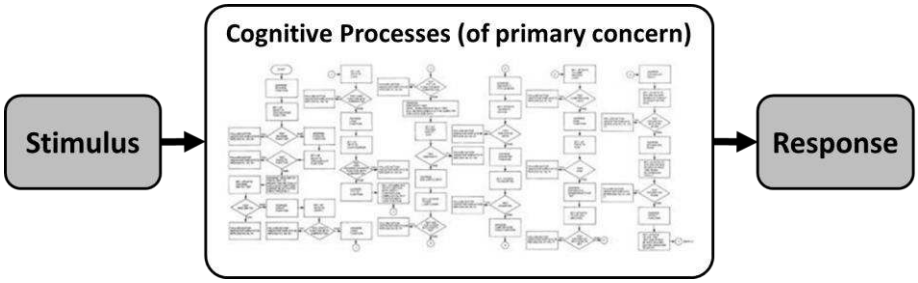
Behaviorism is largely frowned upon by the educational research community today, but still persists in some elements of educational practice. In engineering education, examples of behaviorism in action are online systems that allow students to practice solving mathematical problems and provide students with immediate feedback regarding whether their solution is right or wrong. Consistent with the behaviorist learning paradigm, these systems measure learning not by students' cognitive processes or solution procedures, but solely whether they offered the correct response (the right answer) for the given stimulus (the problem.)

Cognitivism

Cognitivism began as a learning theory when people got curious about the black box of cognitive processes that allowed people to translate stimuli into responses. While cognitivism emerged from many researchers' works, perhaps the most influential contributor was Jean Piaget, who in the 1930's observed and documented distinct levels of cognitive development in children. In the cognitivist learning paradigm, of prime concern is how people understand things, rather than how they respond to stimuli. Accordingly, the goals of cognitivist pedagogy are to help student develop effective mental models of concepts and develop expertise in a discipline.

Several subtheories have spawned under cognitivism. The most prominent subtheory is **constructivism**, which posits that all knowledge is constructed on top of a learner's prior knowledge and prior understanding of the world. From a constructivist perspective, the goal of instruction is to help learners make meaning of new concepts and information by helping them connect this new material to their prior understanding of the world. Another prominent subtheory is **information processing theory**, which seeks to explain how people translate new stimuli into long-term memory for later retrieval. From an information processing perspective, the goal of instruction is to present new material in a way that minimizes cognitive workload and makes it easy for learners to translate that material into long-term memory.

The figure below summarizes the focus of cognitivism.

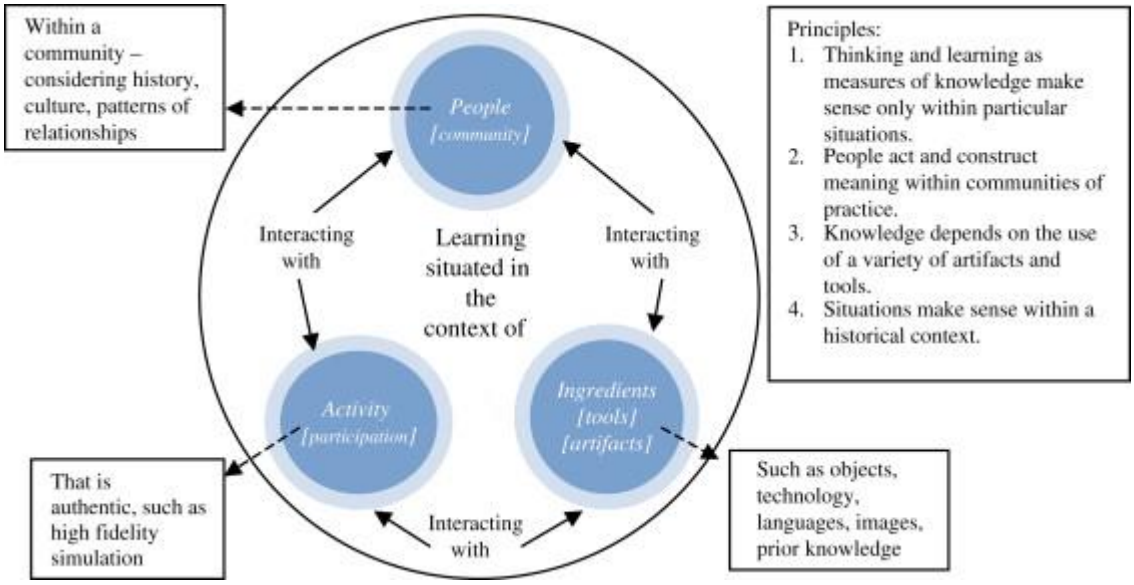


Flowchart image from: https://lockerdome.com/6373415921665601/6373443436299796

Cognitivism is the most popular learning paradigm in educational research today, and the basis for most contemporary educational psychology work. Examples of cognitivist instructional practices abound in engineering instruction. For instance, most colleges structure their curriculum using a prerequisite model, positing that students should have a certain level of prior knowledge before taking a particular course—this is fundamentally a constructivist way of thinking. As another example, many engineering instructors offer study guides to students or allow students to bring an equation sheet into tests, which (from an information processing perspective) reduces students' cognitive workload and allows them to focus on the most important material when studying.

Situative Learning

While cognitivism is useful in creating designed learning experiences in formal educational settings, it is less useful in examining how people learn in informal learning settings, such as a job in industry. Thus some researchers founded situative learning theory (sometimes called "situated learning") as a way to explaining how people learn in informal settings. Situative learning is based largely on the **community of practice** model proposed by Jean Lave and Etienne Wenger in the 1980's, which posits (among other things) that people tend to learn the practices of a particular community through increasingly active participation in that community. From a situative perspective, learning is context-dependent and strongly rooted in the practices of a specific discipline or community. Learning occurs through interacting with people and artifacts within that community or discipline, via activities that authentically represent the kind of work that community performs. The images below offers a poignant summary of situative learning.



Source: https://www.sciencedirect.com/science/article/pii/S1876139909001443

While situative learning is as widely leveraged in educational research or practice as cognitivism, examples exist in engineering education wherever students are encouraged to *do* engineering as part of the curriculum. For example, some project-based learning approaches attempt to simulate real-world engineering work, allowing students to engage in the practices of disciplinary engineering communities and utilize engineering tools. Senior design programs that partner with industry and community-based service learning programs are other great examples of situative learning in action.

Week 3. Constructivism

Constructivism

Constructivism is less a learning theory and more a philosophical stance on the nature of our relationship with reality that has important implications for learning. Constructivism emerged as a response to the enlightenment-era stance that objective reality exists and can be fully understood through scientific inquiry. Instead, constructivist philosophy asserts that objective reality exists, but we can never fully understand it. Rather, all of the knowledge and models we generate through scientific inquiry are **models of reality** that fit our observations and our useful for our goals (e.g., the goal of being able to predict how the world behaves.) From a constructivist perspective, knowledge should never be viewed as "true" and unchanging, but rather as **representative** of human observations, **useful** in achieving societal goals, and **subject to change** as new observations become possible.

From a learning perspective, constructivist perspectives can help students **build a sense of authorship** in creating knowledge. In other words, students can come to see knowledge not as a set of objective facts that they have to know and understand, but as a system of models that humans have created to understand the world and advance society over several centuries. When students come to understand knowledge as malleable and goal-driven, they can more easily grasp the purpose and significance of new things they learn, and they can more easily envision their role in shaping knowledge in the future (whether that be through academic research, or through developing goal-driven models in industry.) Knowledge becomes less a chain of facts and more a story of human development across the centuries that is still being authored today.

Constructivism also have important implications for teaching, as it asserts that all knowledge is **built upon experience** (observation) and **created for a purpose**. Accordingly, constructivist teaching prioritizes providing learning activities that allow students to experience concepts first-hand (a lab, a demonstration, a connection to a common real-world observation, etc.), and provide goals that knowledge of the concept would help them achieve (a problem to solve, a project to complete, etc.)

There are multiple kinds of constructivism, but two stand out in terms of implications for learning: **radical constructivism** and **social constructivism**. The figures on the next page illustrate the fundamental philosophies of these two kinds of constructivism (based on my understanding), and contrast them to enlightenment-era objectivism.

Figure 1: Enlightenment-era objectivism. Objective reality is totally observable, and those observations become knowledge. Knowledge is something that is out there waiting to be "discovered."

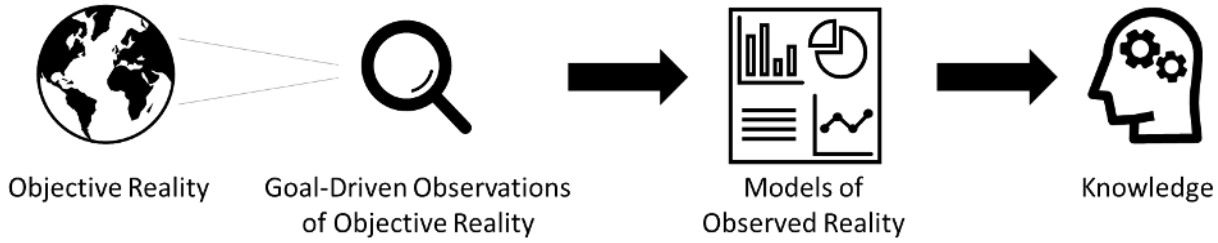


Figure 2: Radical constructivism. Objective reality exists, but our observations of it are limited and driven by goals. We construct mental models of how the world works based on these observations, which comprise our knowledge of the world.

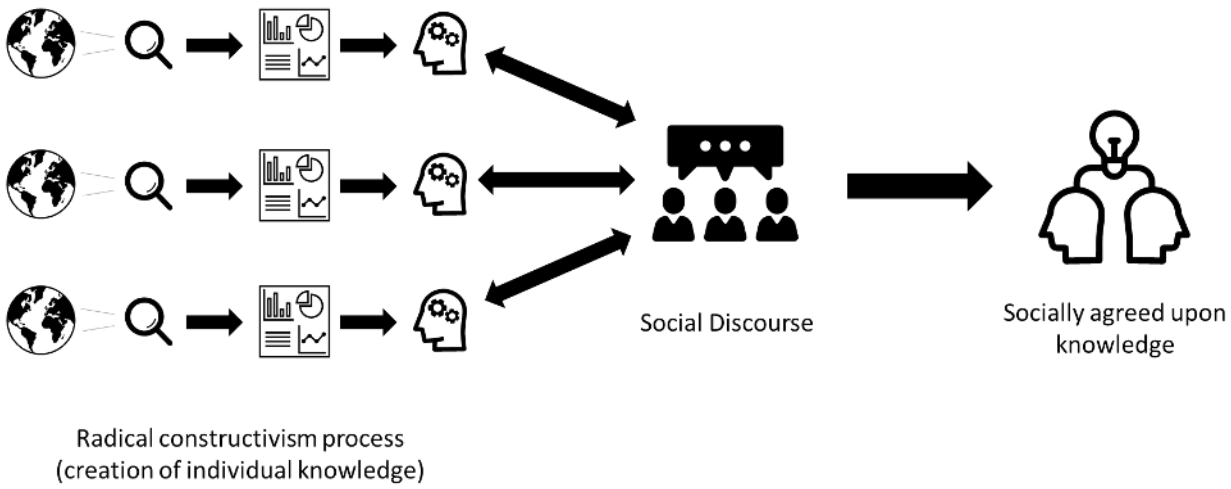


Figure 3: Social constructivism. Knowledge is still individually constructed (as in radical constructivism), but is also modified through social discourse with others who bring different mental models to the conversation. This discourse is how people collectively arrive upon socially accepted models of the world (e.g., evidence-based concepts.)

Week 4. Situative Learning

Situative Learning

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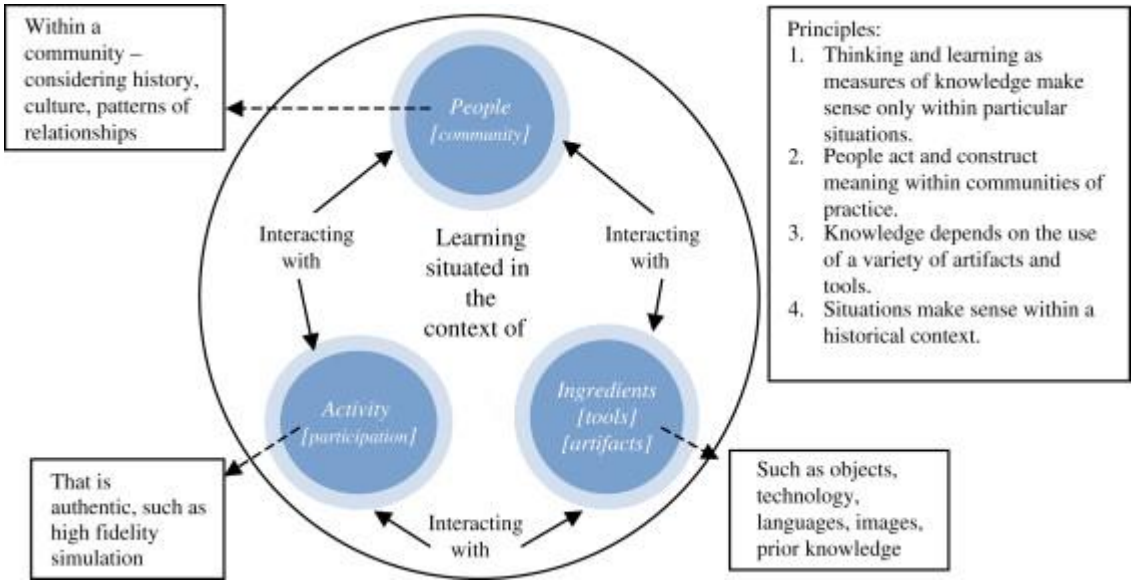

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Week 5. Information Processing Theory

Information Processing Theory

Information processing theory deals with the features and limitations of how our brains process information, which has implications for a wide range of fields, including human factors engineering, psychology, and education. The theory was designed over 60 years ago by psychologists for use in psychological experiments, and thus its development over past several decades has left an enormous trail of empirical literature in its wake. Below is a diagram presenting a simplified (but useful) representation of how information processing occurs, according to the theory.

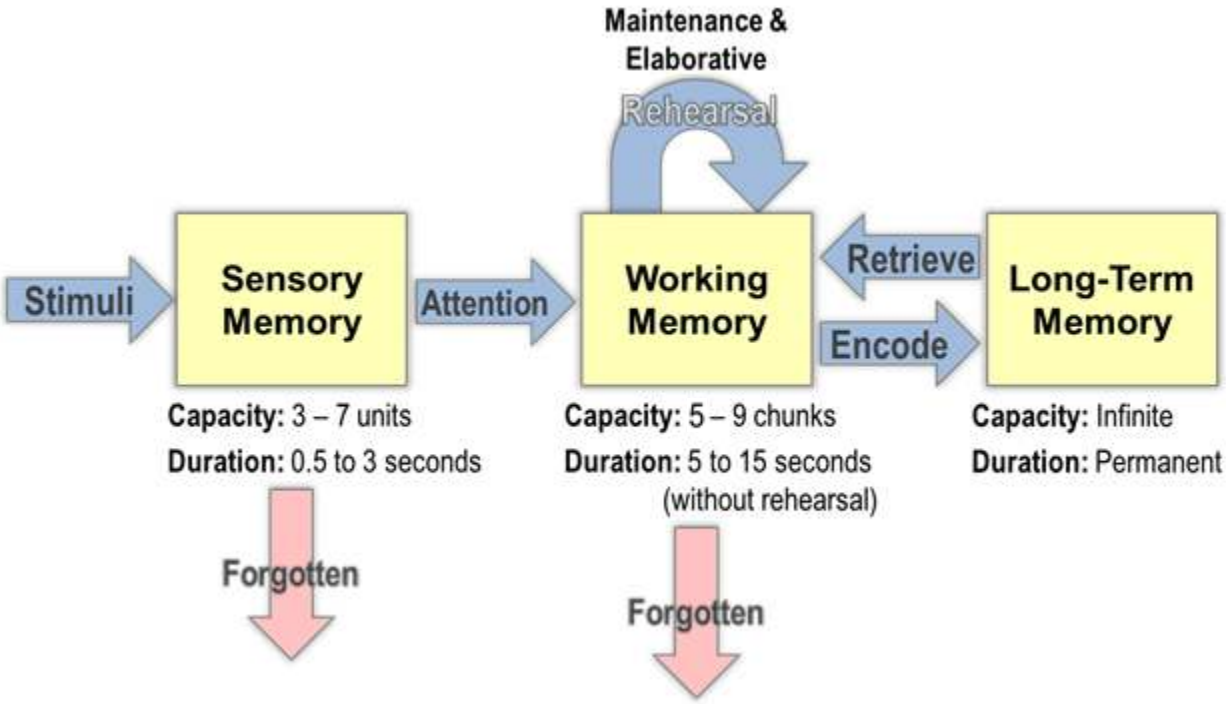

Image adapted from: https://dataworks-ed.com/blog/2014/07/the-information-processing-model/

There are a few key points not captured clearly by the reading, and I have summarized these below.

What it means to learn

According to Information Processing Theory, learning happens in two ways. The first kind of learning is the acquisition of **declarative knowledge**, which is knowledge about events, things, concepts, etc. It encompasses all of the facts and models of the world that could be recalled and recited to others. Learning declarative knowledge involves the translation of new information from short-term memory to long-term memory, and Information Processing Theory focuses on ways to do that most efficiently.

The second kind of learning is the acquisition of **procedural knowledge**, which is knowledge about how to do something. This knowledge contrasts with declarative knowledge in that it is **implicit**; we know how to do it, but we cannot readily recite the procedure to someone without converting it to declarative knowledge (imagine tying a shoe – you know how to do it instinctively, but you would likely have to think about how to explain it to someone.) Learning procedural knowledge involves developing **automaticity** in a task through repetition, such that fewer mental resources are needed to perform it.

Working memory capacity

The reading discusses how a given person can hold 7 ± 2 chunks of information in working memory (working memory capacity.) What it does not discuss is that **educational psychology has not found a way to increase working memory capacity for general tasks**. This means who approaches a new task with a working memory capacity of 5 chunks is inherently at an information processing disadvantage compared to someone who approached that task with a working memory capacity of 9 chunks. It is possible to increase working memory capacity for specific tasks (out working memory capacity increases as our relevant prior knowledge increases), but initial capacity for a task will vary greatly from student to student. Accordingly, working memory capacity becomes an issue of **diversity and inclusion**, recognizing that some students inherently take longer to process new information in a given domain than others.

Long-term memory capacity and retrieval

The reading correctly states that, as far as we know, long-term memory has unlimited capacity and duration. Why, then, do we often have trouble remembering things from decades past that we used to know very well? The answer, information processing theory posits, is that **our retrieval of long-term memories is imperfect**. Certain memories are easy to retrieve; events that happened recently (what did you have for breakfast this morning?) or events that you consider very important (e.g., those coupled with strong emotional reactions) can be recalled with more ease than memories that are older or fail to stand out as significant. However, the longer a memory goes without being retrieved, the harder it is to recall that memory with substantial detail and accuracy. It is easy to misremember an event given enough passage of time (especially when false details are implanted by someone else—a major problem in eyewitness accounts in courtrooms), or do not recall knowledge in enough detail to apply it to a new situation. As educators, this means we cannot assume the prior knowledge students bring into our classes is easily retrievable; often, that knowledge is several months old. We can help them prime that knowledge for use in our classrooms by including exercises that refresh their memories with more recent experiences.