Key Ideas from the Literature: How People Learn

(A) The Brain System and Prior Knowledge

Scientists have identified different kinds of memory in humans, including long-term memory and working memory.

- We are conscious of and can monitor only the contents in our *working memory* (*1*). Working memory is used to process information, such as organizing, contrasting, comparing, or working on information in some manner. Such mental tasks may include language comprehension (e.g., keeping in mind ideas from a sentence to be combined with ideas later in that same reading); problem solving (e.g., remembering the price and number of items to calculate the per-unit cost of an item when comparison shopping); and planning (e.g., figuring out the order and route for picking up your children when timing that task with dinner and extracurricular activities). The capacity of our working memory is limited. It's capable of holding only about 5–9 items of information at one time (the average is 7) (*2*), and that diminishes to about 2–3 items when we're *processing* information, because interactions between items held in working memory takes more capacity (*1*). That said, limitations in working memory only apply to *new information obtained through sensory input*, i.e., vision, hearing, touch, etc. (*3*). There are no known limitations on working-memory capacity when dealing with information retrieved from long-term memory (*4, 5*).

- Long-term memory consists of a large, relatively permanent collection of information. This information is organized and stored in the form of *mental models* (*schema*) and can be retrieved and used automatically with little, if any, mental effort. Scientists call this effortless process *automation* (*3*). For example, driving involves attending to and processing many mental and physical tasks simultaneously (checking mirrors, signaling, knowing rules of the road, etc.); these tasks get organized and automated over time and with practice. Even highly complex mental models can be treated as a single item in working memory—or not require working memory at all (e.g., concurrent driving tasks that have become automated = one item: driving). Schemas vary in their degree of complexity and automation. They reduce strain on working-memory capacity, because expertise comes from knowledge stored in these mental models, not from engaging in reasoning using the many unorganized elements in long-term memory (*3*). Expertise develops as learners mindfully organize and connect simple ideas into more complex ones. If nothing has been changed in long-term memory, nothing has been learned in an enduring way (*5*)

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Key Ideas from the Literature: How People Learn *(continued)*

- Mental models constructed from prior knowledge and experiences dictate how new information is processed and organized in working memory (*3*). For example, when we don't have a schema for a language foreign to us, we might not hear where one word ends and another begins. Mental models enable an expert chess player to recognize a particular mid-game position at a single glance, while a novice player only sees an unstructured set of single chess pieces. If there is no prior knowledge (no existing schema), then we organize the new information randomly. That randomly organized information needs to be tested for soundness and effectiveness as we begin to build a mental model. In other cases, prior knowledge may exist but be incomplete or poorly organized, and new information may or may not "fit" into the existing mental model. In both cases, working-memory capacity is required for processing the new information.

- Prior knowledge exists not only at the level of "concepts," but also at the levels of perception, focus of attention, procedural skills, modes of reasoning, and beliefs about knowledge (*6*). Learners' prior ideas, their "common sense" and "everyday thinking," are intelligent and useful. If those ideas are not engaged, learners are liable to dismiss new learning as irrelevant (*7*).

(B) Conversations and Social Activities

Opportunities to externalize and reflect on one's thinking facilitate learning, especially of complex science concepts.

- *Externalizing* refers to expressing one's evolving understanding, whether by writing, talking, or drawing; it creates opportunities for learners to share their unformed ideas with others (*8*). *Reflection* is the act of thinking about the process of learning and thinking; it's an opportunity to detect inconsistencies in one's thinking and identify connections between areas of conceptual understanding (*9, 10*).

- Students from K–12 to university show greater understanding when they engage in collaborative dialogue with peers, in which they a) provide explanations to bolster their arguments and justifications, and b) seek and provide help (*11–14*). Students given the opportunity to talk, argue, and defend their ideas in small groups have shown positive changes in their understanding of difficult and complex concepts such as evaporation (*15*) and climate change (*16*).

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Key Ideas from the Literature: How People Learn *(continued)*

- Learning occurs in a complex social environment. Understanding how people learn should not be limited to what happens solely on an individual level. Learning is a social activity. It involves people, the things they use, the words they speak, the cultural context they're in, and the actions they take (*17, 18*). Members taking part in the learning activity build knowledge together (*19*).

- Learning opportunities situated in everyday experiences provide learners with a *reason* to understand (*20, 21*). Contextual learning generates memories within a retrievable frame of reference, which in turn facilitates application of prior knowledge and experiences to new situations (*22*). Authentic contexts help learners form connections between new and old information, which leads to better, larger, and more associated conceptual understanding (*23–25*).

- Families, friends, peer groups, and larger social networks are all units of learning, and also constitute significant contexts in which learning occurs (*17*). These units and contexts support social interactions that may occur in different, interdependent ways, such as imitation, collaboration, and instruction.

  - Imitation—learning from watching other people—is ubiquitous among humans across the lifespan (*17, 26*).

  - Collaboration—learning from working with people—is a coordinated, synchronous activity that results from (and in) a continued attempt to build a common understanding of an idea or a problem (*27*). The emerging understanding is a product of the group (*28*).

  - Instruction—learning through guidance from an adult, peer, or other conversant individual—is the process whereby more knowledgeable individuals help less experienced learners make meaning of new experiences (*29, 30*).

(C) Engagement in Learning

Learners must expend considerable mental effort and persistence in order to learn complex ideas deeply. Such commitment requires various types and levels of engagement.

- Engagement is presumed to be malleable, because it can change depending on the situation and circumstances. (*31*). Engagement is neither fixed nor permanent.

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Key Ideas from the Literature: How People Learn *(continued)*

- Engagement is multi-dimensional because it's an interaction between the individual and his or her environment. There are three types of engagement:

  - <u>Behavioral engagement</u> refers to the *ways in which learners participate* in learning experiences (*31*). The concept includes learners' conduct (e.g., showing up and adhering to rules of the environment) and levels of involvement in tasks (e.g., attention, concentration, effort, and contribution).

  - <u>Emotional engagement</u> refers to *learners' affective reactions* to (their feelings and emotions about) the learning context. This may be influenced by their interactions with the people and context involved, their interest in the subject matter, and/or how they value the subject matter (*31*). "Value" may be intrinsic (e.g., interest in the topic), functional (e.g., perception of how tasks are related to future goals and life), or attainment-oriented (e.g., personal importance placed on the task).

  - <u>Cognitive engagement</u> refers to *learners' psychological investment in (motivation for) learning*, and also the *cognitive learning strategies (methods) they employ* (*31*). It incorporates thoughtfulness and willingness to exert the effort necessary to understand complex ideas and master difficult skills.

    - Motivation to participate may a) be affected by learners' feelings about the role of competence in being able to succeed (e.g., either believing that abilities are learned and can be developed, or assuming that abilities are innate and cannot be changed), and b) be driven by their learning goals (e.g., in order to either master the task and achieve understanding, or to perform well and accomplish the task).

    - Learning strategies include <u>cognitive</u> (e.g., memorize, elaborate, connect, and organize ideas); <u>metacognitive</u> (e.g., set goals, plan, self-monitor, evaluate progress, and make adjustments); and <u>volitional</u> (e.g., manage attention, affect, and effort in the face of distractions)

    - Motivation can lead to achievement by increasing the quality of cognitive engagement. Conceptual understanding and skills are enhanced when students are committed to building knowledge and using deeper learning strategies (*25*).

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