Key Ideas from the Literature: How People Learn

The Brain System & Prior Knowledge

- Humans are conscious of and can monitor only the contents in our working memory (Sweller, Van Merrienboer, & Paas, 1998), which is capable of holding only about 7 items of information at once (Miller, 1956). Working memory is used to process information, such as organizing, contrasting, or working on information. We process ~2-3 items of information simultaneously because any interactions between items held in working memory requires working memory capacity, which in turn reduces the number of items that can be dealt with concurrently (Sweller, et al., 1998). Limitations in working memory likely only apply to novel info obtained through the senses (Van Merrienboer & Sweller, 2005), as there appears to be no known limitations when dealing with information retrieved from long-term memory (Sweller, 2003, 2004).

- Information is stored in long-term memory in the form of mental models (Van Merrienboer & Sweller, 2005). These models organize and store knowledge, and vary in their degree of complexity and automation. Expertise comes from knowledge stored in mental models. Mental models also reduce strain on working memory because even highly complex mental models can be treated as one item in working memory.

- Thus mental models, which are constructed from prior knowledge and experiences, direct how new information and knowledge is processed and organized in working memory (Van Merrienboer & Sweller, 2005). These 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 to organize new information, it is organized randomly and then the organization tested for effectiveness. Prior knowledge may have also been organized poorly or ineffectively, and thus new information may or may not fit. This situation, in turn, also strains working memory to process and organize new information into existing mental models.

- 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 (Roschelle, 1995). Learners' prior ideas, their "common sense," and "everyday thinking," are intelligent and useful. If those ideas are not engaged, learners often dismiss science teaching as irrelevant (Hammer & van Zee, 2006, p. 14).

Conversations & Social Activities

1. The opportunity to externalize and reflect on one's thinking facilitates learning, especially complex science concepts. Externalizing is written or verbal articulation of ones' evolving understanding, which allows learners the opportunity to share their unformed ideas with others (Sawyer, 2006). Reflection is the act of thinking about the process of learning and thinking, as a means to detect inconsistencies and help to identify connections between areas of conceptual understanding (NRC, 2007; Davis, 2003).
    a. Students (K-university) show greater understanding when they engage in collaborative dialogue with peers where they provide explanations as part of arguments and justifications, and seek and provide help (Mercer et al., 2004; van Blankenstein et al., 2011; Veenman et al., 2005; Venville & Dawson, 2010). Students given the opportunity to talk, argue, and defend their ideas in small groups showed positive change in their understanding of complex concepts, like evaporation (Tytler & Peterson, 2000) and climate change (Mason & Santi, 1998).
2. Learning occurs in a complex social environment, and thus should not be limited to being examined or perceived as something that happens on an individual level. It is a social activity involving people, the things they use, the words they speak, the cultural context they're in, and the actions they take (Bransford, et al., 2006; Rogoff, 1998), and members in the activity build that knowledge (Scardamalia & Bereiter, 2006).
3. Learning opportunities situated in everyday experiences provide learners with a reason to understand (Greeno, 2006; Kolodner, 2006). It generates memories with a frame of reference, which facilitate retrieval and application of prior knowledge and experiences to new situations (Kolodner et al., 2003). Authentic contexts help learners form connections between new and old information, which lead them to develop better, more associated conceptual understanding (Blumenfeld, et al., 2006; Kolodner, 1993; Schank, 1982).
4. Families, friends, peer groups, and larger social networks are all units of learning, as well as significant contexts in which learning occurs (Bransford, et al., 2006). These units and contexts support social interactions that may occur in different, interdependent ways, such as imitation, collaboration, and instruction.
    a. Imitation—learning from watching other people—is ubiquitous among humans across the lifespan (Bransford, et al., 2006; Meltzoff & Decety, 2003)
    b. Collaboration—learning from working with people—is a coordinated, synchronous activity that results from a continued attempt to build a common understanding of an idea or a problem (Roschelle & Teasley, 1995), where the emergent understanding is a product of the group

(Dillenbourg, et al., 1996).

c. Instruction—learning through guidance from people—is the process of more knowledgeable individuals helping less experienced learners to make meaning of new experiences, where the knowledgeable person may be an adult or peer (Vygotsky, 1978; Wood, Bruner, & Ross, 1976).

Engagement in Learning

Learners need to expend considerable mental effort and persistence in order to learn complex ideas deeply; such commitment requires various types and levels of engagement to learn. There are three types of engagement:

1. *Behavioral engagement.* Behavioral engagement refers to the ways in which learners participate in learning experiences (Fredricks, et al., 2004). The concept includes learners' conduct (e.g.,attendance and adhering to rules of the environment) and levels of involvement in tasks (e.g., attention, concentration, effort, and contribution).
2. *Emotional engagement.* Emotional engagement refers to learners' affective reactions (their feelings and emotions) to the learning context, which may be influenced by their: interactions with the people and context involved; interest in the subject matter; and how they value the subject matter (Fredricks, et al., 2004). Value may be: intrinsic (e.g., interest in the topic), instrumental (e.g., perception of how tasks are related to future goals and life), or attainment placed (e.g., personal importance placed on the task).
3. *Cognitive engagement.* Cognitive engagement refers to learners' psychological investment in learning (the motivation), and also the cognitive learning strategies they employ (the methods) (Fredricks, et al., 2004). It incorporates thoughtfulness and willingness to exert the effort necessary to comprehend complex ideas and master difficult skills.
    a. Motivation to participate may be affected by their feelings of competence in being able to succeed (e.g., abilities are learned and can be developed versus abilities are innate and cannot be changed); and be driven by their learning goals (e.g., mastering the task and understanding versus for performance and task completion)
    b. Learning strategies include: cognitive (e.g., memorize, elaborate, connect and organize ideas); metacognitive (e.g., setting goals, planning, self-monitoring, evaluating progress, and making adjustments); and volitional (e.g., regulate attention, affect, and effort in face of distractions
    c. Motivation can lead to achievement by increasing the quality of cognitive engagement. Conceptual understanding and skills capabilities are enhanced when students are committed to building knowledge and using deeper learning strategies (Blumenfeld, et al., 2006, p. 476).

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