Cognitive Strategies to Promote Learning

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Abstract

In this paper, the architecture of the mind is considered; the sensory register, the working memory and the long-term memory are explored. They are followed by a discussion of how educators can maintain a focus on cognitive development in their instructional technique, in addition to content-driven learning outcomes. Implementation of rehearsal practices of the cognitive processes of sensation, perception, attention, learning, remembering and knowing can lead to cognitive development. While cognitive command is likely an intuitive skill for many educators, hence their chosen career, cognitive command is not universally understood. Educators will do a great service to their students by promoting a classroom experience that is built on cognitive science and modern learning theories.

The human mind is an expansive quantity that is not fully understood to date. Perhaps we will never understand the human mind completely, but at least neuroscientists have come a long way in uncovering how the mind works. Educators can learn from neuroscientists how the brain might be stimulated to induce more efficient and effective learning. Early education theorists relied heavily on research in the realm of animal behavior. The behaviorists (Pavlov, 1927), as they were aptly named built their theories upon principles of behavior alone. However, behaviorist-purists, possibly locked within the scaffolding of their own design, caused their own demise with a lack of flexibility when incorporating new hypotheses of learning into existing constructs. As the human mind became an object of research, neobehaviorists attempted to bridge the behavioral theories with novel concepts of cognition. Constructivists moved even farther afield from behaviorists, presenting concepts of cognitive learning that now informs multimodal delivery of content to be learned. Bruner (1957) was the first to describe how the mind is actively involved in perceiving and processing stimuli.

As with most technologically-informed research, big breakthroughs occurred in the field of cognitive science in the mid-20th century. Big breakthroughs also occurred in computing, hence the almost-unavoidable comparison of the human mind to the computer. While there are many dissimilarities between the mind and a computer, the primary similarity is indisputable: the role of the mind and the computer is to transform information. *How information is transformed* is the primary topic of this paper. An understanding of the basic operational framework of the mind provides an excellent framework for instructional strategy.

Information is constantly presented by our environment. More information is presented in any one second than can be assimilated. In other words, our senses are constantly bombarded with sensations but we can only perceive certain quantities of this information. The environmental sensations first enter the sensory register, the first of three components of the cognitive system (Martinez, 2002). The sensory registers accepts information primarily in the form of visual and auditory stimuli. The sensory register is an extremely temporary residence for information. The key to successful control of the sensory register for the learner is to decide upon what sensations to focus. We will return to this concept when discuss instructional strategies.

The working memory, i.e. the short-term memory, is the locus of conscientiousness. The working memory is stimulated by awareness and although the working memory also contains a limiting factor of residence time, this limitation can be overcome with concentration. George Miller (1956) presented another limitation of the working memory. Miller's research suggested that the human mind has a capacity to work with only 7 +/- 2 objects at one time. Since Miller's time, strategies have been developed to overcome both the temporal and quantitative limitations of the working memory. For example, information packets have been further defined and studied as *chunks* of information (Mayzner and Gabriel, 1963). Metacognitive learning strategies can both increase the residence time of the working memory and increase pattern and category identification.

Learning is the migration of information from the working memory to the long-term memory. In turn, remembering is the reverse, ie the retrieval of information from the long-term memory to the working memory, where it can be worked on again. In fact, fluidity in retrieval is a key component of advanced, expert-level learning. Nonetheless, one does not need to be an expert to engage in retrieval practice. Retrieval of information is the first step in sequential learning and therefore all learners, even very young children, can learn how to access their long-term memories and put them back into action to learn additional, deeper, and tangential information.

Without any instruction at all, it is clear that humans engage in this movement of information from the sensory register to the working memory to the long-term memory and back again. In biology, learning is called *adaptation*. Parents give their offspring *nature*, i.e. the genes that code for a unique self. Parents, and any other mentors along the way like peers, siblings, and teachers, also give *nurture*, i.e. guidance in how to survive and adapt to environmental conditions that threaten survival. For example, a caregiver says “put on your coat” to teach a child to stay warm in winter. A teacher says “write notes to remember this information” when in the classroom.

The guidance of mentors is usually experiential and anecdotal but it can also be cognitively enriching. The cognitive enrichment is a silent or invisible learning objective but its applications are neither. There are concrete ways in which educators can cultivate cognitive and metacognitive skills. The scaffolding for these instructional strategies lies in the architecture of the mind. Martinez (2002) presents the cognitive processes in terms of their residence in the sensory register, working memory or long-term memory:

> **Sensation** is the brief recording of environmental stimuli in the sensory register.
> **Perception** is the cognitive act of imposing order on sensory data as it enters working memory.
> **Attention** is holding information in conscious awareness in working memory.
> **Learning** is moving information from temporary working memory to enduring long-term memory.
> **Remembering** is moving information from long-term memory back into working memory.

Knowing is holding knowledge in long-term memory. (Martinez 2002)

In this schematic, you can see many important features of the cognitive system.

The sensory register is constantly, every waking minute of the day and arguably even when you are sleeping, bombarded with environmental stimuli in the form of human-constructed objects, nature and other humans. If sensory data is held at all, it moves to the working memory, but there is no movement of information from the working memory back to the sensory register. However, by learning together learners can influence each other's sensory register.

The working memory can hold only several items (7 +/-2). The learner is working on this information. The hands are holding the information to signify work being accomplished.

The treasure, the knowledge, is in the treasure chest. The key to learning is to figure how to get the information you are working on into that chest and then how to take that knowledge and use it (pull it back into the working memory).

Instructional Strategies

A classroom structured for cognitive development will exercise the cognitive processes involved in the three components of the cognitive system. Let us now turn to a discussion of instructional strategies that exercise these cognitive processes.

Sensation

The sensory registers, as I noted, captures information primarily in auditory and visual packets of information. The multimodal nature of the sensory register is easy to accommodate as our whole world is filled with sights and sounds, in addition to smells, tastes and physical stimulation. The primacy of experience in learning is touted by many learning theorists John Dewey (1958).

Even traditional lecture is bimodal, if lecture is presented with a slideshow, which is common. However, the lecture format is inappropriate in duration. The sensory registers needs to be stimulated but it cannot hold information but for a few seconds. It would be more appropriate to approach sensory stimulus opportunities with smaller bites of information, but a caution proceeds. If there is too much stimulus, it is difficult for the learner to decide what to focus on.

A common problem in course design is the inclusion of too many learning objectives. The educator must think to himself: “What *one or two* things do I want my students to remember five years from now?” What is more common is that the educator longs to fill the void in the learner’s mind with a complete understanding of an expert-level conceptual framework. While the latter can be accomplished over time, it cannot be accomplished in short order and therefore it should not even be attempted. Rather, the complete gestalt understanding of the concept framework will be nurtured by other cognitive processes.

The educator can exercise the cognitive process of sensation by providing simple but appropriate stimulus to engage the learner at the beginning and throughout the learning engagement.

Thinkscape: The educator enters the classroom and writes two words on the board. The students shuffle in, void their minds of previous knowledge through light conversation.

Perception

Sensations are so ephemeral and so numerous, the vast majority of them go unnoticed. Those that are noticed are said to be perceived by the learner. The stimulus that is perceived is informed by previous learning. The previous informative learning helps the learner create order within the stimulus. This is the application of categorical information and patterns. Educators help learners to both identify and employ this organizational scaffolding. For example, to preface a lesson about a particular plant species, the educator can first prompt the learner to identify all of the possible categories that exist for living organisms (plant, fungi, animals, bacteria).

This activation of prior learning (Merrill, 2002) is an important factor that leads to deeper understanding. If the learner cannot identify types of life, it would be appropriate for the educator to assess this prior learning and make accommodations for this deficiency. This is an example of inclusive teaching. If all learners must learn at the same pace, as is common parameter for American education, it is necessarily the educator's role to identify and promote the learning outcomes for all learners. This is quite challenging depending on the circumstances and learning environment. It is probable that the only information the educator receives about a learner's previous knowledge is the information the learner can provide about himself. This can be provided via pre-testing, formative assessment, and/or conversational interaction in the classroom.

Thinkscape: As the learners settle in, some notice the two terms and start to consider their purpose and meaning. These two words were bolded in the reading from the previous night, a kind of scaffolding afforded in most textbooks. How many students will have noticed those terms when reading? How many will have thought about whether the meaning is known to the individual? After the casual conversation subsides, the educator's voice is perceived by the students. In fact the sound of the educator's voice is a sensation that already has categorical information associated with it. In other words, the students already know that when *that* voice speaks, it is different from the voices of other students, and therefore the students pay attention.

Attention

Holding the attention of the students requires stimulating the learner's previous knowledge and interest in the subject. Indeed, stimuli that is interesting to a student will likely be perceived more readily than other stimuli. But what if the learner enters the learning environment with no interest in the subject at hand? If the educator can influence the knowledge of the student, he might also be able to influence the learner's interest. The educator can influence the knowledge of the student by mentoring the student in cognitive strategies to increase attention.

Metacognition is the deliberate will to control cognition and this can be modeled by the instructor (Pederson and Liu, 2002). This can also be practiced in the classroom. Once a learner has perceived an object of stimulus, they can learn to hold their attention to that object through cognitive strategies. Educators can model their thinking processes through auditory narrative. By describing one's thought process in words to another person that thought process can come alive for the student. That is to say, the student can adopt a similar strategy and adapt it as their own.

The educator can also create proximate activities that do not immediately drive at the learning outcomes but instead drive at cognitive strategy practice. To illustrate the point of attention practice while also teaching how to increase attention, an educator could present the same short instructional video several times.

Thinkscape:

Sample experiment to teach students how to practice paying attention
Experimental set-up: Split the class into four groups of students. Ask the other groups to sit outside as each group conducts the "experiment."

Control	Show the video with normal lighting and no intentional distractions. Before the video starts, ask the students to record the comments made by the speaker in the video regarding the two words written on the board.
Experimental group 1	Show the video with normal lighting and no intentional distractions. After the video is over, ask the students to record the comments made by the speaker in the video regarding the two words written on the board.
Experimental group 1	Show the video with a radio playing in the classroom and flick the lights on and off several times during the clip. Ask the students to record the comments made by the speaker in the video regarding the two words written on the board.
Experimental group 2	Show the video with a radio playing in the classroom and flick the lights on and off several times during the clip. After the video is over, ask the students to record the comments made by the speaker in the video regarding the two words written on the board.

At the end of the experiment, record the results. How many students recall any connection between the speaker's words and the words on the board? How many students reported trouble focusing during the disruptive stimuli? Is there a difference between the groups who were prompted with cues before the video started versus those who received no cues? The latter drives at another point of instructional expertise: scaffolding and the Serial Position Curve. By providing the students with a cue regarding what they are to focus on, the educator helps to hone the cognitive skill of attention by bringing the sensory data into a particular focus. This is like saying "watch out for…", a common guiding comment in any adaptive environment.

The Serial Position Curve was popularized by Deese and Kaufman (1957). The main concept here is that learners remember what is said first and what is said last far more than what is said in the middle. In other words, if you preface the learning object (the video) with a cue, like the statement "watch out for commentary on the two words on the board," the learners will hold this prompt in their memory. If the video is not prefaced in this way, the learner will tend to focus on whatever the speaker in the video says first, which is likely to be somewhat meaningless to the object of attention, the words on the board.

Learning

If the educator succeeds in helping students hold the object of attention in the working memory for longer than a couple of minutes, it is likely that the information will migrate to the long-term memory, which is the definition of learning. Anything the educator does to promote retention of information in the working memory will likely promote the cognitive process of learning because this preserves the write time parameter. There are various instructional techniques to accomplish this end. By circling around the same concept with dialogue, additional reinforcing examples, or active learning components like note-taking and discussion, the educator will succeed in ushering students toward knowledge of the learning outcomes and towards development of cognitive skill. Unfortunately, the learning outcomes to necessarily accomplish in one course’s time are often too numerous to allow for ample consideration of each learning outcome. The tragic end might be a focus on rote learning.

It is inappropriate to assume that rote learning is possible based on what cognitive scientists have concluded about cognitive function. Furthermore, rote learning is not helpful in developing long-term memory (Martinez, 2002). Memorizing material fails to develop the connective nature of knowledge. Cognitive science tell us that the knowledge stored in the long-term memory is interwoven and deepened with each additional connective application. In other words, knowledge is increased when the learner can approach the constellation of understanding from any angle and still understand and apply the knowledge to new concepts.

Modern learning theories such as connectivism expound on this concept and bring to bear the computer analogy renewed. Connectivism's primary tenets include that knowledge is growing exponentially. "We can no longer personally experience and acquire learning that we need to act. We derive our competence from forming connections." (Seimens, 2004). In this framework, the educator becomes a mentor in learning how to form connections. These connections, as previously mentioned, might come as a realization of how patterns and categories apply to new objects of learning, a fundamental component of perception. Connections might also be demonstrated through conversation. Conversation is crucial to learning because social development cannot be divorced from cognitive development (Bandura, 2001).

Thinkscape: The students return to the classroom. The educator presents the results of the attention experiment as it relates to the two words on the board. Did any students write significant information after watching the video? Did the cue alter the results? Did the distracting stimuli alter the results? The students continue to work in their groups after hearing the educator describe the results. When the students engage in discussion and evaluation of the results, they continue to hold learning object in their minds, causing learning to occur.

Remembering

Once a learning outcome is achieved, it is stored in the long-term memory. It is in the proverbial treasure chest. But what good is a treasure chest if one cannot open it? Remembering is a cognitive process that can be stimulated and practiced in the classroom. The educator can layer and revisit the learning outcomes through the passage of time. Thinking back to the concept of the Serial Position Curve, the educator can commence a learning experience with reference to the past learning experience. Again this is facilitated by discussion, and an opportunity for recall and recognition. By stimulating the episodic memory (Tulving, 2002) through conversation about the previous class meeting, the educator can bring information back from the long-term memory and into the working memory. After this review session at the beginning of class, the educator must afford an active break to break the Serial Position Curve.

By interjecting active breaks in instruction, the educator allows for processing and creates categorizing scaffolding. By simply informing the students of the outline of the learning objectives, the educator shows the students how the content of the last lesson links to the content of the present lesson. The break that follows concludes the packaging element of the concept: "Now that we have thoroughly considered the meaning of the two words on the board from last time, we can build on this knowledge as we consider today's topic."

This is yet again another example of the activation of prior learning (Merrill, 2002). This is also akin to Vygotsky's zone of proximal development (Vygotsky, 1978). It is like a primer on a stove. If you do not prepare the environment, the fire will not light. By reminding the student of what he should remember in order to handle this lesson's stimuli, the educator cultivates the cognitive process of remembering. There is a difference however between recall and recognition. Recall is remembering what actually happened to you. Recognition is remembering what you have been taught. In other words, recall is the "been there" memory and recognition is the "I remember that story" memory.

The educator, through multimodal delivery, can cultivate all learning in the classroom so that it is of the "been there" variety. If every learning experience is brought alive by tactical, auditory and visual stimuli, the student will thusly remember in a rich and multimodal recall capacity. The sensory register accepts multimodal information, chiefly of auditory and visual quality, and so does the long-term memory. Therefore, multimodal instruction delivery not only stimulates students to want to learn, it also helps them retain knowledge in their long-term memory. Thus we see that cognitive science confirms what learning theorists are concluding: experience is crucial to knowledge attainment. If you could *experience* the two words on the board, why would you settle for reading about them?

Thinkscape: The students went home and came back for their next lesson. After the class settles in, the instructor asks “Does anyone remember what two words were written on the board last week?” Please write down what you remember about this learning experience. Time elapses (at least 3-4 minutes). Now turn to your neighbor and find out what she remembers about those two words. Time elapses (another 4-5 minutes). Now please send one person up to the board to write your collective definition for the two words. As a class, the educator leads a comparison of the definitions and corrects any misconceptions. The students are released for a 5 minute break. When the break concludes, the instructor notes “we learned that the two words from our last meeting mean ________________. Now that we understand these concepts, let’s us consider [the next sequential concept].

Knowing

When students can build upon prior learning, they have achieved knowledge. This building block scaffolds their future learning of deeper, more challenging concepts. More challenging concepts may include more facets of the learning object but if the educator has successfully aided the student in understanding and applying categories and patterns to this knowledge, it should be easily retrieved from any perspective and applied to new learning.

Thinking back to the two parameters that must be satisfied to hold the learner's attention, both knowledge and interest are required. The knowledge a learner gains is only useful if it applied. After all, what good is a treasure chest if you can't, or have no reason, to open it. Therefore, the educator should continually seek opportunities to both re-employ the learned information and to find ways to connect that knowledge to the learner's personal life so that it has import and is worth by interested in. The learning objectives in a course should therefore be designed to have sequential connectivity. This allows the learner to construct knowledge from comfortable scaffolding. This is the central tenet of constructivism.

Sequential connectivity is a fine focus for the learning objectives of the course but it is not an appropriate way to describe cognitive development. The cognitive processes described in this paper are not contents of declarative knowledge. Rather, the development of cognitive processes is procedural knowledge. The educator can cultivate procedural knowledge in the realm of cognitive development by providing appropriate rehearsal time of cognitive strategies. Practice makes perfect. The more an educator keeps the silent or invisible learning objective of cognitive development at the fore of the instructional theory, the more liking learning will occur.

In this paper, the architecture of the mind is considered; the sensory register, the working memory and the long-term memory are explored. They are followed by a discussion of how educators can maintain a focus on cognitive development in their instructional technique, in addition to content-driven learning outcomes. Implementation of rehearsal practices of cognitive processes of sensation, perception, attention, learning, remembering and knowing can lead to cognitive development. While cognitive command is likely an intuitive skill for many educators, hence their chosen career, cognitive command is not universally understood. Educators will do a great service to their students by promoting a classroom experience that is built on cognitive science and modern learning theories.

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