Information processing

From Emerging Perspectives on Learning, Teaching and Technology

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Review of Information Processing

Contents

Introduction

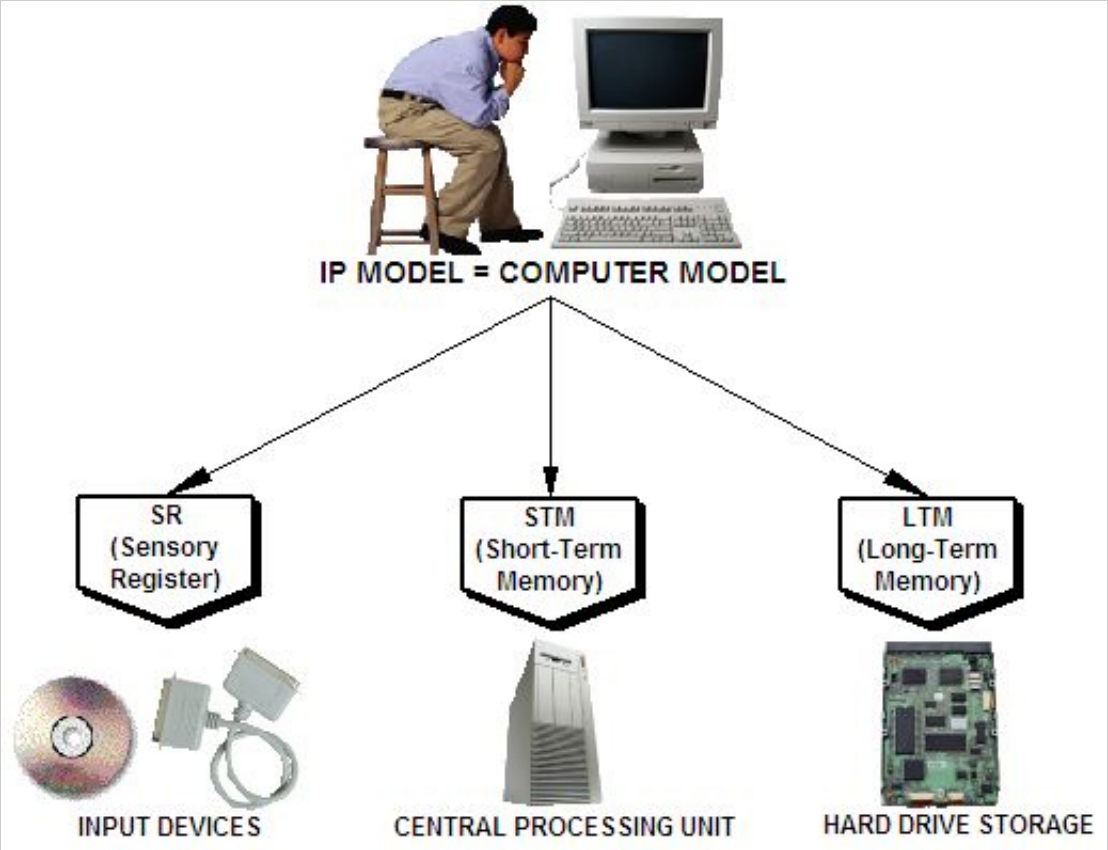


Figure 1. *The Inspiration web above shows how Information Processing can be likened to the model of a computer. The Sensory Register would include input devices like CDs. Short Term Memory includes the Central Processing Unit. Long Term Memory would be viewed as the hard drive or storage. By Tiffany Davis, Meghann Hummel, and Kay Sauers (2006).*

Information processing (IP) is a cognitive processing theory (see, Ashcraft, 1994). While other theories in this e-book are learning or instructional in nature, IP theory seeks to explain how the mind functions. Learning components such as rehearsal and elaboration are associated with IP; however, most emphasis is placed on understanding how information is processed rather than how learning happens.

Another aspect of this theory is that it is explicitly analogous to a computer's processor. The basic IP model has three components: sensory register (SR), short-term memory (STM) or working memory, and long-term memory (LTM). The corresponding components of the computer are input devices or registers, the CPU, and hard drive storage, respectively. This metaphor is superficially valid, but as it is taken to its limits, the mechanical comparison breaks down. However, knowing that this model is a cognitive processing model and knowing that the model is based on an explicit metaphor with a computer is helpful in understanding IP theory.

Let's start with the model and an example. As I write this, I see my cup on my desk. Let's follow this image through the system. The model is depicted below and shows the cup being processed. In the narrative that follows, I will refer back to this cup as it is being cognitively processed.

Caption: The illustration above represents my coffee cup example. Light reflects off the cup and into the eye. The image is then transferred through the optic nerve to the sensory register. From the sensory register, the image is moved into Short-term Memory (STM) as information about the cup is drawn from Long-term Memory (LTM). The process of elaboration occurs when information is retrieved from the LTM in order to link to the new information. I would like to thank Liyan Song for her work on the Flash model shown above.

Sensory Registers

The best understood of the sensory registers (SRs) are for hearing (echoic) and seeing (iconic). Very little is known about tactile (touch), olfactory (smell), and gustatory (taste) SRs. In the cup example, light reflecting off the cup hits my eye; the image is transferred through my optic nerve to the sensory register. If I do not attend to it, it fades from this memory store and is lost. In fact, my cup is on my desk most of the day, and I see it without really "seeing" it many times during the day. Each memory stage has four attributes: representation, capacity, duration, and cause of forgetting. For the visual sensory register, for example, representation is iconic-- limited to the field of vision, and lasts for about 250 milliseconds. The main cause of forgetting is decay. Representation in the auditory register is echoic (based on sound); its duration is 2-3 seconds, it is only limited to the sounds we actually can hear and decay is the primary cause for forgetting. As previously mentioned, much less is known about the other three register types.

Short-term Memory

Short-term memory (STM) is also known as working memory, and is where consciousness exists. In the cup example, if I attend to the cup, it will be moved into STM. At this point, it is difficult to talk about the cup in STM memory without referring to long-term memory (LTM). For example, I might attend to the cup and think, "That's my cup. It has coffee in it. I poured that coffee 3 hours ago." Each of those statements draws on LTM. I know it is my cup because it is the one that a potter friend of mine made for me. I know it has coffee in it, because I remember getting it this morning. I know that I poured that cup at 9:00 am. The statement that the coffee is 3 hours old required me to look at the current time, and retrieve from LTM that subtracting the current time from pouring time tells me how old the coffee is. Performing the subtraction used no STM processing

space, because experience in doing arithmetic allows me to do this automatically.

STM is where the world meets what is already known, and where thinking is done. You perceive and attend to stimuli; that information is then actively processed based on information stored in LTM. In terms of the characteristics of this memory stage, the representation is echoic. It is limited to 5-9 items, and it lasts only about 20 seconds. Interference is the principal cause of forgetting. The most important of these characteristics is the 5 to 9 items. A common example of this is calling information for a phone number. After the operator gives you the number, you begin repeating it to keep it in STM. This repetition is termed rehearsal. Rehearsal can also be used to get information into LTM, but it is very inefficient. Rehearsal primarily serves a maintenance function; it can be used to keep information in STM. In the phone number example, if someone interrupts you to ask you a question while you are rehearsing the number, responding interferes with rehearsal, and the phone number is lost. You must call information again.

Long-term Memory

The final stage in the IP model is long-term memory (LTM), which is typically termed call memory. LTM is everything we know and know how to do. For most cognitive psychologists, the world of LTM can be categorized as one of three types of memory: declarative, procedural or episodic. Declarative knowledge can be defined as knowledge needed to complete this sentence. "Knowing that..." By contrast, procedural knowledge is, "Knowing how..." These two types of knowledge,account for most of what is learned in work and school. The remaining type of knowledge is episodic which might also be called anecdotal. This is memory for specific events in one's life: a memory of your first kiss or of your graduation. The personal stories in our lives comprise episodic memory. While this makes for a neat tautology, some have suggested that it is incomplete.

Pavio (1980) has asserted that memory for images differs from memory for words. He offers a dual coding hypothesis asserting that when we see an image, both the image and a label for that image are stored in memory. He has extended the hypothesis, suggesting that dual codes may exist for the other senses as well. For example, the smell of an orange is stored along with its label, "orange."

Others have suggested that there are mechanisms that control thinking and learning. These control processes are called metacognition. Metacognition often takes the form of strategies. For example, learners attempting to master a complex topic might choose to use a strategy such as drawing pictures to help them understand the complex inter-relationships of the various components of the topic. Strategic readers might stop and mentally summarize what they have just read in order to ensure comprehension.

The 1970s saw great expansion of understanding of human learning. It became clear that there was no one method of teaching that ensured successful learning. Many researchers, especially in the field of second language (L2) acquisition, recognizing this fact, turned their attention to learners, attempting to answer the question, "Why is it that some learners succeed in learning regardless of the methods used to teach them?" Joan Rubin (1975) and H.H. Stern (1975) formulated lists of the characteristics and strategies that "good" language learners use in their study; Rubin and Thompson (1982) offered guidance to foreign language students on how to make themselves better learners. Extensive study of this notion of learning strategies in the 1980s led Michael O'Malley and his associates (1985) to formulate a list of 24 strategies used by English as a Second Language (ESL) students in their study. Perhaps most important, the strategies were classified into three categories, as follows:

Metacognitive strategies is a term borrowed from IP theory. These strategies, according to O'Malley et. al. (cited in Brown,1987), "indicate an 'executive ' function...that involve planning for learning, thinking about the learning process as it is taking place, monitoring...and evaluating learning (p. 94)..." Metacognitive strategies might include using advance organizers, self-planning, self-monitoring, and self-evaluation.

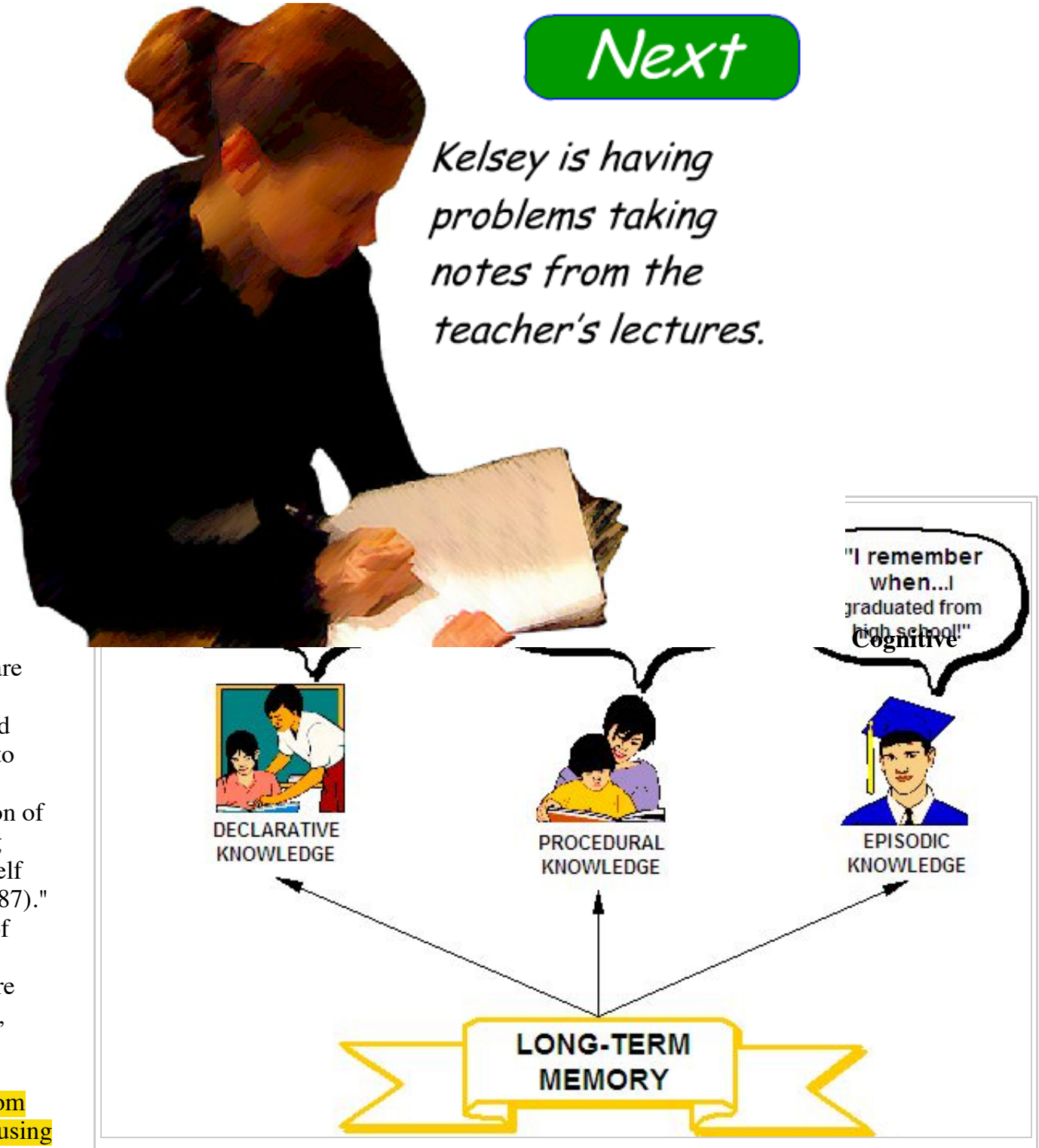
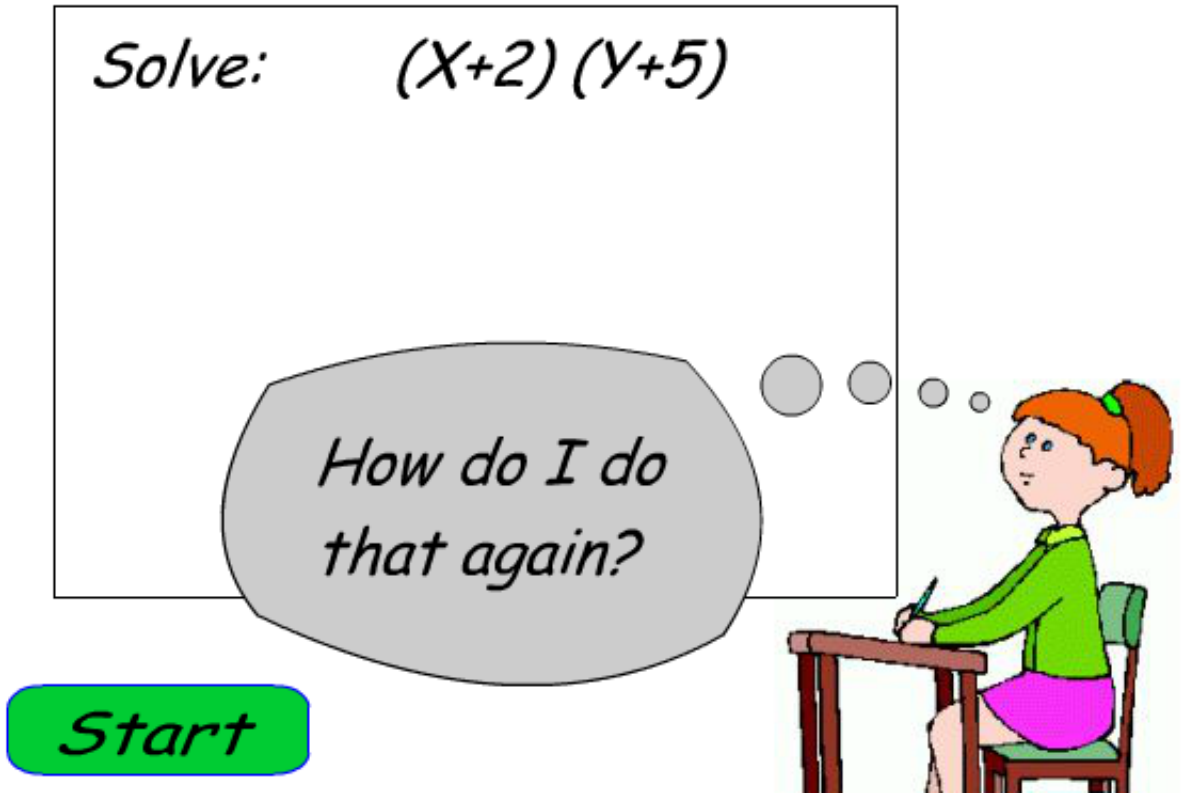


Figure 2. *This Inspiration web illustrates that Long Term Memory consists of declarative knowledge ("I know that...even numbers end with the digits 0, 2, 4, 6, and 8!"), procedural knowledge ("I know how& to pronounce and comprehend new vocabulary!"), and episodic knowledge ("I remember*

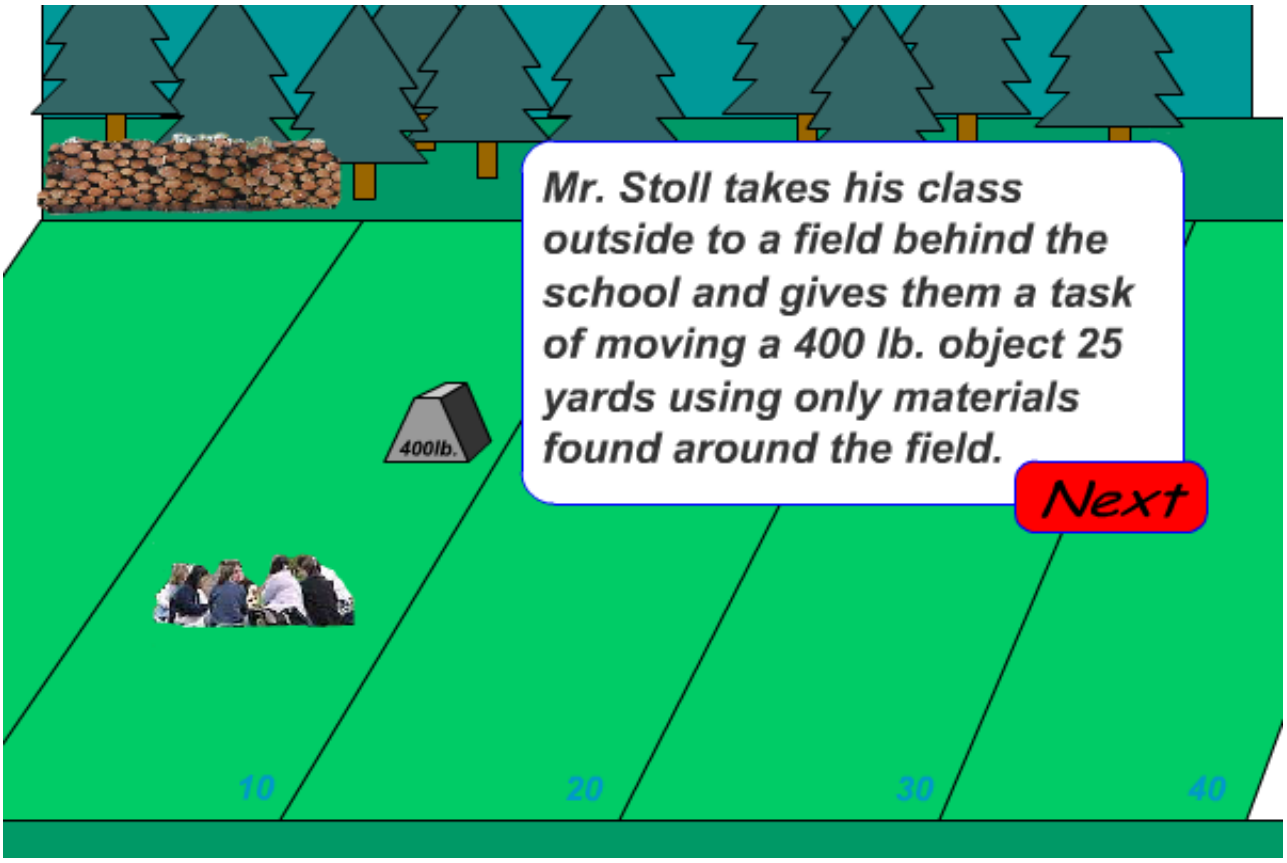
strategies are more task-specific, and often refer to "direct manipulation of the learning material itself (Brown, 1987)." Examples of cognitive strategies are note-taking, repetition, guessing meaning from context, or using mnemonic devices.

when& I graduated from high school!"). By Tiffany Davis, Meghann Hummel, and Kay Sauers (2006).



Caption: The animation illustrates the use of cognitive strategies to help solve a mathematical equation. The FOIL method, when used as a mnemonic, will take the student through the appropriate steps to solve the problem. The student has used a cognitive strategy to recall the mnemonic that is most useful in this situation. By Mari-Amanda Grigsby, James Holden, Aron Scott Foster, and Lucas Amaral (2006).

Socioaffective strategies refer to strategies that use association with or input from teachers or peers.



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O'Malley and his colleagues have gone on to suggest that these strategies can be overtly taught to learners, facilitating one of the most important goals of learning, learner autonomy.

Finally, there is another viewpoint that offers the notion of concepts. For example, there exists a concept called "bird," which can be reduced to declarative statements such as: "It has feathers," "It has wings and flies," "It lays eggs," and the like. The concept of "bird" can also include our episodic experiences with birds--the parakeet I had when I was a child, the sparrow I found dead by the fence one morning, etc. It can also include the hundreds of images that we have seen of birds, as well as all instances of real birds we have seen. All of this collectively is what we know of as "bird." It is the concept of bird, the tightly woven collection of knowledge that we have for birds.

In the end, there are five types of knowledge in LTM--declarative, procedural, episodic, imagery, and strategic knowledge; there also exists one collective type called conceptual knowledge. For the LTM stage, the representation is semantic (based on meaning). Capacity and duration are considered unlimited in LTM, and the cause of forgetting is failure to retrieve.

The final issue regarding the IP model is how information gets into LTM. This primarily takes place through a process called elaboration. When I think about teaching learners, I need to know what they already know so that they can relate the new information to their existing knowledge. This is elaboration. While teachers can do some of that for learners, elaboration is an active process. The learner must be actively engaged with the material that is to be learned. This does not necessarily mean that the learner must be physically active; rather, it

implies that they should be actively relating this new piece of information to other ideas that they already know. LTM is often regarded as a network of ideas. In order to remember something, ideas are linked, one to another until the sought-after information is found. Failure to remember information does not mean that it has been forgotten; it is merely the procedure for retrieval has been forgotten. With more elaboration, more pathways to that piece of information are created . More pathways make retrieval of the information more likely. If it is found, it is not forgotten.

References

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Stern, H. H. (1975). What can we learn from the good language learner? The Canadian Modern Language Review 31:304-318.

Instructional Scenarios

We have two educational stories to help you, the reader, understand how information processing, particularly metacognition, can be applied in the classroom.

Language Learning

Focuses on a scenario in a language arts class in a suburban American high school: Language Learning

Teacher Practice

Focuses on a scenario incorporating metacognitive strategies in teaching: Teacher Practice

Bibliography

Additional Resources

Here is a nice chapter from a book by Lloyd Rieber about the IP model and graphics. The title of the chapter is, "Psychological Foundations of Instructional Graphics" (http://www.nowhereroad.com/cgl/chapter4/) Lloyd has

also made a nice interactive model for the dual coding theory. You can get to that module by clicking here. (http://it.coe.uga.edu/~lrieber/edit6150/animations/DCT.html)

Cognitive Learning Theory http://faculty.soe.syr.edu/takoszal/Thailand_Workshops-Su05/web-links/cognitivism_overview_04.pdf

The Information Processing Approach http://www.edpsycinteractive.org/topics/cognition/infoproc.html

Information Processing Theory http://tip.psychology.org/miller.html

Reciprocal Teaching http://www.ncrel.org/sdrs/areas/issues/students/atrisk/at6lk38.htm

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