WHAT IS HAPPENING IN THE BRAIN WHEN PEOPLE LEARN

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Learning Process

Learning, in terms of physiology of learning, is a kind of higher brain functions of human brain processing the incoming information from all kind of sensory perceptions, i.e., vision, hearing, equilibrium, smell, taste, and skin sensations. In other words, learning, in terms of neuropsychology of learning, is the act of acquiring new, or modifying and reinforcing, existing knowledge, behaviors, skills, values, or preferences and may involve synthesizing different types of information (1).

Teaching and Learning Components

According to Bloom's taxonomy, educational objectives consist of three domains: cognitive domain or knowledge, psychomotor domain or skill, and affective domain or attitude (2). Teaching and learning are composed of a number of processes transferring knowledge, skill and attitude from learning resource to the learners (Figure 1). In an "IPO System Concept", learning resource is regarded as "input", learner is regarded as "output", learning process is regarded as "process", the learner can feedback to the learning resource as "feedback" to the system.

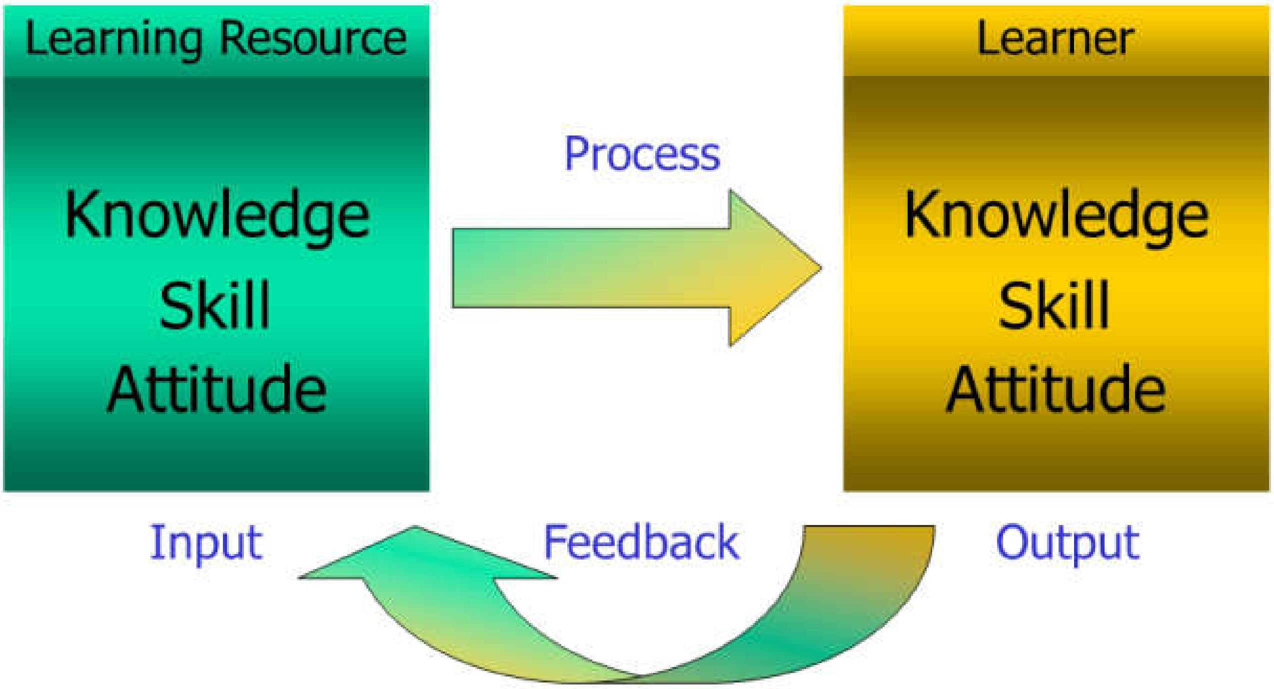

Figure 1. Teaching and learning components shown in the IPO System Concept

How to study what is happening in the brain when people learn

When people learn something, what is happening in the brain is quite amazing and worth for either neuroanatomical imaging or electrophysiological studies. To study how the brain, learn by using anatomical studies like functional Magnetic Resonance Imaging (fMRI) and Positron Emission Tomography scan (PET scan) results in a more accurate location mapping of areas of the functioning brain, namely high spatial resolution, however, these two techniques need longer processing time of at least 2-3 seconds or more.

Functional magnetic resonance imaging or functional MRI (fMRI) is a functional neuroimaging procedure using MRI technology that measures brain activity by detecting associated changes in blood flow. This technique relies on the fact that cerebral blood flow and neuronal activation are coupled. When an area of the brain is in use, blood flow to that region also increases (3).

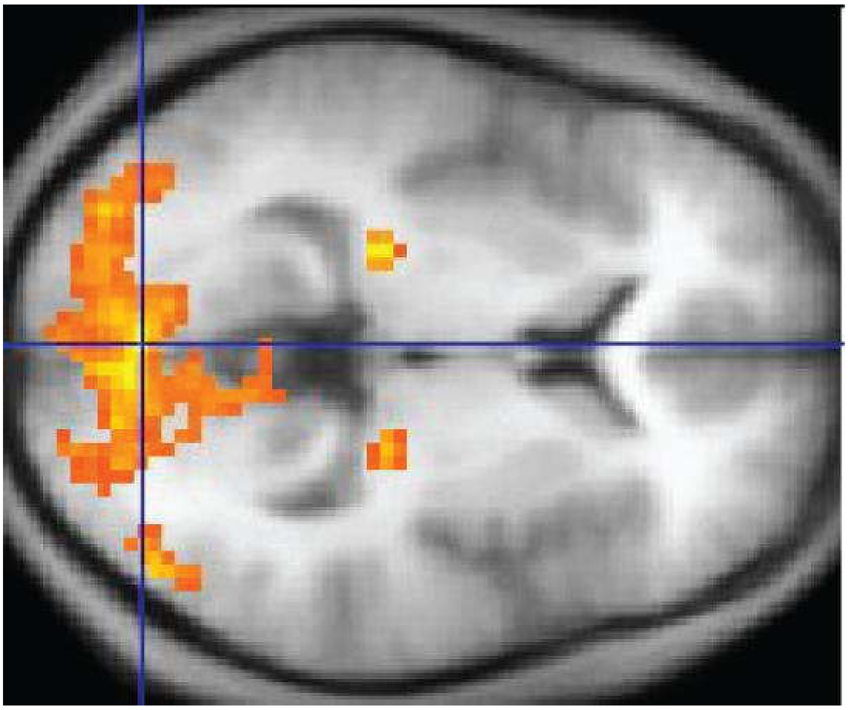

Figure 2. An example of fMRI image, the orange and red areas on the left demonstrate increased cerebral blood flow areas at the occipital areas (3).

Positron emission tomography (PET) is a nuclear medicine, functional imaging technique that produces a three-dimensional image of functional processes in the body. The system detects pairs of gamma rays emitted indirectly by a positron-emitting radionuclide (tracer), which is introduced into the body on a biologically active molecule. Three-dimensional images of tracer concentration within the body are then constructed by computer analysis. In modern PET-CT scanners, three dimensional imaging is often accomplished with the aid of a CT X-ray scan performed on the patient during the same session, in the same machine (4).

To study how the brain, learn by using electrophysiological studies like Electroencephalography (EEG) or Event-Related Potential (ERP) results in a more rapid capturing of the brain wave in the order of 0.001 to 1 second, namely, high temporal resolution. An event-related potential (ERP) is the measured brain response that is the direct result of a specific sensory, cognitive, or motor event. More formally, it is any stereotyped electrophysiological response to a stimulus. The study of the brain in this way provides a noninvasive means of evaluating brain functioning in patients with cognitive diseases. ERPs are measured by means of electroencephalography (EEG). The magnetoencephalography (MEG) equivalent of ERP is the ERF, or event-related field (5).

Learning must be started from stimuli which are originated from a variety of energy, i.e., light, sound, and chemicals, stimulating sensory receptors and organs in the eye, ear, nose and tongue, respectively. In addition, force, pressure, irritating chemicals, warmth and cold stimulate cutaneous sensation through skin. Gravity, acceleration and deceleration give rise to awareness of body position through inner ears, and body balance through muscle tendons and joints.

Normally, visual and/or auditory stimuli are used to stimulate subjects to evaluate the learning processes occurring in the brain because these two modes of sensory perception are generally used to learn. All of the information is then processed and integrated in the brain, resulting in the more detailed sensory perception in the higher center in the brain, for example, calculation, thinking, feeling, emotion, learning, and memory. Finally, one would voluntarily command his skeletal muscles to contract via somatic nervous system resulting in human behavior, and also resulting in involuntary responses on smooth muscle and heart muscle via autonomic nervous system. The time used from the very beginning of sensory stimulation to responses of muscular contraction is called “Reaction Rime” or RT. The RT is normally used for evaluating behavioral study, and it is used in conjunction with the electrophysiological study of ERP.

To study how people, learn, one can design the input stimuli like visual and/or hearing input stimuli, and use ERP to capture the brain wave occurs once the stimuli entering the brain within 0.001 to 1 second. Normally, the visual input will result in perception of light and then it is interpreted by a higher brain center and it is then compared with the retrieved memory. If it is a new experience, the interpreted information will then be either memorized for short term memory or discarded. If the learner thinks and writes down the read information, the brain will need to synthesize from language area in the brain and command via the motor function. This can be considered learning three times, once from the eyes, the second time learning from the language area, and the third time from the motor function. Then the eyes must read the written information and process through the visual pathway again to check whether one is writing correctly. This can be considered learning for the fourth time. This explains why learners who read and make a note in their own words learn more than those who read without making a note.

Similarly, if the learner listens to audio information, the brain will learn once via the auditory pathway. If the learner thinks and asks questions, the brain will need to synthesize from language area in the brain (the second time of learning) and command via the motor function by articulation of vocal cord, tongue, lips and mouth (the third time of learning). Then the ears must listen to the spoken information and then the information is processed through the auditory pathway again to check whether one is speaking correctly (the fourth time of learning). After the learner listens to the answer, if he jots down the listened information, then he learns another four more times. This explains why learners who listen and ask questions learn more than those who listen without asking questions. And those who listen, ask questions, and jot down with their own words learn most.

In summary, learners with active participation either by making a note of their own words or asking questions will result in more iteration of learning in their brain and hence forming more neural connection circuitries. These events occurring in the brain can be studied in detailed by using neuro-imaging or electrophysiological techniques.

References:

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