From: Matheson, D. (Ed.) 2014. *An Introduction to the Study of Education*, 4th Ed., Routledge, London.

Learning styles: Implications for teaching and learning

John Pelley

"The purpose of an educational institution is to lead the students, who initially believe the educational institution is there to educate them, to the realization that they must educate themselves."

"They must …learn how to learn [*integratively*]…"

From Willis Hurst, MD, Medscape, 2001 [*and Pelley, 2008*]

Introduction

Learning style is a preference, not a limitation. It becomes a limitation, however, when it is used to design instruction. This limits instruction by taking attention away from important outcomes-based learning objectives that should be achieved regardless of the student's learning preferences. It also limits learning by appealing only to what the learner already does well, thus taking attention away from what the learner needs to develop. If, instead, learning style is used to help identify underused learning skills, the learner can develop the skills needed to learn how to learn at any level of complexity.

The goal of education is the development of the whole brain and learning style should be used as a tool to achieve this end. This chapter is designed to address how and why learning style can be employed as part of a deliberate whole brain method for achieving "educational self-actualization," (see *self-actualization* in, Maslow 1954). The primary message of this chapter is that learning style is only useful as a means for developing whole brain thinking – and for that, it is essential.

The literature abounds with commentary, pro and con, concerning the concept of learning style (Felder and Brent 2005, Pashler et al. 2008) and it is also addressed in this volume in Chapter 3. In order that the frame of reference for this chapter is clear, the terminology and/or semantics related to learning style need to be defined. An interesting example of the need for semantic clarification is the distinction between learning style and cognitive style (Cuthbert 2005). Cognitive style as first proposed by Riding (1997), is considered as an inborn preference for how a learner responds to new information. This definition can be usefully compared to a definition of learning style as originally proposed by Kolb (1984) in that it is also preference for responding to new information. However, Kolb more thoroughly extends the definition to include a preference for the way new information is "transformed through whole brain learning" from experience into knowledge. Further review of the literature on the learning style concept will reveal mental models that involve either a reductionistic or a holistic construct based on the basic psychological concepts of: 1) perception, 2) cognitive controls and processes, 3) mental imagery, and 4) personality. The primary error made in many studies of learning style is to define it as different ways that people learn. As this chapter will clarify, it is different ways that people "prefer" to learn and that all learning occurs through precisely the same steps.

The extensive variety of semantic interpretations of "learning style" has led to the inevitable debate over the utility of the concept. One argument that continues to emerge in the educational research literature, and also continues to be rejected by the evidence, is that learning style can be used to design instruction in order to enhance learning (Pashler 2008, Coffield *et al*. 2004). Kolb has also additionally posed a caution concerning the adoption of stereotypes that trivialize human complexity (see Chapter 3, page 59). Kolb did not have access to the MBTI Manual (Myers *et al*. 1998) at the time he authored his book on learning styles, or he would have been aware of the extensive caution given regarding the interpretation of Jung's psychological type theory. The view of learning style in this chapter supports the arguments that instructional design, and even curriculum design, should not be based on learning preferences of the learners. Instead, it will be shown here that the learning style concept is highly relevant when used for self-assessment to develop additional learning skills in the learner. Both the Constructivist model (see Chapter 3, page 40) and the Transformative model (Mezirow 1997) will be used to illustrate how both teaching and learning are enhanced when the metacognitive perspective is used to teach learners about their learning.

We will first establish a functional correlation between the Kolb Experiential Learning Cycle (ELC, see Chapter 3, Theories of Learning, Experiential Learning Theory, page 52) and the Jungian mental functions (JMF) that are identified by the Myers-Briggs Type Indicator (Myers, *et al.* 1998). This correlation between the ELC and JMF provides a basis for understanding whole brain thinking because it shows how every learner processes information through the same process (ELC) while placing different emphasis (JMF) on the individual ELC steps. The process of whole brain thinking will then be described in the context of the ELC to provide a way to visualize experiential learning occurring within the brain (Figure 1). The connection between the ELC, JMF, and whole brain thinking will then be used to help understand how higher order thinking skills (HOTS) are achieved [footnote1]. When the teacher obtains a complete grasp of the correlations between learning style, the ELC, and regional specialization of the brain, the phrase "sense-integrate-act" will serve as a reliable reminder of the self-directed learner. The theoretical groundwork will be balanced by a discussion of practical recommendations that can be broadly applied. As a final introductory note, this chapter was not conceived as a review or a critique of existing learning style theories, each of which has endured due to their utility in various venues. Instead, the broad goal is to help develop an appreciation of how learning style as a concept can be applied to an understanding of how the brain learns.

From: Matheson, D. (Ed.) 2014. *An Introduction to the Study of Education*, 4th Ed., Routledge, London.

Learning style relationship to Experiential Learning Cycle.

Learning style models attempt to identify observed learning behaviors that are habitual due to preferences held by the learner. The learning behaviors described by the ELC were proposed by Kolb to represent a sequence of four characteristic learning behaviors: 1) involvement in the experience (concrete experience); 2) reflection about the experience (reflective observation); 3) using analytical skills to conceptualize the experience (abstract generalization); and 4) using decision making and problem solving skills in order to act on the new ideas gained from the experience (active testing). These individual behaviors had already been recognized as important in learning theory, but Kolb arranged them in a specific order to comprise a cycle whose output became fresh input for the cycle to continue (see Figure 3.2, page 55). As will be shown here, the ELC sequence is fundamental to all learning – even rote learning – and thus constitutes a universal truth.

As a Constructivist model, the ELC is a complete description of the steps that show how the human brain uses prior experience to transform new experience into knowledge (Figure 1). But, the ELC does not provide the critically important insight concerning the efficiency with which each of the four steps is performed by different learners. For example, if the abstract conceptualization step is performed less efficiently than the reflective observation step, it will impair the learning cycle in a characteristic way. In this case we would expect a strong command of factual information (reflective observation) but a sense of uncertainty in posing possible predictions from those facts (abstract conceptualization). Reciprocally, if the reflective observation step is performed less efficiently than the abstract generalization step, we would expect skillful formation of alternative possibilities, but without the complete use of the facts. Thus, the same sequence of information processing in different brains would lead to different learning outcomes. This emphasis of one step over another is precisely how the Jungian mental functions work.

In Jungian personality type, the mental functions also have a functional sequence of information processing (Figure 2), but it is not considered to proceed as a cycle, nor does it need to be[footnote2]. This insight is readily provided by the four Jungian personality preferences: sensing, intuition, thinking and feeling, referred to as the “mental functions” (Myers *et al.* 1998). For the Jungian Sensing type, facts and concepts receive most of the thinking time compared to an emphasis on alternatives and possibilities in the thinking time spent by the Intuitive type. Just as all learners use the complete ELC, they also use both sensing and intuition in the sequence of mental functions. The differences in the final outcome of thinking are due to the relative amounts of time spent with facts and concepts compared to time spent with possibilities and “big picture” thinking. The consistent unequal use of time for the steps in both the ELC and the Jungian sequence helps us to see that learning style is both unconscious and habitual.

The habitual use of one part of our thinking more than another is supported by other mental models such as Gardner's multiple Intelligences (Gardner 1993). It is not difficult to see that if any particular activity is easier to perform, it will be preferred. If an individual is clumsy at catching and throwing a ball but facile in pressing keys on a piano, their favorite pastime is not going to be baseball. The likelihood of a genetic basis for using different areas of the brain differently is well established and will be addressed shortly, but at this point the primary emphasis is simply that different people use their brains differently. This different use of the brain produces different responses to experience, thus producing different behavioral outcomes. The external evidence of these responses is identifiable as a personality type, or when thinking of a learner, a learning style.

If we try to match steps in the ELC with steps in the JMF, we will not find a complete overlap. The first step in the ELC, concrete experience, does have a partial match with the Sensing preference in the JMF because sensing types are identified by their preference for giving attention to facts and details. This is the basis for Jung's choice of terms, i.e. Sensing types paid most attention to that which is immediately observed by the senses. The second step in the ELC, reflective observation, also has a partial match with the Sensing type because this step in the ELC is concerned with whether the learner recognizes elements in the concrete experience from previous learning. Recognition from previous learning can introduce a bias in what the learner thinks they are perceiving with their senses.

The third step in the ELC, abstract conceptualization, compares well with the Jungian Intuitive preference because the thinking is about the future instead of the past. The ELC describes how the learner seeks to understand through generation of hypotheses or alternative possibilities – educated guesses, if you will. The learner is proposing what the new experience might mean. The Intuitive type likewise pays more attention to alternatives and possibilities about what the new experience means. They are seeking to understand the experience instead of simply making a record of it. Both of these mental models make active use of the imagination to create the alternatives that they must choose for active testing. The creation and testing of alternatives provides an opportunity to distinguish between the terms: creativity and intelligence. The process of creating alternative possibilities is a simple way to define creativity and the ability to test and choose the best possibility is a simple definition for intelligence. The latter is evident on intelligence tests when learners are asked to choose the most correct answer.

The fourth step in the ELC, active testing, has a similarity to both the Thinking and Feeling preferences in the JMF. The ELC allows the choice of methods for active testing to be chosen by the learner, but does not specify whether the outcome criteria are logical or emotional, or both. Active testing can be as simple as paraphrasing (written or spoken) or drawing a concept map (both require action). If an alternative can be verbalized intelligently or can be diagrammed in a clear meaningful structure, then the active testing step can confirm meaning or understanding. The JMF tells us what criteria the learner might use as a basis for accepting the outcome of active testing. The Jungian Thinking type will trust more the use of logic in assessing outcomes compared to the Jungian Feeling type who will trust more the use of emotive or subjective values. In either case, the assessment is rational. The remaining preferences in the Jungian personality types, Extraversion and Introversion (not considered to be mental functions), might be thought to relate to active testing, but that would be too restrictive. These preferences relate to the inherent level of arousal in the learner's brain (Ornstein 1995) and only indicate how the learner prefers to conduct either the learning sequence. The Extravert will attempt to increase the level of arousal through active processing, e.g. speaking, in order to provide immediate sensory feedback, while the Introvert will attempt to decrease the level of arousal through more subdued outward behavior, e.g. quiet contemplation, in order to reduce excessive arousal.

Of primary importance in using either mental model, the ELC or the JMF, is the capacity for free will in the learner to compensate for their preferences when the circumstances demand. These demands can be teacher directed or learner (self-) directed. Fundamental to the intelligent use of the learning style concept is the awareness that preferences only tell us how information is learned under conditions that permit freedom of choice. However, learning objectives often require the Sensing type to develop alternative possibilities (an Intuitive preference) and often require the Intuitive type to memorize details (a Sensing preference). Because every learner uses both mental functions in everyday life, they can shift their learning emphasis to fit the objectives. The only difference in learning when using the non-preferred functions is that it takes more mental energy and is not trusted as much. The basis for preferences in individuals is more easily understood from an explanation of how they relate to the functional areas of the brain during learning.

<u>Experiential Learning Cycle relationship to whole brain thinking.</u>

What is whole brain thinking? Is it using "all" of the brain instead of only part of it? Is it just being able to use selected parts of the brain depending on the nature of the learning? An overview analysis of the functional specialization of the major areas of the brain will help us see that we always use all of our brain during the ELC, but that we each use these major areas slightly differently. These differences help us to understand learning style. A correlation between the major functional areas of the brain and the four steps in the ELC has been described by Zull (2002, Figure 1). The areas involved in the ELC are part of the cerebrum, also called the neocortex, the area of the brain responsible for thinking and learning. The areas of the cerebrum that we will consider are the occipital/parietal (sensory) cortex, temporal (long term memory) cortex, prefrontal (decision making) cortex, and frontal/motor (voluntary action) cortex. A correlation can also be made between the major areas of the brain and the JMF if we include an older area of the brain, the limbic system (emotion, feeling) which is not part of the cerebrum. Before describing the comparison of how the ELC and the JMF use these areas of the brain to produce learning, it is important to explain how and when the brain changes during learning.

The brain changes its structure during the learning process (see Zull, 2002, for more detailed explanation). The change would not be visible to the naked eye, but rather occurs at the level of the nerve cells, called neurons. The permanent formation of a new pattern of connections between the neurons during learning is called consolidation. If we are referring to memory then the term is "consolidation of memory." However, other functions of the brain will also undergo change when they are used and so decision making will lead to "consolidation of decision making skills." Learning also involves a temporary storage of information referred to as short term memory which is like the RAM memory in a computer. As soon as attention is shifted to a new "concrete experience," the information in short term memory is lost. The consolidation of memory is more analogous to storage on the hard drive of a computer. It will remain there until it is erased. Interestingly, the brain has a counterpart to erasing, termed "pruning." At the level of the neuron, consolidation happens when networks of connections are formed (learning) and pruning occurs when these connections are later removed (forgetting). This explains why learning a new concept may also require unlearning, i.e. pruning, a conflicting and incorrect concept.

These connections between neurons can be seen as a form of "computing power" for each nerve cell. It is known that, in order to bring about consolidation, the repeated transmission of new learning patterns is necessary. However, it is not generally known that these changes occur only during sleep. Specifically, during non-dreaming deep sleep the hippocampus, an area of the limbic system, rehearses (replays) and records the activities from the previous day through the process of consolidation (Stickgold and Ellenbogen 2008). If the active testing stage of the ELC is not done, then the hippocampus has nothing to rehearse and no consolidation takes place. This cannot be overcome by simply taking in information through reading or listening, even with repetition. Repetition can only reinforce what has already been learned. Furthermore, because the hippocampus represents the emotional brain, it will only record learning that has an emotional connection. Such connections can be realized through the feeling of closure in completion of concept maps or skillfully written organization of notes, or especially through interpersonal dialogue. To summarize, the brain learns during sleep through rehearsal of activity that it cares about. With this in mind, we can now correlate the

ELC with the functional areas of the brain and emphasize how consolidation of learning can be purposely stimulated in each of the four stages.

The ELC begins with concrete experience transmitted through the sensory pathways where it is organized by the sensory areas of the brain (figure 1). This activity has prompted many neuroscientists to claim that we see with our brain, not our eyes. However, more than vision is sensed. Smell, touch, sound, and taste provide sensory information that the brain can process during learning. As an activity, sensing the environment is a process that can undergo development through directed training. This is especially evident when one of the senses, such as vision, is lost and others, such as hearing and touch, develop to compensate.

Sensory information is both interpreted by the nearby area called the temporal cortex that engages in the second step, reflective observation. The temporal cortex processes long term memory and thus is responsible for recognition of sensory information. Since long term memory is connected through neural networks with other memories during integrative learning, sensory information can trigger recall of patterns as well as facts. If a learner has incorrect or incomplete memory, the temporal cortex can readily misinterpret what is being learned during reflective observation. This is emphasized by the report by Bransford, et al. (2000) where they recommend that teachers draw out preexisting understandings that learners bring with them. Thus, the sensory cortex that processes concrete experience influences the temporal cortex that processes recognition of the concrete experience, and that influence is reciprocal.

It is the neurons in the temporal cortex that grow network connections while facts and concepts are consolidated during sleep. When experiments are conducted that block the growth of connections, memory is blocked. Individuals who have easier consolidation in the temporal cortex compared to other areas, will have a learning style that prefers the use of facts and specifics, such as the Sensing type in the JMF.

Whenever one area increases its connections, another unused area undergoes pruning to compensate for the physical space required. This does not mean that other learning is lost, since pruning only occurs in areas that do not contain emotionally important, or meaningful, information. As more and more patterns are stored, the capacity to attach meaning to what is observed is increased. The consolidation of meaning is not the same, however, as the creation of meaning.

Meaning is created for the learner during the third step of the ELC, abstract conceptualization. The area that engages in this activity is the prefrontal cortex. It is distinguished from the more general term, frontal cortex, in that the latter also includes the motor area that is involved in the last step of the ELC, active testing. Experience can be conceptualized as “a problem requiring a decision." Whether we are engaged in formal learning or in the normal everyday activities of living, our behavior is made up of decisions. Writing a thought a certain way or speaking a thought a certain way requires a decision among the words chosen. This is evident when different learners express the same thought uniquely. In order to come to a decision, the prefrontal cortex must create options each of which has meaning. Each option must project an outcome into a future scenario. "If I do this, then this will happen." The greater development of the prefrontal cortex in humans helps to explain why we are able to conceive of a future, an ability not present in lower animals. These future scenarios that form a basis for active testing are a result of the act of creation – creating possibilities and attaching meaning to each.

The prefrontal cortex has two sources of information that can be used to create meaningful possibilities: the sensory cortex and the temporal cortex. The sensory cortex provides new information for creative thinking and the temporal cortex provides remembered information. The prefrontal cortex is able to create new pattern arrangements with the information provided and the new pattern arrangements are called generalizations. Thus, the ELC abstract conceptualization step amounts to a "guess" about future knowledge. A learning style that prefers to see possibilities, such as the Intuitive type in the JMF, may be explained by easier consolidation in the prefrontal cortex compared to other areas.

Creativity, the creation of alternative meanings, is only one of the processes necessary for a decision. The other process is the use of intelligence to select the alternative or possibility that makes the most sense, both logically and emotionally. This process is also mediated by the prefrontal cortex. The selection of an alternative possibility constitutes a decision. This is the point in learning where new knowledge is created – and it is created by the learner, not by the teacher. The knowledge provided by a teacher is simply another sensory resource that the learner uses to create meaning in the new experience [footnote3]. The prefrontal cortex with its short term memory is not designed to remember a decision, and it would be a disadvantage to do so. How do we know if it is a good decision unless we test it?

The motor cortex is responsible for carrying out the active testing of the decisions made by the prefrontal cortex. The motor cortex has the capacity to physically act on decisions by using tools for writing, by keyboarding, by speaking to others, and by any combination of these and other actions. Like the other areas of the brain, the motor cortex can also acquire a memory of how to communicate thinking and how to carry out physical tasks. The results from active testing constitute new concrete experience for the ELC to continue through its stages. Thus, learning "from" experience is not complete until learning decisions "are" experienced.

Learning style is more readily understood as a preference by considering that different individuals carry out each activity in the ELC in its respective area of the brain with different degrees of ease. One learner might use their temporal cortex with greater ease than the prefrontal cortex and thus have a greater ability with memory for facts and details and an avoidance of finding meaning. The important educational principle revealed here is that all of the activities in the ELC are critical to higher order thinking. We must teach to all of the cerebral cortex, the whole brain, if we are to develop higher order thinking skills.

Importance of whole brain thinking.

Whole brain thinking produces the maximum possible transformation of experience into knowledge by the cerebral cortex and the limbic system. We can evaluate this more easily by reviewing the ELC in reverse order (refer to Figure 1). If active testing by the motor cortex is to be most effective, it must act on highly creative and intelligent decisions in the prefrontal cortex. If the prefrontal cortex is to make highly intelligent decisions, it must be supplied with high quality information available from the temporal cortex and sensory cortex. If the temporal cortex is to retain the high quality information that is needed by the prefrontal cortex, the sensory cortex must convey accurate information from the environment, including outcomes of active testing. This reverse order review illustrates that each of the mental activities in the ELC are critically dependent on those that precede them.

A similar dependence is seen for the Jungian mental functions (refer to Figure 2). Similar to the sequence above, reversing the order will consider first the Feeling function, then the Thinking function, the Intuitive function, and finally the Sensing function. If subjective values (Feeling function) in the form of emotions are to be used by the limbic system to evaluate a decision, they will be of little value if the decision is not logical. How can one feel good about a decision that makes no sense, i.e. a decision that is unworkable? If the most logical decision (Thinking function) is to be determined by the prefrontal cortex, it will be dependent on having all of the alternative possibilities to choose from. If the prefrontal cortex is to determine a complete list of alternative possibilities (Intuitive function), then it will be important to have all of the high quality information available. If there is to be a reliable and sufficient amount of information available (Sensing function) from the temporal cortex, then a well-developed ability to create a present moment awareness of experience by the sensory cortex as well as an ability to remember enough information will be necessary. Thus, the Jungian sequence uses all of the brain, just as the ELC sequence.

If learning style informs us about the part of the brain that the learner uses most readily, it can also inform us about what is being neglected. Neglect is not caused by inability, but rather by unequal time sharing. We spend more time with the abilities that we trust the most, those that are more comfortable. We give our preferences more of our thinking time, but the other steps in the ELC, and also the JMF sequence, are also accessible and responsive to a knowledgeable teacher. This ability of each student to utilize their whole brain forms the basis of the Growth Mindset (GM) postulated by Dweck (2006). Growth Mindset theory states that learners who understand how their brains learn will demonstrate higher achievement than those who don't. GM learners understand that there are some aspects of learning that are more difficult (their learning style opposite), and they take steps to compensate during their learning activities. Again, high academic achievement can only come from mastery of each of the steps in learning, that is, from balanced use of all of the areas of the cerebral cortex.

The GM works because the brain can grow neural networks (i.e. consolidate) in any area that is specifically used. GM learners deliberately practice with their learning style opposite (non-preferred) to produce neural network branching in that area. The mastery of long term memory in the temporal cortex in Jungian Sensing types must be balanced by development neural networks used for creative activity in the prefrontal cortex, the learning style opposite of the Sensing type. Similarly, active testing is a motor skill that can be developed through construction of concept maps or through clear verbal arguments – or both! Sensory input can be improved by developing the brain through appropriate exercises that help focus and attention in the present moment.

The most effective method for development in GM learners is that of Deliberate Practice (DP). This approach to learning has emerged from human performance studies that have examined the development of expert skills (Ericsson *et al*. 1993). DP has been applied to thinking skills in chess players as well as physical skills in jet pilots. In general, DP focuses attention on areas of limitation with immediate feedback. With teacher support, the learning skill in the area of limitation is brought into balance with other skill strengths. The identification of learning style helps to determine not only the learning skills that are used with greater ease, but to also identify areas of skill limitation. Non-preferred steps in either the ELC or the JMF are an indication of potential underuse and underdevelopment.

If instruction were designed to conform to a learner's learning style, it would retard their learning by neglecting the very areas that need attention. The neglect of any part of the cerebral cortex will result in minimal neuron growth and consolidation in that area. Thus, a critical part of instruction is in metacognition, that is, in teaching "how people learn" (Bransford 2000).

Since the function of the brain during learning can be understood by both the teacher and the learner, we can identify their respective responsibilities in the educational process. Fulfillment of these responsibilities is the only sure route to producing lifelong learning as discussed in Chapter 15.

<u>Teacher responsibilities for whole brain learning.</u>

In the report of their key findings, a select committee of the National Research Council (US) provided three overall recommendations to be addressed in education (Bransford *et al*. 2000) and these form a basis for addressing teacher responsibilities for whole brain learning. The Council recommendations are summarized as:

1. Adopt a metacognitive approach to instruction to help learners become self-directed,

2. Engage learners at their preexisting level of understanding to help them grasp new concepts in order to prevent preparing only for the test and then reverting to preconceptions.

3. Teach selected high impact topics in greater depth to provide a contextual framework for organizing knowledge and solving problems.

Integration of metacognition

Learners can't develop whole brain thinking until they know what it is. A stage and age appropriate introduction to how we think and learn can be integrated into other existing topics in the curriculum. For example, it has been demonstrated that an inquiry based approach to physics that allowed students to compare reflective assessments with other students, the *Thinker Tools Curriculum,* produced higher achievement in sixth grade than those taught by conventional methods in grades 11 and 12 (White and Frederickson 1997). Information on teaching the Growth Mindset is available (Dweck 2006) and an introduction to the concepts and application of DP are explained in Ericsson, *et al*. (1993) and Colvin (2008). One of the key advantages to inclusion of principles of DP is that it teaches self-monitoring. Also, the focus on expert skill development is more favorable for producing high achievement than a focus on minimum adequate standards.

Preexisting level of understanding

The Constructivist model of learning prescribes that we design curriculum and instruction to build upon prior learning. However, prior learning from prerequisite courses or topics can be difficult to interpret from records alone. If learners have not learned through whole brain thinking, the likelihood of long term memory or of problem solving skills that match the course grades is unlikely. Many learners are capable of preparing for and performing on examinations and forgetting all of the knowledge tested within weeks, if not days. Thus, an understanding of how the learners have been assessed is important in determining their preexisting level of understanding. Assessment has no meaning without clear learning goals and objectives, and goals and objectives have no purpose without skillful assessment. Goals and objectives acquire a consistent meaning and are useful for planning lessons when they are classified within a taxonomy of learning complexity. A simple taxonomy has been proposed by Quellmalz (Stiggins, *et al*. 2000)[footnote4]. The five levels in increasing complexity are: 1) recall (facts, details) , 2) analysis (grouping), 3) comparison (similarities, differences), 4) inference (generating possibilities), and 5) evaluation (prediction). Each level uses the thinking skills of the levels below it and, likewise, each level engages the prefrontal cortex to a greater extent than the levels below it. The same topic can be taught and learned at any one of these levels of complexity, so when determining the preexisting level of understanding it is important to know the level in the taxonomy.

Regardless of the level of complexity in either objectives or examinations, each learner's learning style will have influenced their performance and their current level of understanding. By inclusion of instruments such as the Myers-Briggs Type Indicator to identify the learners' learning preferences, the teacher can individualize the application of DP to achieve whole brain learning. Examinations and other forms of assessment are much easier to compose when clear objectives have been written. Every objective, like every examination question can then be classified within the learning taxonomy. An example of one of the useful reference guides for writing learning objectives is Gronlund and Brookhart (2009).

Teaching topics in greater depth

Teaching in greater depth equates to whole brain thinking. It provides more factual knowledge needed for more thorough abstract conceptualization. More thorough conceptualization creates deeper understanding through more sophisticated active testing. Since time for teaching is limited, this approach cannot be comprehensive, nor does it need to be. The ability of the brain to transfer learning by generalization will extend the value of each in-depth teaching lesson.

The importance of dialogue during whole brain teaching cannot be overstated. Dialogue amplifies the entire ELC and the JMF sequence by engaging the whole brain. As learners speak to each other (frontal cortex), they are involved in active testing, because composing and expressing a thought can be successful, or a failure to communicate. Without a partner or team members, there would be no measure of sensibility or clarity. Learners will express their thinking primarily through their learning style so that an Intuitive type learner will use language that poses possibilities and alternatives, also matching the abstract conceptualization of the ELC. Those learners with the Sensing type learning style will benefit by hearing this expression and acquire this skill through transfer of learning. Equally important, however, the Sensing learner will also contribute facts and concepts that are missing and in doing so they fill in concrete experience and reflective observation (ELC) for the Intuitive learner. Dialogue that concerns problem solving always engages the whole brain for any learning style preference. It also engages the limbic system, not because all dialogue is emotional but because it involves people. There is an inherent satisfaction in reaching agreement or in debating the choice between alternatives.

Like interpersonal dialogue, internal dialogue can also be encouraged as a part of the process of DP. Speaking to oneself can be audible or silent, but an advantage is gained if it is made audible since the area of the brain responsible for speech (Broca's area) is in the frontal cortex. The development of self-assessment skills through self-talk is fundamental to DP. The research in DP shows that the moment self-assessment diminishes, skill performance becomes automated and deteriorates (Ericsson *et al*. 1993).

Learner responsibilities for whole brain learning.

Transformative learning theory (Mezirow 1997) encourages a change, or transformation, in the learner from a receiver of information to a producer of knowledge. The "receiver" approach best describes assimilative learning where learners simply acquire new information that fits into their preexisting knowledge. Assimilative learning does not require whole brain learning and as a result does not produce higher order thinking skills.

It is not surprising that the term "transformation" has multiple uses in educational thought. Education is permeated with transformational events. Information is transformed into knowledge, the brain is transformed into new physical arrangements, teachers are transformed through their own experience, and learners are transformed into self-directed producers of their own understanding. Whole brain learning requires all of these forms of transformation.

There are two primary areas of responsibility for each learner that are essential to achieve their transformation into a producer of their own understanding. These are summarized as:

1. Responsibility for conscious application of the Experiential Learning Cycle.

2. Responsibility for seeking assistance in Deliberate Practice.

Conscious application of the Experiential Learning Cycle by the student

The ELC can be consciously applied in a stepwise protocol. Each step can be a major focus and can be a task undertaken by either an individual learner or a group of learners. Such a stepwise protocol is only appropriate as an initial focus for developing thinking. The actual process of learning will involve a progressive blending of the ELC steps as the learner produces their own understanding of the concepts. A four stage learning model called the Conscious Competence sequence illustrates this (Figure 5, Howell 1982). The first stage, unconscious incompetence, represents the inexperienced learner. At this stage the dependence on a step-by-step ELC protocol is useful and helpful for organizing thinking. The second stage, conscious incompetence, represents the learner's first attempts at learning from new concrete experience. As progress is made in skillful use of the ELC, the learner is able to process the results of active testing in the ELC to produce self-directed learning and proceed to the third stage, conscious competence. Repeated use of the ELC produces meaning by refining the results of active testing for each experience. As the learner further associates these new meanings with new concrete experience through reflective observation, they freely employ any step in the ELC in any order that is appropriate – and, they are unaware of it. This final stage of unawareness in thinking is called unconscious competence. Thus, as the learner progresses through the Conscious Competence sequence to reach unconscious competence, they become less linear in their use of the ELC.

The conscious application of the ELC will prompt the learner to work first on establishing that all of the facts and concepts provided by the teacher are available for reflective observation. The learner has the benefit of teacher generated learning objectives and teacher provided instruction for this stage. The learner then employs reflective observation to find and verify definitions for new terminology. Other activities such as reviewing examples that have been taught as well as use of additional learning organizers provided by the teacher also facilitate reflective observation. The learner or group of learners then pose possibilities concerning the meaning of the new experience (abstract conceptualization). This can be a list of predictions of cause and effect, a reorganization of the material, or the construction of similarities or differences. It is worth emphasizing the advantage held by group dialogue at this stage since each learner will increase the total learning perspective from their own unique thinking. Finally, the different conceptualizations are tested through various activities that produce new concrete experience. Learners can explain their preference for one possibility compared to others, they can reorganize the material in a concept map, or they can predict the outcome of acting on a possibility.

If such a learning approach is habitual, it will become a skill that is used with increasing facility. Such a self-directed learner will automatically assume the responsibility for making certain that all the information from the experience is available, that the information has been recognized, that the experience has meaning, and that the meaning can be tested in order to generate new experience. At that point, the learner will produce their own knowledge.

Seeking assistance in Deliberate Practice by the student

Learners with the Growth Mindset experience high achievement through DP through an understanding of how their brain learns. Learners will demonstrate different preferences in learning and those preferences can extend to the psychomotor domain as well as the cognitive domain. The learner cannot make use of DP without both an awareness of their preferences and an awareness of how these preferences can be balanced. When the student is aware that their preferences are not limits on their learning, it permits a focus on developing non-preferred learning skills. The awareness of the ELC steps that they prefer and awareness of their Myers-Briggs personality type (JMF preferences) will be sufficient for any student to achieve this development. An understanding and acceptance of the Growth Mindset can only be accomplished by the learner. Without this mindset, DP will be ineffective.

The teacher's finest moment may well be in the assistance of the learner through DP. The learner is at their most vulnerable because they are getting feedback on the thinking that is least comfortable for them. The ability to support and guide the learner to persist in this development is one measure of a master teacher. Because DP is not fun, it may well produce results that are less dependent on intelligence and more dependent on motivation. Motivation like self-awareness is not in the teacher, it is in the learner.

Selected teaching and learning strategies

Examples are always helpful in illustrating the application of theory. There are many publications, such as Harmin (1995), that describe teaching strategies for application in the classroom. These learning strategies can be used to produce whole brain learning. The following additional selected strategies help to illustrate how teachers can help learners fulfill their responsibilities:

1. Flipped classroom
2. Prefrontal pause
3. Concept mapping
4. Question analysis

Flipped classroom

A flipped classroom (http://www.knewton.com/flipped-classroom/) delivers instruction online outside of the classroom so that homework can be completed in the classroom. This recent innovation was made possible by the ability to record lectures and other instruction and make it available on the Internet. Thus, learners work on the ELC concrete experience and reflective observation steps at home. During class time, the learners are able to clarify misunderstandings to complete the reflective observation step and then to complete the remaining ELC steps under the teacher's supervision. This facilitates the use of DP by supporting the needed individual development of learning skills for them to master whole brain thinking. The Intuitive type learners will have a greater ease with this process than the Sensing types. The primary concern of the Sensing type is that they need the certainty that they are coming up with the most correct possibility. The flaw here is clear. The most correct possibility isn't determined until the active testing step, but the Sensing learner is attempting to determine it from recognition (reflective observation). This is where the teacher can provide support by simply offering reassurance that it is natural for a brief period to not know something with certainty. The Sensing type learner will want the correct possibility to already be known. However, with regular support, the Sensing type learner will adapt and perform this ELC step with greater skill. Thus, this type of learner will become a more skilled learner through DP. The Intuitive type learner will experience difficulty with using all of the facts that are needed during the concrete experience and reflective observation steps of the ELC. Again, the teacher can provide support through exercises that facilitate present moment awareness and that temporarily discourage distraction from the "interesting" material. This illustrates the nature of a big picture learner. They become uninterested in details once they have formed their big picture.

Prefrontal pause

A prefrontal pause is a brief interruption at a suitable break point in the concrete experience step of the ELC, during a lecture for example, to allow the learners an opportunity to turn to a neighbor and discuss the answer to a question. The question is framed to use concepts just taught in the previous 10-15 minutes and it is a higher order question, not a recall question. The task could be to list the similarities between two concepts (Quellmalz – comparison level) or to list other components that would be part of a grouping (Quellmalz – analysis level). Because the question requires more than recall, it pushes the learner to think at the abstract conceptualization step of the ELC, or in other words, to use the front of their brain to make some decisions. Hence, the term "prefrontal pause." If the teacher labels the exercise consistently as a prefrontal pause, it will reinforce the learners' awareness of how they are using their brain and facilitate both the Growth Mindset and the application of DP.

Concept mapping

Concept mapping is a method of recording information that is otherwise contained in text or outline form by representing it as a series of bubbles, called nodes, containing one or more terms that name a concept and are connected by lines, called links (figure 4). The links can have additional terms such as verbs that are drawn on the line to clarify the nature of the link. A simple link represents a single fact. If a node is a grouping term then several links will branch from it. A branch point, then, becomes a level of hierarchy. When one branch is compared to another, a special type of link called a cross-link is created.

There are numerous definitions of a concept map. One definition refers to concept maps as "living documents." Since concept maps are hierarchical, they can continually be linked or networked by connecting new information, hence they "grow." The significance to this definition is that it relates directly to the Constructivist view that new knowledge is based on existing knowledge. Another definition for concept mapping is that it is a reading method (Pelley and Dalley, 2008). There is no other method that exceeds the depth of reading produced by the construction of a concept map. The only document that is read more thoroughly is a love letter:

> "…they read for all they are worth. They read every word three ways; they read between the lines and in the margins; they read the whole in terms of the parts, and each part in terms of the whole; they grow sensitive to context and ambiguity, to insinuation and implication; they perceive the color of words, the odor of phrases, and the weight of sentences. They may even take the punctuation into account. Then, if never before or after, they read."
>
> *(Adler, 1972).*

If a learner wants to consciously apply the full ELC to their learning, they can accomplish the task by constructing a concept map of the material that they want to learn. The first step in map construction involves the inspection of the material at hand for concepts that rank highest in the hierarchy, i.e. the grouping terms. Immediately, they are using concrete experience skills (the factual content), reflective observation skills (definitions, examples) and abstract conceptualization skills (determination of likely possibilities) to make a short list from which to begin the concept map. The actual construction of the map constitutes the active testing step as each concept is added. Evaluation of the map is achieved by verbalization of every concept relationship. If the map can guide dialogue that is understandable to both the learner and the teacher, it becomes a new concrete experience. Since each link placed in a map is a decision, it represents active testing skills in creating a logical hierarchy. The activity of recursively adding concepts to the map requires inspectional reading and analysis of options for representing them in the map.

Since the construction of a concept map involves every step in the ELC, it is an ideal tool for the development of learning skills through DP. Every learner will encounter greater ease with some of the steps in map construction and greater difficulty with others. A teacher working with a learner’s concept map in a flipped classroom is in a position to help with the areas of greater difficulty to strengthen whole brain learning.

Question analysis

Since they are so amenable to machine scoring and analysis, multiple choice questions dominate learning assessment. A test preparation industry has emerged in response to their importance in standardized testing, entrance examinations, and certification examinations,. Among the services provided by this industry is the provision of item banks of sample or representative questions. There are two main methods for using such questions: diagnostic and analytic. The diagnostic approach uses sample questions to identify areas of deficiency that are then reviewed by standard methods of study. This is inefficient and counterproductive for two reasons. First, the learner is attempting to refine learning in a general topic identified by the incorrectly answered question without establishing a concrete issue to learn. Second, the question itself contains needed information that can guide learning.

Question analysis follows four main steps (Pelley and Dalley, 2008): 1) concept identification, 2) verification of the correct answer, 3) verification of the incorrect answers, and 4) rephrasing to make some answer choices correct. Because the process requires research concerning all of the answer choices, it is less effective with questions requiring only simple recall. Question analysis can take the reader outside of assigned reading materials to additional resources when needed. All steps in question analysis require inspectional reading. While a learner might read passively in preparation for an examination, it is impossible to read passively while engaged in question analysis.

Concept identification requires the learner to verify that definitions are known and understood. Because all of the terms in the question are related concepts, there is a strengthening of the reflective observation step through pattern recognition and association. Verification of the correct answer requires that the learner determine a verbal rationale for justifying the correct answer. This requires a decision to include only the information necessary to make logical sense and excluding information that does not contribute to the rationale. This process seems subtle, but it trains the learner to give attention only to the subset of information relevant to the rationale. This involves the abstract conceptualization step by deciding between relevant and irrelevant information and active testing by verbalizing the rationale. Similarly, verbalization of the incorrect answers requires seeking out specific information that is relevant to the decision to rule out the incorrect answer. Again, decision making in the prefrontal cortex is selecting from all of the available information only that information needed to know that the incorrect answer is wrong. Verbalizing the rationale is the active testing that completes the ELC.

The question analysis is finalized by an attempt (not always possible) to rephrase the question to make other answer choices correct. This deepens understanding by strengthening associations which, in turn, strengthen reflective observation. The overall process has the benefit of causing the learner to review analytically an entire topic from the outcomes point of view. A test question can serve as a learning objective in this way and thus drive reading that covers the topic by using the entire ELC. An additional benefit is obtained since each incorrect answer in a proper test question is a rational alternative. That means that each can be a correct answer in a related question. Analysis of one question can prepare a learner for five or more questions on the examination.

Further study by those learning to be teachers will reveal similar use of the ELC in other active learning methods. Engaging all of the steps in the ELC to produce whole brain thinking, will transform learners from receivers of information to producers of their own knowledge.

From: Matheson, D. (Ed.) 2014. *An Introduction to the Study of Education*, 4th Ed., Routledge, London.

Epilogue

Educating a robot or any other machine only requires devising an algorithm to be programmed into the machine's memory, and it only requires this be done once. Machines provided with search/select algorithms can have a well-developed capacity for searching stored information and selecting that which is needed, but they lack the creative ability to determine what alternatives to apply this searching and selecting. Machines don't create alternatives to choose from, but people do.

Educating a learner requires that the instruction causes them to make decisions. They must make decisions that they can act on, that is, decisions they can experience. Ideally they must learn how to do this through Deliberate Practice using their own awareness of their learning style and its application in the Experiential Learning Cycle. Decision making learners are self-actualizing problem solvers that take their learning style into account.

Footnotes

Footnote 1: The concept of HOTS is functionally equivalent to critical thinking and/or analytical thinking skills.

Footnote 2: Each mental model provides a different window for looking into the mind. Each reveals its own metaphor of the working of the mind.

Footnote 3: Thus, the ELC helps us to delineate the responsibilities of the teacher and the responsibilities of the learner, a topic that will be discussed later in this chapter.

Footnote 4: A similar learning taxonomy, that of Bloom, has been referred to in Chapter 1.

References

Adler, M. and Van Doren, C. (1972) *How To Read A Book*. New York: Touchstone

Bransford, J. D., A. L. Brown, and Cocking, R. R. (2000) *How People Learn: Brain, Mind, Experience, and School*. Washington, DC: National Research Council.

Coffield, F., Moseley, D., Hall, E., and Ecclestone, K. (2004) *Should We Be Using Learning Styles? What Research Has To Say About The Practice*. London: LSDA.

Colvin, G. (2008) *Talent Is Overrated: What Really Separates World-class Performers From Everybody Else.* New York: Penguin Group.

Cuthbert, P.F. (2005) 'The student learning process: Learning Styles or Learning Approaches?', *Teaching in Higher Education*, **10**, 235-249.

From: Matheson, D. (Ed.) 2014. *An Introduction to the Study of Education*, 4th Ed., Routledge, London.

Dweck, C. (2006) *Mindset: The New Psychology Of Success*. New York: Random House.

Ericsson, K. A., Krampe, R., and Tesch-Römer, C. (1993) 'The Role Of Deliberate Practice In The Acquisition Of Expert Performance,' *Psychological Review*, **100**, 363-406.

Felder, R. M. and Brent, R. (2005) 'Understanding Student Differences', *Journal of Engineering Education*, **94**, 57-72.

Gardner, Howard (1993) *Frames Of Mind: The Theory Of Multiple Intelligences.* 2nd Ed. New York: Basic Books.

Gronlund, N. E. and Brookhart, S. M. (2009) *Gronlund's Writing Instructional Objectives*. 8th edn. Upper Saddle River, NJ: Prentice Hall

Harmin, M. (1995) *Strategies To Inspire Active Learning*. Edwardsville, IL: Inspiring Strategy Institute.

Howell, W.S. (1982) *The empathic communicator*. University of Minnesota: Wadsworth Publishing Company

Kolb, D.A. (1984) *Experiential Learning*. Englewood Cliffs, NJ: Prentice Hall.

Maslow, A. (1954) *Motivation and Personality.* 3rd Ed, New York: Harper and Row Publishers

Mezirow, J. (1997) 'Transformative Learning: Theory to Practice' *New Directions for Adult and Continuing Education*. **74**, 5–12.

Myers, I.B., McCaulley, M.H., Quenk, N.L., and Hammer, A.L. (1998) *MBTI Manual: A Guide To The Development And Use Of The Myers-Briggs Type Indicator*. 3rd Ed, Palo Alto, CA: Consulting Psychologists Press.

Ornstein, R. (1995) *The Roots Of The Self: Unraveling The Mystery Of Who We Are*. New York: HarperCollins Publishers.

Pashler, H., McDaniel, M., Rohrer, D., and Bjork, R. (2008) 'Learning Styles: Concepts and Evidence', *Psychological Science in the Public Interest*, **9**, 106-119.

Pelley, J.W. and Dalley, B. K. (2008) *SuccessTypes In Medical Education*, www.ttuhsc.edu/SOM/success.

Stiggins, R. J., Rubel, E., and Quellmalz, E. (1988) *Measuring Thinking Skills in the Classroom*, Alphareta, GA: National Education Association.

Riding, R. J. (1997) "On The Nature Of Cognitive Style', *Educational Psychology*, **17**, 29-49.

Stickgold, R. and Ellenbogen, J.M. (2008) 'Sleep On It: How Snoozing Makes You Smarter', Scientific American Mind, August.

White, B.Y. (1997) *The ThinkerTools Inquiry Project: Making Scientific Inquiry Accessible to Students*. Princeton, New Jersey: Center for Performance Assessment, Educational Testing Service.

Zull, J. E. (2002) *The Art Of Changing The Brain*. Sterling, VA: Stylus

Figure Legends

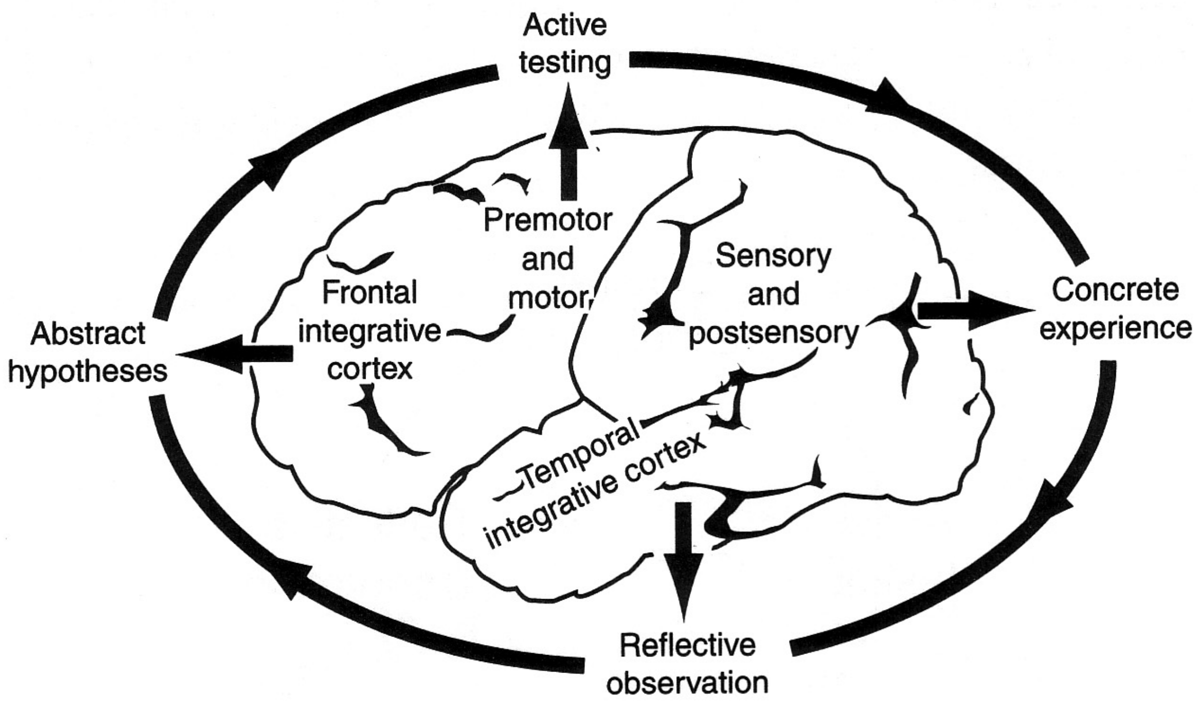
Figure 1. The link between functional areas of the brain and Kolb's Experiential Learning Cycle.

Figure 2. The Jungian mental functions: sensing, intuition, thinking, and feeling – an information processing model.

Figure 3. The Conscious Competence Cycle.

Figure 4. Concept map of "water."

Figures



Zull, 2002, The Art of Changing the Brain

From: Matheson, D. (Ed.) 2014. *An Introduction to the Study of Education*, 4th Ed., Routledge, London.

Figure 1

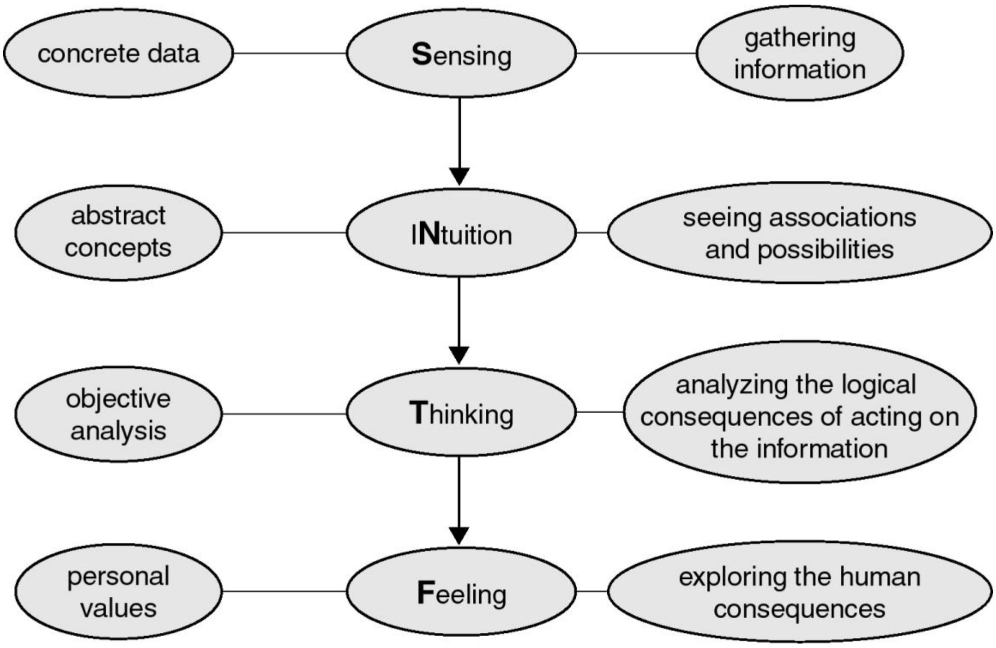


Figure 2

From: Matheson, D. (Ed.) 2014. *An Introduction to the Study of Education*, 4th Ed., Routledge, London.

Conscious Competence Cycle

Unconscious Incompetent (inexperienced)

↓

Conscious Incompetent (beginning to learn)

↓

Conscious Competent (meaningful learning)

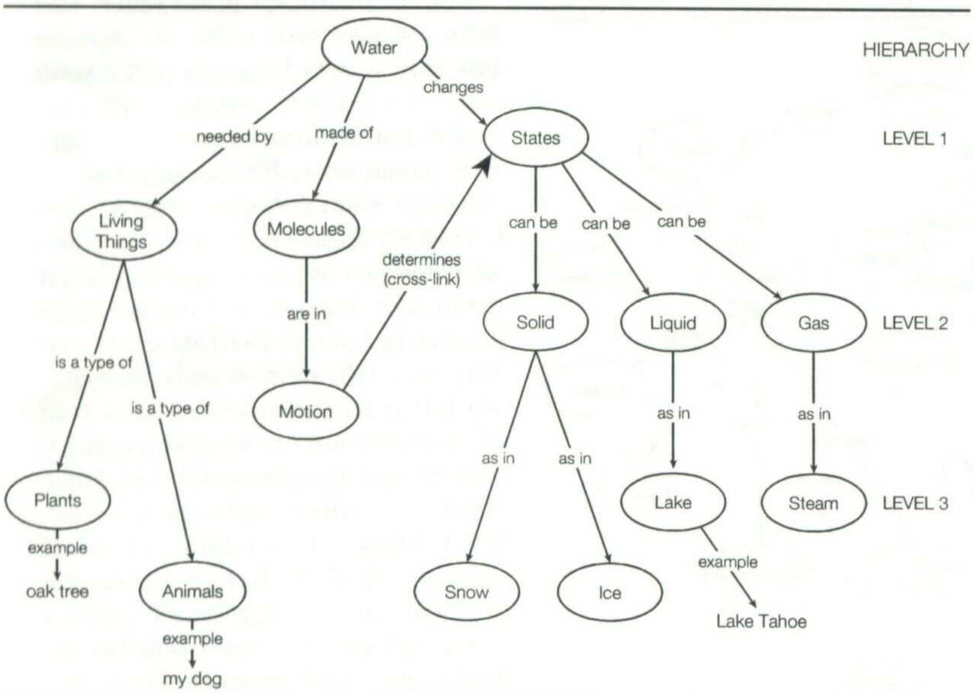
↓

Unconscious Competent (expert skills)

Figure 3

From: Matheson, D. (Ed.) 2014. *An Introduction to the Study of Education*, 4th Ed., Routledge, London.

Figure 1. Example Concept Map



Example map of *water* demonstrating the basic components of hierarchical concept maps. Note the cross-link (bold arrow) between the concepts *motion* and *states*. Reproduced with permission from Cambridge University Press.[14]

1106 JAMA, September 6, 2000—Vol 284, No. 9 (Reprinted) ©2000 Ameri

Figure 4