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Review of the current knowledge of brain-/mind-based learning to present the optimum climate for, and the guided experience approach to teaching

Ronald Jean Degan
International School of Management Paris

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Center of Research in International Business & Strategy

INDEA - *Campus 5*

Rua das Olhalvas

Instituto Politécnico de Leiria

2414 - 016 Leiria

PORTUGAL

Tel. (+351) 244 845 051

Fax. (+351) 244 845 059

E-mail: globadvantage@ipleiria.pt

Webpage: www.globadvantage.ipleiria.pt

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Review of the current knowledge of brain-/mind-based learning to present the optimum climate for, and the guided experience approach to teaching

Ronald Jean Degen
Ph.D. Candidate at the International School of Management Paris
Vice Chairman of Masisa Chile

Address:
E-mail: rjdegen@gmail.com
Phone: +55 21 8068 9000
Av. Pasteur 333 Botafogo/Urca
Iate Clube do Rio de Janeiro
22290-240 Rio de Janeiro, RJ
Brazil

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Abstract

The purpose of this paper is to review the current knowledge on brain-/mind-based learning, by drawing on the recent advances in cognitive science (particularly neuroscience) that have changed traditional education practices. The findings and theories that have influenced current understanding of learning are reviewed, without inclusion of the detailed descriptions of anatomical functioning of the human brain on with they are based (these descriptions can be found in the reference material). These findings, and the brain-/mind-based learning principles developed by Caine & Caine (1990), are used to describe the optimum climate for learning. Finally, the guided experiences approach to learning, as developed by Caine et al. (2009), is presented as the best way to develop the learner´s actor-centered adaptive decision making, and to thereby to strengthen an individual's executive functions (Goldberg, 2001) and ability to plan and organize thinking, use reason, engage in risk assessment, make sense of ideas and behavior, multitask, moderate emotions, work with longer time horizons, and think critically.

Keywords: brain-/mind-based learning, cognitive science, optimum climate for teaching, guided experience approach to teaching

Introduction

In the past, educators have assumed that learning takes place primarily through the memorization of facts and specific skills. This traditional approach has neglected the immense capacity of the brain to remember the thousands of bits of information occurring during moment to moment life experiences (a process that Hayek (1976) described as *mental maps*) and the capacity to instantly connect theses to other experiences. Similarly neglected is the innate predisposition of the brain to search for how things make sense (Caine & Caine 1991, p. 4).

Jensen (2008, p. 3) has observed that the word *brain* only started to replace the word *mind* in popular self-help books as late as the 1970s. He cited as examples the very successful books *Use Both Sides of Your Brain* by Buzan (1974) and *Drawing on the Right Side of the Brain* by Edwards (1979). Jensen further identified that it was not until the 1980s that brain-based learning emerged, driven by advances in neurobiology and cognitive neurosciences.

In his book *Human Brain and Human Learning*, Hart (1983) was one of the first researchers to establish the connections between brain functions and traditional education practices. He indicated that the cognitive process has been significantly impaired by traditional classroom practices. Hi research was followed by a number of new applications: for example, Gartner (1983), in his book *Frames of Mind: The Theory of Multiple Intelligences*, made a connection between brain functions and new models of thinking, and Caine & Caine (1991) made a connection between brain functions and classroom pedagogy in their book *Teaching the Human Brain*.

Cognitive science is the interdisciplinary study of the brain/mind, embracing philosophy, psychology, anthropology, sociology, education, linguistic, neuroscience, and artificial intelligence. The adjective *cognitive* derives from the noun *cognition* and is the scientific term for the capacity of processing information, for knowing, or more precisely, the process of being aware, thinking, learning and judging. The term is derived from the Latin root *cognoscere*, meaning to become aquatinted with, to know, to conceptualize, or to recognize.

In the 1990s cognitive science gained widespread acceptance, and neuroscience and education where definitively linked into brain-/mind-based education with the peer reviewed journal *Mind, Brain, and Education* (the official journal of the International Mind, Brain, and Education Society published by Wiley) and the master and doctoral programs in brain-based education offered at Harvard University Graduate School of Education.

Some relevant facts and theories about cognitive science

The philosopher John Dewey (1998), in his book *Experience and Innovation* (originally published in 1938) postulated that experience and knowledge are different. He explained that individuals learn by processing experience. The development of the human brain cannot be separated from life experience, as life experiences changes the brains psychological structure and operation.

The brain is always performing many actions simultaneously, and thoughts, emotions, and predisposition constantly interact with its information processing capability and with the ability to develop social and cultural knowledge. Everything that affects a person's psychological functioning affects that person's capacity to learn. The brain is a psychological organ functioning according to psychological rules (Caine & Caine, 1991, p. 80).

The branch of cognitive science that studies how the brain grows psychologically with the interaction with the environment is called *theory of mind*, and this refers to our understanding of ourselves and others in terms of an inner psychological state. Theory of mind is the ability to attribute mental states like beliefs, intents, desires, and knowledge to ourselves and to others and to understand that others have beliefs, intents, desires and knowledge that are different from ours. The acquisition of a theory of mind is an innate ability in humans that requires social and other learning experiences to fully develop. This ability is fundamental to human cognition and social behavior.

Extensive research has been done on the development of a theory of mind in the context of children (see Astington, Harris, & Olson, 1990;

Wellman, 1992; Sodian, 2005; Doherty, 2008; Sodian & Kristen, 2010). One of the most comprehensive was conducted by Josef Perner (1993) from the University of Salzburg, and is described in his book *Understanding the Representational Mind*. He conducted experimental work on the process wherein children develop a theory of mind, and offered a theoretical account of this development. He also provided examples of how increased sophistication in a child's theory of mind will improve their understanding of social interaction.

Curiously, it was not a psychologist but an economist, Friedrich Hayek (1976), who set forth the classic theory of mind, in his book *The Sensory Order: An Inquiry into the Foundations of Theoretical Psychology.* Hayek described the mental mechanism that classifies perceptions, and suggested that the qualities which we attribute to experienced objects are not the properties of the objects but a set of relations by which our nervous system classifies them. He explained that every sensation must be regarded as the interpretation of an event in the light of the past experience of the individual (or even of our species). He indicated that an experience operates on physiological events and arranges them into structures or orders, which then become the basis for their mental significance. This structure is subject to a process of continuous reorganization of the elements of the phenomenal world by interaction within the environment we live in. The relations between elements of this environment at any given time represent a kind of 'map' in our mind. This concept of a mental map, developed by Hayek, became a fundamental tool for analyzing brain mechanisms and behavior.

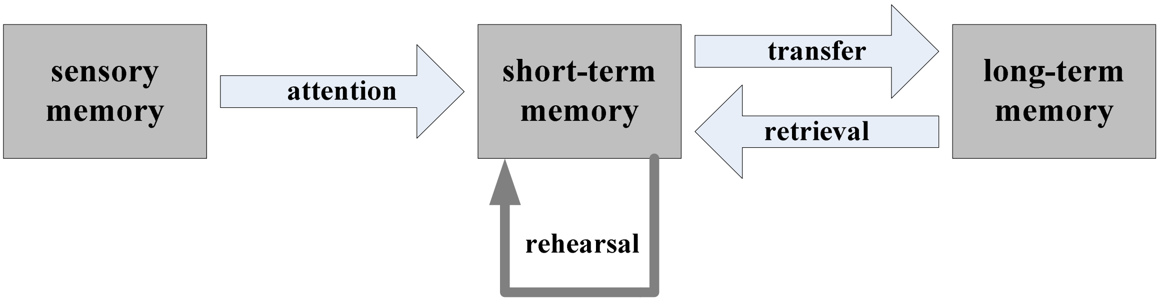
An important finding, initially made from studying rats, was that the brain changes as a result of the environment (Hebb, 2002, original published in 1949; Bennett, Diamond, Krech, & Rosenzweig, 1964; Rosenzweig, Love, & Bennett, 1968). The initial evidence that an enriched environment could enhance brain development was supported by further research (Greenough & Anderson, 1991; Jacobs, Schall, & Scheidel, 1993; Diamond & Hopson, 1998; Eriksson et al., 1998). Based on these and many subsequent studies, we now know that the human brain responds to challenging environmental stimulation by increased neurogenesis and growth (that is, an increased production of new brain cells), which consequently improves learning and memory. These findings mean that even through the human brain loses brain cells each day, new ones can be germinated in a enriching and challenging environment.

O'Keefe & Nadel (1978) have suggested that everything that happens to a person happens in space. They explained that spatial maps guide every person's movements and interaction with their surroundings, and that these maps are constructed in the person's memory. They have pointed out that the maps are not limited to psychical space, but that there are also mental maps of information (they called these *thematic maps*). These thematic maps are critical for the transfer of knowledge.

Psychologists have created models of memory to provide abstract representations of how memory is believed to work. The *multi-store model of memory* (also known as the *Atkinson-Shiffrin memory model*) was proposed by Richard Atkinson and Richard Shiffrin (1968) and remains a popular explanation of how memory processes work (see Figure 1). According to this model, the human memory involves a three-stage sequence:

> **Sensory memory** retains the impressions of sensory information (visual and/or sound) after the original stimulus has ceased. These impressions are retained temporarily in the sensory registers, which have a large capacity for unprocessed information, but are only able to hold accurate sensory information momentarily. Miller (1956) explained that of all the information that reaches the sensory register, a person will focus only on the few "chunks" or maps of information that seem important. He also noted that the normal capacity of an individual is about seven such maps and that only these maps move into the short-term memory.

Figure 1. The Multi-store Model of Memory, Also Known as the Atkinson-Shiffrin Memory Model



Adapted from "Human Memory: A Proposed System and its Control Processes," in K. Spence & J. Spence (Eds.), *The Psychology of Learning and Motivation* (Vol. 2, p. 89–195). New York: Academic Press.

Short-term memory (also called *primary* or *active memory*) holds a small amount of information. According to Miller (1956), the maximum is seven (plus or minus two) maps of information active in mind, which are in a readily available state for a very short period of time. For these maps in temporary hold to become long-term memory a process of rehearsal and/or meaningful association is needed (Miller, 1956).

Long-term memory holds information for as little as a few days, or for as long as decades. The information stored is subject to fading in the natural forgetting process. For the information to last for years, several recalls/retrievals may be needed (Miller, 1956) and/or meaningful association is needed (Miller, 1956).

Attention is the cognitive process of selectively concentrating on one of the maps while ignoring the others, so that the map will be stored in long-term memory. The pioneering psychologist and philosopher William James (2007, pp. 403-404), in his textbook *Principles of Psychology*, explained attention as follows:

> Everyone knows what attention is. It is the taking possession by the mind, in clear and vivid form, of one out of what seem several simultaneously possible objects or trains of thought. Focalization, concentration, of consciousness are of its essence.

> It implies withdrawal from some things in order to deal effectively with others, and is a condition which has a real opposite in the confused, dazed, scatterbrained state which in French is called distraction, and Zerstreutheit in German.

The human brain is constantly performing many tasks at once (Ornstein, Sobel, & Crnstein 1999): it is continually attempting to match, compare, categorize, and pattern new information with what it has already stored, in order to discern and understand patterns as they occur and to create unique patterns of its own (Hart, 1983; Luria, 1973; Nummela & Rosengren, 1986; Caine & Caine, 1991). The constant search for meaning to make sense of environmental experiences, and the need to act on these experiences, is automatic. This activity is survival oriented and therefore fundamental to the human brain.

The process of meaningful organization and categorization of information by the brain was called *patterning* by Nummela and Rosengren (1986, May). This process is done by the brain almost instantaneously (Hart, 1975) and in random order on both conscious and unconscious levels. Because the brain works with patterns, it resists having meaningless patterns (patterns that are unrelated to the already stored patterns, such as a simple, unrelated list) imposed on it (Caine & Caine, 1991, p. 80).

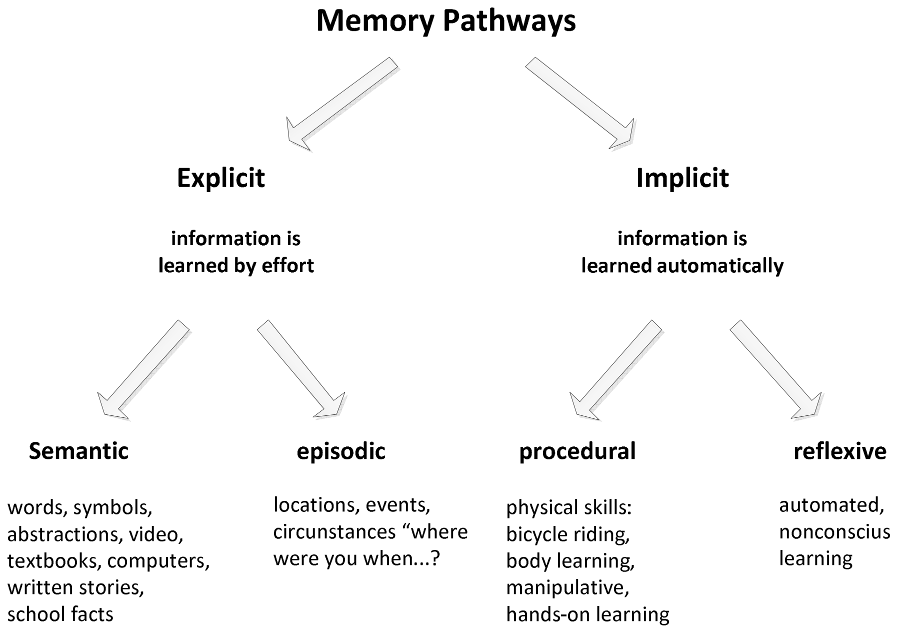
Memorization (the memorizing of a list of names, for example) and the recall of an enriching life experience (such as a dinner last night) are two fundamentally different activities for the human brain (Caine & Caine, 1991, p. 37):

> Recalling the list will usually require repetition and some connected effort at memorization. The second task, recalling dinner, on the other hand, is almost ridiculously easy. Details such as the type and quality of food, who served, the furniture, floor, room layout, and so on are embedded in our memory. Yet never once did we repeat to ourselves during the meal: "Peas, peas, peas" or "blue carpet, blue carpet" to ensure memory of the meal.

The reason that information is learned automatically is that if its content is embedded in context (which means that it is stored in relationship to a particular location, circumstance, or episode) memory forms quickly, is easily updated, requires no practice, is effortless, and is used naturally by everyone. On the other hand, if information is isolated from context (facts that are usually derived from reading and studying) it is learned only by effort and memory forms (or attempts to be formed) only through rote practice or memorization (Jensen, 2008, p. 163). It is difficult for the brain to remember content when it is removed from context.

The ways that the brain deals with information define two major memory pathways to learning (Jensen 2008, p. 163). The first is the *automatic learning* or the *implicit learning* memory pathway, and the second involves learning by effort or the *explicit learning* memory pathway (Figure 2). Implicit learning can be subdivided into reflexive or automated non-conscious learning, and into procedural or hands-on physical skills learning. Explicit learning occurs in two primary ways: information embedded in context is stored in the episodic memory (which means that it is related to a particular episode) and information embedded in content is stored in the semantic memory, which means that it is related to facts that are usually derived from reading and studying.

Figure 2. Two Major Memory Pathways to Learning



Adapted from Jensen 2008, *Brain-based Learning: The New Paradigm of Teaching* (2nd ed.). Thousand Oaks, CA: Corwin Press, p. 163.

The difference between the two basic explicit learning pathways has been explained by Jensen (2008, p. 164):

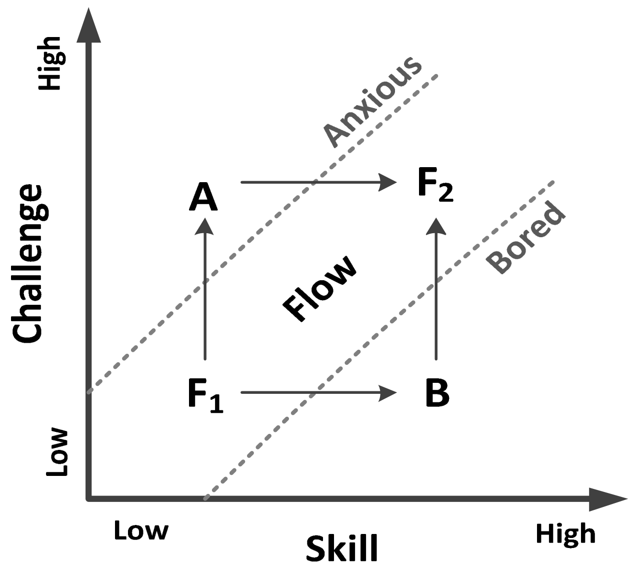
> Episodic memory forms quickly, is easily updated, requires no practice, is effortless, and is used naturally by everyone. What did you have for dinner last night? This question triggers your episodic memory. Not only will context cues help you remember the answer, a body movement or posture, particular music, smell, sound, and so on can trigger your memory.
>
> Semantic memory, on the other hand, is usually formed (or attempted to be formed) through rote practice or memorization. It requires rehearsal, is resistant to change, is isolated from context, has strict limits, inherently lacks meaning, and is linked to extrinsic motivation. If I ask you, "Who was the author of the book we read last night?" your semantic memory is being tapped. This memory pathway is more difficult to establish; it is unnatural and requires practice and consistent rehearsal to encode.

It is now well-established that a person's learning ability is directly affected by motions (Freiberg, 1999). Learning is positively affected by relaxation and challenge and inhibited by perceived threats. Caine, et al. (2009, p. 21-33) explained that the foundation for success in every endeavor is the right state of mind. They have termed the optimal state of mind for learning "relaxed alertness", as shorthand for describing the individual's self-efficacy as the innate belief in herself and her ability to achieve.

To effectively learn, the individual earn must be given the right learning challenges. These must be motivating and compatible with existing abilities (not to easy to bore and not to difficult to frustrate) so that the optimal cognitive state (termed by Csikszentmihalyi (1991, 1996 and 2008) as flow) can be reached. This is the mental state in which a person living an experience is fully immersed in this with a feeling of energized focus, and is completely involved in its process (in some cases to a degree of neglecting all other activities). The person living such an optimal experience is only satisfied when mastering or succeeding with the challenge of the experience.

Flow, according to Csikszentmihalyi (1991, pp. 71-77), can only occur when the experience or activity that the person is performing represents a challenge that forces the person to develop skills. He called this an *optimal experience* (Points F_1 and F_2 in Figure 3). If the challenge is too easy for the person (does not require to develop skills to perform), the person becomes bored (Point B in Figure 3). On the other hand, if the challenge is too difficult for the person (who does not have the required skills to perform it), the person becomes anxious and frustrated (Point A in Figure 3).

Figure 3: Optimal Experience



Adapted from Csikszentmihalyi, 1991, Csikszentmihalyi, M. (1991). Flow: The psychology of optimal experience. New York: Harper Perennial. (Original work published 1990), p. 74

A person living an optimal experience is continuously in flow. Each time the person develops the required skills to meet the challenge (person moves from F_1 to B in Figure 3), the challenge grows proportionally and the person returns to flow (person moves from B to F_2 in Figure 3). If the challenge is too great for the person capability to develop the required skill the person becomes anxious and frustrated (person moves from F_1 to A in Figure 3), and will (in most cases) abandon the optimal experience or require coaching to develop the required skills to return to flow (person moves from A to F_2 in Figure 3).

When a person is adequately challenged for a limited period some positive stress (eustress) occurs, and the body releases chemicals like cortisol, adrenaline, and norepinephrine, which heighten perceptions, increase motivation, and strengthen the body: All conditions that enhance learning. On the other hand, if a person feels threatened by some danger, intimidation, embarrassment, loss of prestige, fear of rejection, or general helplessness negative stress (distress) occurs the brain loses its ability to correctly interpret subtle clues from the environment and reverts to familiar, tried-and-true behaviors (Jensen, 2008, p. 43). The narrowing of the perceptual field of a person under some perceived treat was termed by Hart (1983) as *downshifting*.

Emotions also influence how and what a person learns. The individual's emotions and mindset (based on expectations, personal biases and prejudices, degree of self-esteem, and the need for social interaction) influence the meaningful organization and categorization of what she learns (Caine & Caine, 1991, p. 82). For this reason emotion and cognition cannot be separated. Emotions also facilitate the storage and recall of information in the brain (Rosenfield, 1988). Any life experience with a strong emotional impact may be remembered for a very long time.

Information is absorbed by the brain when it is aware of it, and when the person is focusing attention to it. But the brain also absorbs information that lies beyond the field of direct attention. These are stimuli associated with the information that a person perceives within its field of peripheral attention but that are not consciously noticed. This indicates that the brain responds to the entire sensory context in which the information is generated (O'Keefe & Nadel, 1978).

Miller & Cohen (2001, March) argued in their influential article "An Integrative Theory of Prefrontal Cortex Function" that the cognition processes of planning, cognitive flexibility (the ability to switch behavioral response according to the context of the situation), abstract thinking, rule acquisition, initiating appropriate actions and inhibiting inappropriate actions, and selecting relevant sensory information, are managed by the cognitive control that is the primary function of the prefrontal cortex. The cognitive control is theorized in psychology as cognitive system that controls and manages other cognitive processes. These are also referred to as the *executive functions* (Goldberg, 2001; Molfese & Molfese, Eds., 2002; Miller, Vandome, & McBrewster, Eds., 2010).

People with developed executive functions have the ability to plan and organize their thinking, use reason, engage in risk assessment, make sense of ideas and behavior, multitask, moderate emotions, work with longer time horizons, think critically, access working memory, and reflect on their own strengths and weaknesses (Caine, Caine, McClintic, & Klimek, 2009, p. 9). Anatomically, the executive functions are present in infancy in very basic and limited ways. They reach maturity sometime in late adolescence or early adulthood (Caine, Caine, McClintic, & Klimek, 2009, p. 13).

The executive function of a person cannot be developed by memorization, and can only be developed in a very limited way by teaching by others. According to Goldberg (2001), a person requires the opportunity for actor-centered adaptive decision making. This is a process in which the actor-centered decisions are the results of questions the person asks that driven by their own purpose, needs, and interests, and relate to the person's current experiences (Caine, Caine, McClintic, & Klimek, 2009, p. 12).

Goldberg (2001) has differentiated between actor-centered adaptive decision-making and veridical decision making. Adaptive decision-making capitalizes on the person´s need to know, and results in answers that are meaningful to the persons. This sparks thinking and the search for solutions. Veridical decision making relies on what is known to the person and what was discovered by others. It relies for the solutions on known answers.

Alertness and memorization are also influenced by each individual's biocycles. Jensen (2008) explained how the hormones released into a person's bloodstream every two hours alter (sometimes dramatically) the person's mood and learning capacity:

> Based on measurements of psychomotor tasks, intellectual tasks, affective state tasks, and physiological function tasks during various times of the day research reveals that overall intellectual performance (thinking, problem solving, debating) peaks in the late afternoon. Although comprehension increases as the day progresses, reading speed decreases (p. 24)… Our short-term memory is best in the morning and least effective in the afternoon, as opposed to our long-term memory, which is generally best in the afternoon (p. 25)… Our brains consistently run on two learning cycles: a low-to-high-energy cycle and a relaxation-to-tension cycle. Learners often focus better in the morning and early evening, and are more pessimistic in the middle to late afternoon (p. 27).

Research has revealed that one of the brain's key cycles is the high/low biocognitive cycle, which alters blood flow and breathing. The brain's right and left hemispheres alternate cycles of efficiency (from high verbal/low spatial to high spatial/low verbal processing abilities) every 90 to 100 minutes (Klein, & Armitage, 1979; Kennedy, Ziegler, & Shannahoff-Khalsa, 1986; Orlock, 1998; Jensen, 2008, p. 26). The implication of this is that the brain switches from right-brain to left brain dominance 16 times throughout the day. Research also suggests that at each low end of a cycle a person's attention decreases, signaling that the brain needs a break. This is the explanation for the natural attention and productivity highs and lows that affect people during the day.

Brain-/mind-based learning principles

Caine & Caine (1990, p.66) tried to make sense of all the findings and theories of cognitive science research. They wrote:

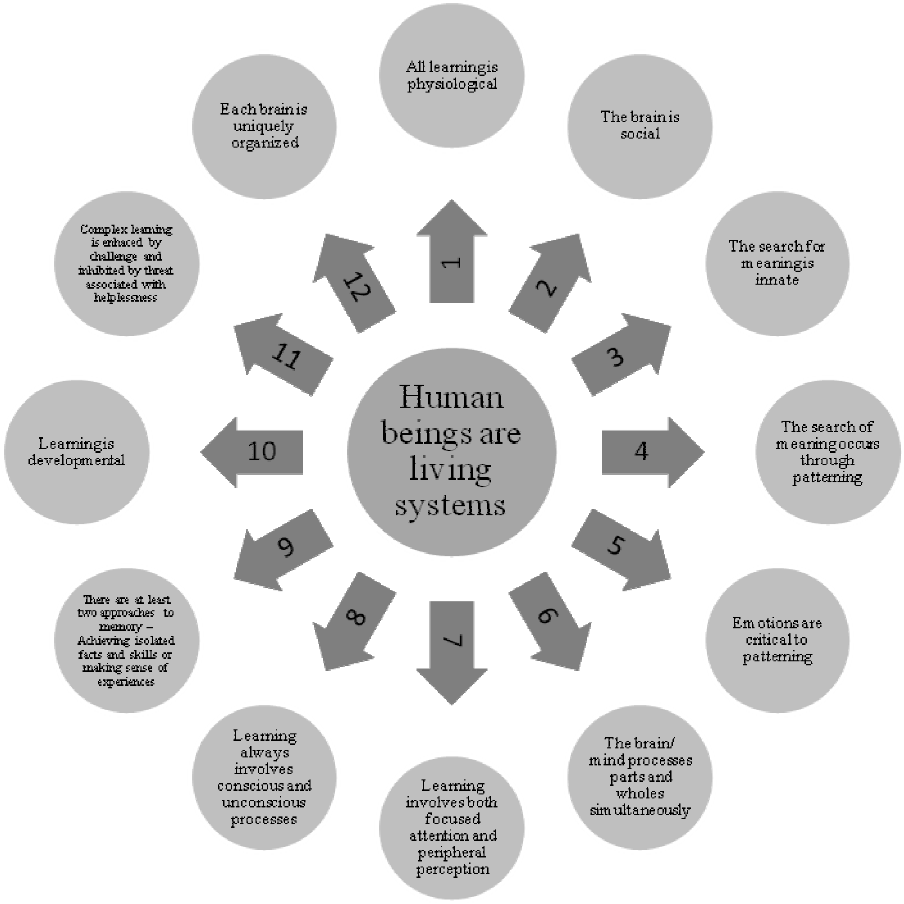
> The great challenge of brain research for educator's does not lie in understanding the anatomical intricacies of brain functioning but in comprehending the vastness, complexity, and potential of the human brain… We offer the following brain principles as a general theoretical foundation for brain-based learning. These

principles are simple and neurologically sound. Applied to education, however, they help us to reconceptualize teaching by taking us out in defining and selecting programs and methodology.

These principles were subsequently expanded in their book *Making Connections: Teaching and the Human Brain* (Caine & Caine, 1991), and more recently they were slightly adapted in a new book *12 Brain/Mind Learning Principles in Action: Developing Executive Functions of the Human Brain* (Caine, Caine, McClintic, & Klimek, 2009). These twelve brain/mind based learning principles (Figure 4) are:

1. All learning is physiological
2. The brain/mind is social
3. The search for meaning is innate
4. The search for meaning occurs through patterning
5. Emotions are critical to patterning
6. The brain processes parts and wholes simultaneously
7. Learning involves both focused attention and peripheral perception
8. Learning always involves conscious and unconscious processes
9. There are at least two approaches to memory: archiving isolated facts and skills and making sense of experience
10. Learning is development
11. Complex learning is enhanced by challenges and inhibited by threat associated with helplessness
12. Each brain is uniquely organized

Figure 4. The Twelve Brain/Mind Learning Principles



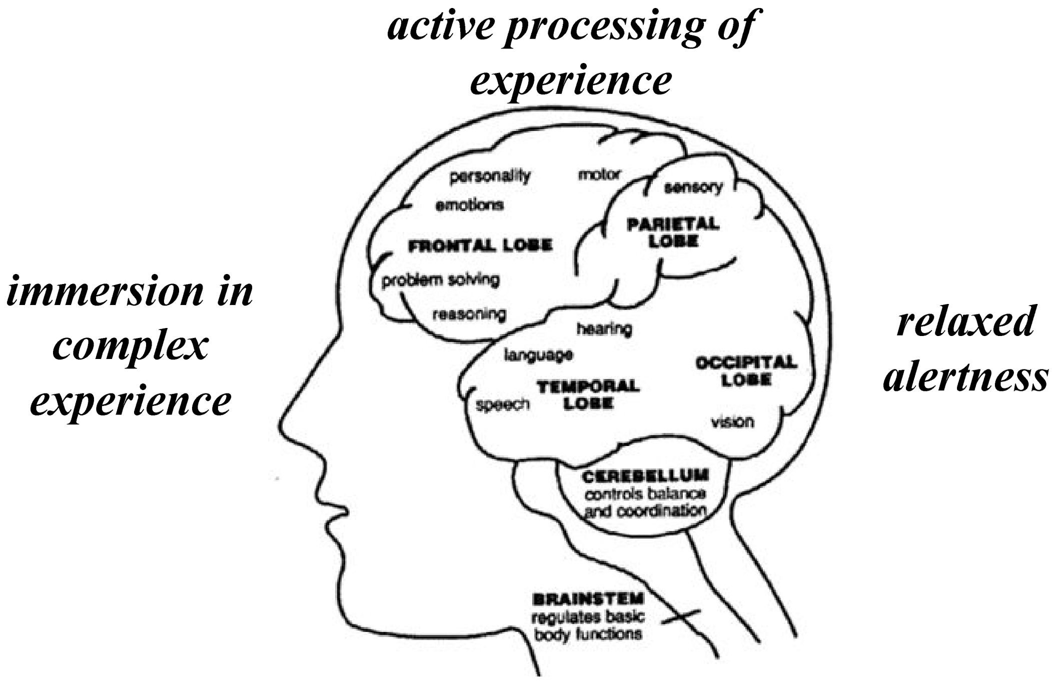
Adapted from Caine, R. N., Caine, G., McClintic, C., & Klimek, K. J. (2009), 12 brain/mind learning principles in action: Developing executive functions of the human brain (2nd ed.). Thousand Oaks, Cl: Corwin Press. (Original work published 2005) p. 4.

The authors explain that each principle may seem obvious, but that the principles are gateway to deeper understanding, and can help educators better understand the link between social relationship, brain development, and learning. They also explain that the principles are not separate and discrete. They describe learning as a system´s property, wherein each principle has a specific focus but involves aspects of others (p. 3-4).

Optimum climate for teaching

These principles suggest that there are three fundamental components or critical elements to great teaching that profoundly affect each other (p. 6). These critical elements (Figure 5) are *relaxed alertness* (the optimal emotional climate for learning), orchestrated *immersion in complex experience* (the optimal opportunity for learning), and *active processing of experience* (the optimal way to consolidate learning).

Figure 5. The Three Critical Elements to Great Teaching That Profoundly Affect Each Other



Caine & Caine (1991, p. 126-145) have suggested that *relaxed alertness* is the optimal state of mind for meaningful learning. People in this state experience low threat and high challenge. Essentially, the person is relaxed and excited or emotionally engaged with the learning experience. This state of mind encourages people to take risks in thinking, to question paradigms, and to experiment with new ideas. This is the state that Csikszentmihalyi (1996) called *flow* and is essential to mastering new skills or engaging in executive functions. It is the state in which the learner feels competent and confident and has a sense of meaning or purpose (Caine, Caine, McClintic, & Klimek; 2009, p. 21). Relaxed alertness draws on the following learning principles (numbers from Figure 4):

> (11) Complex learning is enhanced by challenge and inhibited by threat associated with helplessness and fatigue, meaning that

people learn more effectively in a supportive, empowering, and challenging environment;

(2) The brain/mind is social, meaning that people learn more effectively when their social nature and need for relationship are engaged and satisfied;

(3) The search for meaning is innate, meaning that people learn more effectively when their interest and ideas are engaged and respected; and

(5) Emotions are critical to patterning, meaning that people learn more effectively appropriate emotions are elicited by the learning experience.

The *immersion in complex experience* involves, for example, transformation of information from a page or blackboard to convey it into the person's mind (Caine & Caine, 1991, p. 107- 125). To achieve this, the person has to be immersed into a complex and enriching experience or environment, which provides the best opportunities for remembering facts and skills while also encouraging and nurturing the development of the mind and the use of executive functions. Creating the richest learning immersion in complex experience draws on the following learning principles (numbers from Figure 4):

(6) The brain/mind processes parts and wholes simultaneously, meaning that people learn more effectively when their experience gives them a sense of the whole that links the details (facts and information);

(1) All learning engage the physiology, meaning that people learn more effectively when involved in experiences that naturally call on the use of their senses, action, movement, and decision making;

(4) The search for meaning occurs through patterning, meaning that people increase learning when new patterns are linked to what they already understand; and

(10) Learning is development, meaning that people learn more effectively if their specific differences in maturation and development during the learning experience are taken into consideration.

People acquire knowledge or learn by processing experiences (Dewey, 1998). Thus the *active processing of experience* (digesting, thinking about, reflecting on, and making sense of experience) is the way to acquire knowledge or to consolidate and internalize information in a way that is both meaningful and conceptually coherent (Caine & Caine, 1991, p. 146 - 158). The process of digesting experience and consolidate learning draw on the following learning principles (numbers from Figure 4):

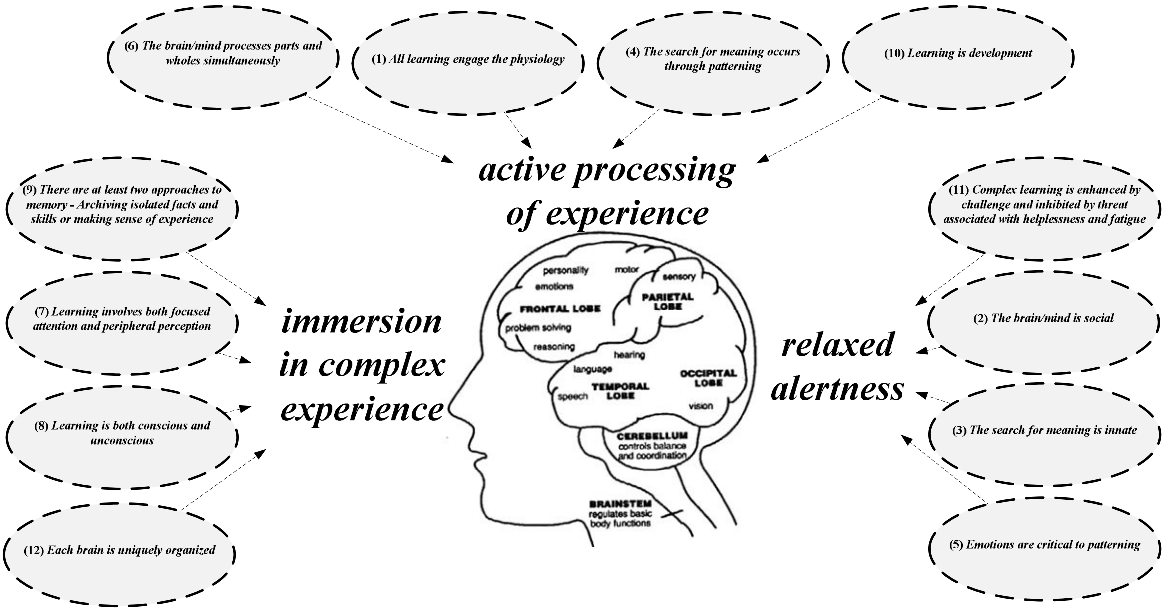
(9) There are at least two approaches to memory (archiving isolated facts and skills or making sense of experience), meaning that a person can use root memorization to remember isolated facts and information. This requires a special effort and engages the executive functions in only minimal ways, or uses the dynamic memory to naturally process experiences in which case learning is more effective, because it engages the executive functions in multiple ways to remember facts and information;

(7) Learning involves both focused attention and peripheral perception, meaning that people can learn more effectively when their attention is deepened and multiple layers of the context are used to support learning;

(8) Learning is both conscious and unconscious, meaning that people learn more effectively when given time to reflect and acknowledge their own learning; and

(12) Each brain is uniquely organized, meaning that people learn more effectively when their unique, individual talents, abilities, and capacities are engaged.

Figure 6: The Optimum Climate for Teaching



The three critical elements to great teaching (Figure 5), based on the twelve brain/mind learning principles (Figure 4), define the optimum climate for learning (Figure 6).

Model of brain/mind approach to teaching

The most effective brain/mind approach to teaching is a model developed by Caine et al. (2009, pp. 266-270) which has focused on guided experiences in an optimal teaching environment. The purpose is to develop the learner’s knowledge by motivating her to understand and make sense of experiences with strong use of actor-centered adaptive decision making. The emphasis on actor-centered adaptive decision making develops the learner´s executive functions (Goldberg, 2001) capitalizing on the need to know. Understanding and knowledge grows out of answers to questions the learner asks herself, which are driven by her own purpose, interests, and need to search for meaning.

The guided experiences must be real-world projects with an embedded academic curriculum, driven by the learner’s choices and interests. The purpose is to go beyond normal academic standards through ongoing questioning, investigation, and documentation by the learners based on experts on the chosen field. This will work only if the instructor (or leader) and learner establish an authentic partnership (or team) with shared procedures and expectations. The instructor must have a clear sense of the essential skills and knowledge that the learner has to master to succeed, and coach the learner to reach these goals.

Using the guided experiences approach, learning does not occur via the traditional method of direct transmission from the person who knows (the instructor) to the one that doesn´t (learner). Learning is embedded and consolidated by the learner´s active processing of experiences. Knowledge and skills are developed by the learner's search for meaning and answers to her questions.

Caine et al. (2009, p. 269) developed some simple and practical guidelines for the use of the guided experiences approach to learning (Table 1). They point out that all applications of the approach will always be different in many ways, but that the described phases of the learning cycle will be present regardless of subject matter, focus, or discipline.

Figure 7. Guidelines for the guided experiences learning approach

Instructor Preparation	Learning Cycle	Active Processing
Know the standards to succeed	Create authentic teamwork	Process continuously to achieve standards
Identify critical concepts learners need to master	Develop global experience	Critical concepts
Know all critical facts and skills to be mastered	Engage research questions	Critical facts and skills
	Organize preliminary research groups	
	Develop rubrics for research	
	Allow for learners research	
	Support in-depth research	
	Assist in planning documentation of research	
	Develop rubrics for documentation	

Adapted from Caine, Caine, McClintic & Klimek; 2009, p. 269

They also emphasize that the approach will work only if the optimal climate for learning is established, and authentic teamwork is developed between instructor and learners.

Conclusion

Since Hart (1983) first established the connection between brain functions and traditional education practices, much researched on brain-/mind-based learning and teaching has been undertaken. Most of the research work has been aimed at correcting individual learning deficiencies, based of the state of the advances in psychology and neurology. This paper has highlighted the relevant findings and theories that influence learning and orient effective teaching, without the description of the anatomical intricacies of the functioning of the human brain on with they are based. For those interested, the descriptions can be found in the reference material.

Two references greatly influenced the research for this paper, and can be considered a reading requirement for those that wish to teach effectively. The are: *12 Brain/Mind Learning Principles in Action* (Caine et al., 2009) and *Brain-based Learning* (Jensen, 2008).

The most objective proposal for a teaching approach based on brain/mind based learning is the guided experiences approach described in this paper, which was developed by Caine et al. (2009, pp. 266-270). This approach is currently being tested by the author to teach the practice of innovation to future entrepreneurs (Degen, 2010).

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O autor

Ronald Jean Degen
Is in the Ph.D. Program of the International School of Management in Paris, and the Vice Chairman of Masisa in Chile. . He was a Professor at the Getúlio Vargas Graduate Business School of São Paulo where he pioneered the introduction of teaching entrepreneurship in 1980 and wrote the first textbook in Portuguese on entrepreneurship published in 1989 by McGraw-Hill. He just published a new textbook on entrepreneurship that was published in 2009 by Pearson Education. He was President (CEO) of Amanco Brasil and Argentina, CPFL - Companhia Paulista de Força, and Elevadores Schindler. He also was General Manager of Editora Abril, and Listel (the company he started in 1983).

E-mail: rjdegen@gmail.com