Development of a model for whole brain learning of physiology

Saramarie Eagleton¹ and Anton Muller²

¹Department of Human Anatomy and Physiology, Faculty of Health Sciences, and ²Faculty of Management, University of Johannesburg, Johannesburg, South Africa

Received 25 January 2011; Accepted 19 July 2011

LEARNING is a complex and field, often ill understood. Current research in the area is increasingly conducted in domains outside psychology, the domain from which many of the central concepts and theories of learning originate (8). With this model, an attempt is made to integrate learning styles into instructional design for physiology.

Most of the existing research on learning styles is based on a single facet of learning and has a learning style inventory associated with it. Some of the most popular learning style schemes include the VA(R)K instrument, which categorizes learning preferences as visual (V), auditory (A), reading-writing (R), or kinesthetic (K) (4). The learning styles for this study were grouped according to Curry’s onion model as those associated with personality, information processing, and instruction and the environment (13).

Learning styles associated with personality include Carl Jung’s psychological types, which are based on how information is perceived and processed during learning (36); the Myers-Briggs personality type indicator is another example and is primarily concerned with the valuable differences in people that result from where they like to focus their attention, the way they like to take in information, the way they like to decide, and the kind of lifestyle they adopt (37). Keirsey’s temperament sorter addresses the relationship between temperament, character, and personality (24).

Learning styles that describe learning based on information processing include Lewin’s cycle of learning, which gives details on the role of concrete experience, reflective observation, abstract conceptualization, and active experimentation in learning (34). This cycle was elaborated on by Atherton (2), Kolb (26), Honey and Mumford (22), and McCarthy, with the 4MAT cycle of learning (29). Different perspectives from the cyclic events of learning have been presented by Herrmann (20) and Neethling (33), who explain the role of the four quadrants of the brain in learning.

The role of instruction in learning has received attention from Bransford (11), who described anchors during instruction, De Bono (15), who elaborated on lateral thinking, and Bandura (3) and Vygotsky (40), who explained the social aspects of learning. The role of environmental factors during learning has been described by Carbo et al. (9).

These different facets of learning need to be integrated to provide educators with a framework of what learning entails. Various models have been used to simplify and categorize learning (8). The model proposed by this article describes whole brain learning based on an elaboration of a recognized model described by Lynn Curry, who used the metaphor of an onion to describe three levels of learning (13). The innermost layer represents the role of personality in learning, the middle layer refers to information processing, and the outer layer stands for the role of the environment and instruction on learning. In the proposed model, the two innermost layers of Curry’s model are integrated with Neethling’s four quadrants of the brain. The learning styles associated with personality and information processing are categorized into the model. Kolb’s cycle of learning is integrated with this combined onion and quadrant model. The constructivist principles of learning are categorized in the information-processing layer into the four quadrants. The outermost layer houses the role of environmental preferences, as described by Carbo et al. (9), and the different instructional preferences that encompass face-to-face and technology-assisted learning. This proposed model can be used to encourage whole brain learning for physiology students.

Development of the Model

Dunn and Dunn (16) explained that learning styles involve “...the way in which individuals begin to concentrate on, process, internalize, and retain new and difficult information.” Slater et al. (37) added that learning style is the manner in which and the conditions under which learners most efficiently and effectively perceive, process, store, and recall what they are attempting to learn. These processes involve personality and information processing.
Knowledge of learning style preferences can help lecturers to assist students to develop effective curricular approaches. Learning style information can also benefit students as they learn about themselves and general learning theories (4). A holistic learning environment nurtures all aspects of learning and helps to establish a supportive learning community (27).

Here, a model for whole brain learning was developed based on Curry’s onion model, which is based on three levels of learning (13). A diagram (Fig. 1) to illustrate these levels was designed to represent the role of personality traits in learning in the inner layer, the role that information processing plays in learning in the middle layer, and the role of the instruction and environment in learning in the outer layer.

**Personality traits.** In the central layer of the thematic learning style model, the focus is on the ability to acquire and integrate information. This refers to an individual’s approach to assimilate and adapt information. This adaptation does not involve interactions with the environment, as these underlying personalities constructs form part of personality (25). In this article, personality typing was based on the research of Carl Jung (36) and Katherine Myers and Isabel Briggs-Myers (32).

The personality traits that have an effect on learning were grouped into the four quadrants of the brain according to Neethling’s four-quadrant model (33). Neethling explained that the different characteristics that suit each quadrant of the brain are based on left and right hemisphere preference. The left brain (hindquarter) is for structured processing; the left brain (front quarter) is for analytic processing; the right brain (front quarter) is for holistic processing; and the right brain (hindquarter) is for emotional processing. Front quarters refer to cortical processing, whereas hindquarters represent limbic processing.

Figure 2 shows the integration of personality traits and Neethling’s brain profile.

The next layer of the proposed model represents the role of information processing in learning.

**Information processing: perceptual modalities and cognitive strategies.** The middle layer of Curry’s onion model represents the intellectual approach to assimilate and process information during learning. This layer is not as stable as the inner layer representing the personality and can be “modified” by instruction. The ways in which people perceive and process information affect how they learn. Different styles are of equal value or can be equally effective at task performance; the same level of performance can be attained in different ways (12).

The perceptual modality is a biologically based reaction to the physical environment and refers to the primary way that the body takes in information. Perception could be visual, auditory, or kinesthetic (27). Perceptual differences affect what and how information is received. People do not use all of their senses to the same extent (18).

Cognitive styles refer to thinking processes that are used to organize, shape, and retrieve perceived information (27). Descriptions of these styles make use of dichotomies to represent the extremes of the dichotomy of each style. The styles should, however, be seen as a continuum between the two extremes. Cognitive styles that have been found to influence learning include left brain versus right brain (5), reflective versus impulsive (41), concrete versus abstract (27, 38), sequential versus global (42), and sensing versus intuitive (25).

Information-processing models focus on an individual’s cognitive approach and processes by which information is obtained, sorted, stored, and used. Knowledge about information processing gives the student vital in-class learning mode...
preferences as well as cues for being aware of possible lecturer learning style preferences (21). This layer is considered to be relatively stable because it does not directly interact with the environment.

In the proposed model, information-processing styles are represented in the second layer of Curry’s onion model and integrate Kolb’s experiential learning styles (26) into the four quadrants of Neethling’s brain model (33). Kolb described the learning cycle as being a concrete experience, followed by observation and reflection, followed by abstraction and generalization, which culminate in active experimentation. Strategies for active learning in each of the quadrants were incorporated into the four quadrants: critical-thinking activities for students who prefer to use the left cortical quarter of the brain (1) and learning structured to use inquiry for those who have a preference for the left limbic quarter of the brain (19). Lateral thinking exercises will develop right cortical functioning of the brain (15). The right limbic quadrant of the brain is used for problem-solving activities (17). An illustration of the integrated model for information processing that was developed is shown in Fig. 3.

The outermost layer of the proposed model for whole brain learning represents the role of the environment and instructional preferences in learning.

Environmental and instructional preferences. The outermost layer houses the role of environmental preferences that affect learning, as described by Burke and Dunn (7), as well as the instructional preferences that distinguish between face-to-face and technology-assisted. This layer, representing the environmental and instructional preferences, is shown in Fig. 4.

A diagram (Fig. 5) was designed to illustrate the integration of personality traits, information-processing styles, and environmental and instructional preferences. This model was used to describe how the integrated learning styles can be applied to teach physiology to undergraduate students.

Application

This model can be used to inform physiology lecturers on the design of learning interventions to stimulate whole brain learning.

The central layer. This layer is used to describe the personality traits that influence learning.

Thinkers decide on things impersonally on analysis, logic, and principle. Thinkers value fairness, focusing on the situation’s logic and placing great weight on objective criteria when making decisions. Feelers make decisions by focusing on human values and needs. They tend to be good at persuasion and facilitation (6).

Judging people are decisive and self-regimented. They prefer making agendas, timetables, programs, lists, and outlines. These students want to know what the essential elements are and then focus on completing a task. By committing themselves to set schedules, they tend to stop looking for alternatives, and, by doing so, they may never know what they are missing. They prefer to complete one task before starting the next. Perceptive people are curious, adaptable, and spontaneous. They start many tasks, want to know everything about each task, and often find it difficult to complete a task. These students are more likely to be adaptable and tolerant; however, they need freedom and flexibility. They find it difficult to stick to deadlines (27).

Introverts find energy in the inner world of ideas, concepts, and abstraction. Introverts are concentrators and reflective thinkers; they want to understand the world. While they can be sociable, they need to be left alone to recharge their batteries. Extraverts find energy in things and people. They prefer interactions with people and are action oriented. They are “on-the-fly” thinkers (6).

The middle layer. This layer is used to distinguish between the perceptual and information-processing styles that influence learning.

Perceptual preferences differentiate between the preferred ways of attaining information. Visual students do not remember well what they only hear. They extract detail from the background, remembering faces rather than names. They are very imaginative, with a keen visual memory. These students need to see the facilitator’s body language and facial expressions to understand the content. They usually sit in the front of the room and take copious notes, are neat and clean, but often doodle, and need a quiet environment to learn their best. They may think in pictures and learn best from visual displays, including diagrams, illustrated textbooks, overhead transparencies, videos, flipcharts, and handouts (41). Auditory students often do better talking to a colleague or tape recorder and hearing what was said. They have difficulty with reading and writing tasks. For auditory students, information that has been written down will have little meaning until it has been heard. They do not form a mental picture but remember the way a word sounds. These students often remember names but not...
faces, do not take notes in class, hum or talk to themselves when bored or concentrating, read aloud under their breath, enjoy talking, and will often do well in a noisy environment (42). **Kinesthetic** students require whole body movement and real-life experience to absorb and retain material to be learned. These students learn best when they are totally involved. Acting, puppetry, and drama are excellent examples of kinesthetic learning. Other methods are using building, designing, visiting, interviewing, and playing as instructional methods (41).

Students have different preferences for processing information. **Sequential** students are reflective, convergent students who prefer learning material to be serial or sequential. They can easily separate important details from a complex or confusing background. They tend to rely on themselves and their own thought system when solving problems. They appear to be more active, autonomous, self-motivated, and task oriented in their approach to life. **Analytic** students resist distractions and have a longer attention span and greater reflectivity than global students have. They tend to be more sedentary and prefer formal learning situations. They can be very competitive. They are usually not so skilled in interpersonal relationships (38, 40, 41). **Global** students are impulsive, divergent students and prefer learning material to give a holistic view and to be randomly presented (31). Global students find it difficult to see the parts in a whole. Persons who are “labeled” as global rely on the environment of the learning situation for structure. They are sensitive to social cues without being alerted to them. They are interpersonally oriented and rely heavily on external stimuli. This motivates them to look toward others for reinforcement of opinions and attitudes. These students have a short attention span, are easily distracted, and like informal learning situations. They respond to learning environments that evoke their feelings and experience. They are less achievement oriented and competitive than sequential students. For them, learning is a social experience (38, 40, 41).

**Concrete** students use real materials and examples for learning; they deal with physical expression of information. They are hands-on experiential students, and they need examples, models, and templates. **Abstract** people prefer pictures and explanations. They learn through lectures and accept theory well. They are book students, enjoying metaphorical expression (27, 38).

The learning process has to pass through the four brain quadrants within the cognitive domain. Within each of these quadrants, one of the stages of Kolb’s learning cycle describes the learning events that need to take place. Each of the quadrants can also be related to a constructivist activity. The **left limbic quadrant** represents logical activities. It is the brain quadrant responsible for sensing and experiencing new information through inquiry. The **left cortical quadrant** is where observations and reflections take place and requires critical thinking. The **right cortical quadrant** is for abstract analysis and allows for lateral thinking, whereas activities in the **right limbic quadrant** are for taking action and solving problems.

The outer layer. The outer layer of the proposed model refers to instructional and environmental preferences. The instructional preferences that are referred to are used to distinguish between face-to-face and technology-assisted learning.
Advances in educational technology have made it possible to implement blended teaching, incorporating both face-to-face and technology-assisted instructional intervention. Face-to-face interventions can combine lecturing, cooperative group activities, tutorials, and practical sessions, whereas technology-assisted learning can be used to create vivid, playful, interactive learning environments that support multimedia presentations as well as adaptive online exercises and virtual discussions that allow for greater student control of learning (22). Technology-assisted learning can be used effectively in physiology by including simulations of experimental procedures and making use of interactive animations of physiological processes. Neither of these instructional strategies have been proven to be more effective than the other under all circumstances; however, they can be used to complement each other (33). All interventions need to be planned to incorporate the learning strategies as described by the inner layers of the model. A number of educationalists have described the role that the environment plays in student learning (7, 10, 17, 28). The role that the teaching environment plays is the most adjustable variable. Students are either stimulated or inhibited by the location in which they are trying to learn. Their reactions are determined by their biological makeup. While some students need sound, either noise or music to learn, others need silence to be able to study. Light intensity has an effect on the ability to learn; whereas some prefer bright light, others need dim light to optimize their learning. Heat perception varies among people. Physical discomfort interferes with the ability to concentrate. Students differ in their ability to sit and study at a conventional desk, a bed, a lounge chair, a couch, or on the floor. Students squirming in their seats to try to find a comfortable position are often accused of fidgeting and urged to sit still. Students’ environmental needs are important to them and are beyond their control. Although these needs may change over time, these changes are very gradual (9).

Limitations. The model needs to be “tested” by physiology lecturers to determine if it has an effect on the students’ ability to understand physiology. Students also need to give feedback if they understand better if they are taught according to their preferred way of learning while also being challenged to use different learning strategies to encourage whole brain learning.

Future directions. The importance of understanding the role that learning styles play in the learning of physiology requires further investigation. The role of whole brain learning strategies can be investigated and compared for students registered for different modules in physiology to guide both lecturers and students. The objective is to improve the understanding and application of physiology, especially for students embarking on medical and paramedical careers.

Conclusions. The information gathered during the extensive literature search were integrated to conceptualize learning and motivate the principles for the development of the proposed model. This model, based on Curry’s onion model, merged personality traits, information-processing strategies, and instructional design and environmental preferences to enlighten instructional design for learning interventions. This model relates the personality traits central to learning to the different quadrants of brain preference according to Neethling’s brain profile. These personality preferences are encircled by the different information-processing preferences for each brain quadrant. The different stages of Kolb’s learning cycle were classified into the four quadrants associated with the different brain processing strategies within the information-processing circle. Each of the stages of Kolb’s learning cycle were associated with a specific cognitive learning strategy. These cognitive strategies have been related to the stages of Kolb’s cycle in the information-processing circle. The inner circles are enclosed by the circle representing the role of the environment and instruction. It relates the environmental factors that affect learning to the overall learning process and distinguishes between the significance of face-to-face and technology-assisted learning.

This study makes a contribution to the field of instructional design for physiology in that lecturers are alerted to the importance of incorporating learning strategies that make provision for the personality, information processing, and environment and instructional needs of different students.

GRANTS
This work was funded, in part, by the National Research Foundation’s Thuthuka program and the University of Johannesburg.

DISCLOSURES
No conflicts of interest, financial or otherwise, are declared by the author(s).

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