BRAIN PLASTICITY AND THE ART OF TEACHING TO LEARN

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ABSTRACT

Everyone thinks of changing the world, but no one thinks of changing himself," wrote Leo Tolstoy. Have you ever thought about how learning changes your brain? If yes, this paper may help you explore the research that will change our learning landscape in the next few years! Recent developments in the neurosciences and education research are beginning to have a significant impact on our understanding about empowering individuals to learn more successfully.

Neuroscientists are exploring brain processes and the implications on human learning. They are urging educators to gain a better understanding of the brain plasticity research for improving educational practice. In this paper, readers will see for themselves how specific learning activities change the brain and provide a framework for enhancing the learning process. This framework should follow a 4-step learning process, including sensing, recognition, interpretation, and finally action or integration. Readers will both visualize and experience the learning process and explore their own disposition to learn, examine the theory that grounds this research, and consider strategies and pathways that lead to improved learning for diverse learning audiences.

THE NEUROSCIENCES AND LEARNING

After years of brain research, scientists are discovering brain changes that are important to learning and memory. "In the past, researchers believed that our genes were the main determinants of brain development" (Ariniello, 1997). Many of the popular myths of how people learn have been discounted with recent discoveries. One of the most popular myths was that mental capacity diminished overtime due to the death of hundreds of brain cells each day. Research shows that the brain can and does grow new brain cells (neurogenesis) regardless of age, especially through exercise or in stimulating environments (Exercise 1999; Gould et al. 1999).

Ongoing learning and brain development has implications for life-long learning and improved learning ability, especially for online learners where greater self-motivation and self-direction is needed. Brain research also has implications for career development. "There clearly were more synapses found in subjects with intellectually skilled professions, such as engineering or teaching," said James E. Black, (University of Illinois, Beckman Institute for Advanced Science and Technology). "Subjects with more professional training had 17 percent more synapses for each neuron than did their less educated counterparts. "Synapse formation is thought to be a means of storing the information obtained through experience," (University Of Illinois At Urbana-Champaign, 1999).

Fortunately, with the growing understanding of how the brain works comes the opportunity to provide more appropriate solutions to empower learners. Educators need to rethink what they have learned about the mind, learning, and memory and apply new strategies that tap into the brain's mechanism for learning. This is a wonderful time to be an educator because powerful new technology tools are helping scientists revolutionize most fields, including the field of education.

BRAIN PLASTICITY

Brain plasticity refers to how the brain changes to learn and organize in response to influences and experiences. It is the brain's ability to "be shaped and modified by growth of new and more complex connections among cells. Some neurons develop up to 50,000 connections, a mind-boggling number when one considers there are billions of neurons in the brain" (Eslinger, 2000). As an adult, when we change our behavior due to new sensory input influencing learning and memory, brain plasticity (i.e., new synaptic connections) occurs to adjust to the stimulus in the brain cells. According to a long-standing theory, learning takes place and memories form when the same message travels repeatedly between specific cells in the brain. Communication between these cells grows stronger with repetition and multiple processing. The more we practice a skill, the more the automatic the skill becomes. Eventually the cells no longer need to be stimulated by an outside source such as a teacher or input from the senses. (Cromie, 2002).

The contemporary neuroscience research considers the ongoing evolution of the brain's limbic system (the brain's emotional center) and suggests that what gets our attention (and stimulates negative or positive emotional response) influences how the brain engages in strengthening synaptic connections in the cerebral cortex (Brown University, 2000). Regarding memory, the "most popular candidate site for memory storage is the synapse, where nerve cells communicate with each other. A change in the transmission efficacy at the synapse (called "synaptic plasticity") has been considered to be the cause of memory and a particular pattern of synaptic usage or stimulation (conditioning or priming stimulation) is believed to induce synaptic plasticity--stimulating new neuronal connections and communication. Many questions remain to be answered, such as how synaptic plasticity is induced and how synaptic plasticity is involved in creating in learning and memory hence, the search for Lashley's engram (1950). Lashley suggested that learning was a distributed process and alteration that could not be isolated within any specific part of the brain. "We are now at the dawn of an era when we can use these technologies to see pathways in the brain that underlie emotions such as fear and desire" (National Institute of Mental Health, 2001). Scientists have learned to use neuroimaging technology to see the living, thinking, feeling human brain live at work. Neuroimaging tools include functional magnetic resonance imaging (fMRI), which uses magnetic fields and radio waves to elicit signals from the brain, and positron emission tomography (PET), which uses low doses of a radioactive tracer to obtain signals from the brain" (National Institute of Mental Health, 2001). "As the sciences of developmental psychology, cognitive psychology, and neuroscience, to name but three, have contributed vast numbers of research studies, details about learning and development have converged to form a more complete picture of how intellectual development occurs" (Bransford, Brown and Cocking, 1999).

In other areas, research shows how brain function depends on synaptic connections (Ledoux, 2002, 1996) supporting the communication between trillions of nerve cells in the human brain. Research in synaptic communication between neurons, called synaptic plasticity, is critical for understanding higher brain functions such as learning and memory (Liang & Huganir, 2001).

"The amazing discovery of the brain's plasticity---its ability to physically rewire itself to become smarter---makes mental stimulation, in the long run, more essential to the body than food. That the brain thrives with good nourishment is a concept that has profound significance for individual achievement and for the way parents raise their children. The brain's food is education. Just as the food we eat gives our immune systems the strength to fight off life-threatening infectious germs, education protects us against bad choices. In effect, education acts like a vaccine that boosts our mental powers, making us more resistant to illness and premature aging. Education provides such strong immunity, in fact, that people who acquire more of it are living longer than ever before while those who don't have it are falling farther behind. It is the secret to a healthier, longer life" (Kotulak, 1996).

RESEARCH-BASED PEDAGOGICAL MODELS

Understanding the mechanisms and processes of brain plasticity is essential to understanding learning and improving educational pedagogical models. Today's research has contributed greatly to what we understand and support how individuals like to learn, especially how individuals like to learn and perform differently.

One powerful, consistent finding to emerge from recent advances in neuroscience is the realization that how individuals want and intend to learn differently is a powerful force in how well they manage information, plan, set, and meet goals, learn and perform tasks, and succeed as learnerssome more successfully than others. What is becoming clear is that recognizing and supporting emotional differences in learning to motivate and prepare lifelong learners for a fast-moving economy has escalated to a national priority, especially as information resources increase geometrically.

Rapid scientific and technology changes demand that enough learners are prepared in our educational system to learn smart, fast, and well enough to manage today's fast-paced changes and leadership challenges--successfully and productively. What are the characteristics and solutions involved for more successful learning, despite the differences in learning ability? Developing a "best practice" research-based framework (for design, teaching and learning strategies) that supports differences in learning and improved performance is critical.

Neuroscience research is becoming more sophisticated in exploring how humans learn and particularly how emotions and intentions influence synaptic connections and dendrite growth. At Duke University, researchers are seeking to identify parts of the brain that are associated with multiple processing of input and emotional responses. Researchers at Rutgers have identified cypin, a protein in the brain that regulates and increases dendrite growth when a person learns. Cypin acts as a mortar to the dendrite structure. "An increase in the number of branches provides additional sites where a neuron can receive information that it can pass along, enhancing communication" (Rutgers, 2004).

Researchers at the University of Wisconsin- Madison's Child Emotion Research Laboratory explored how individuals differentially perceived and categorized emotions. These researchers are suggesting that the neural brain processes used to perceive and categorize emotions are both innate and influenced by different environments and experiences. At Brown University, researchers are considering evidence that learning engages a brain process called long-term potentiation (LTP), which in turn, strengthens synapses in the cerebral cortex (Brown University, 2000). At University of Illinois (Beckman Institute for Advanced Science and Technology), researchers are using electron microscopes to count synaptic connections between brain cells (neurons) in healthy people. Results are showing that individuals in more sophisticated professions have more synaptic connections developed through education and professional commitment.

"Studies from around the world show that early stimulation is important to brain development. An enriched environment can boost the number of neural connections that children form. Even animal studies have shown a significant relationship. For example, William Greenough of the University of Illinois exposed one group of rats to a stimulating environment. A second group was housed in standard drab cages. The animals housed in the enriched environments had 25% more connections among their brain cells" (Rauscher, 1997).

If one considers research in other fields, such as marketing or advertisement, tapping into emotions to personalize experiences is a common practice. For example, advertisers or marketers may use a personalization strategy to ensure that customers can tell them who they are, what they value, what they want and how they want it, thus achieving "emotional lock-in" and brand recognition and loyalty. Emotional lock-in is also a foundational concept for learning. Successful instructors identify those key attributes that nurture or drive a similar "emotional lock in" for their audiences and integrate them, along with other key learning attributes, into a more personalized learning model. New pedagogical models should enable instructors and designers to leverage the power of personalization analytics (e.g., audience analysis, measurement, tracking, data collection, and reporting), while still maintaining control and flexibility via the objectives, strategies, context, sequencing, and delivery elements that have long been conventionally integrated into learning solutions.

What is included in the frameworks that can provide learner-centered [and biology-centered] psychological principles and contribute to educational reform and school redesign efforts (Board of Educational Affairs, American Psychological Association, 1997)? What are the challenging measures and goals that can help researchers isolate key learning variables and audience attributes that can influence more "emotionally" successful learning?

New pedagogical and assessment models should help learners understand and know how to (1) feel comfortable and enjoy learning, (2) explore reasons for learning and committing effort and attention to continuous, persistent learning, (3) determine and manage what they already know, determine what they do not know, and acquire what they need or want to know to create new ideas, (4) set and extend challenging goals by building towards accomplishment and improvement, (5) self-motivate, plan, commit resources and mix and match strategies and skills to accomplish short- and long-goals, sometimes beyond those expected by others, (6) improve sophisticated learning ability skills (e.g., problem-solving, holistic thinking, critical thinking, and task-sequencing) with practice, (7) gain confidence, satisfaction, and expertise over time, and (8) self-assess, monitor progress, schedule, and reflect to enhance learning and empowerment.

BRAIN STRUCTURE AND A LEARNING CYCLE

These multiple areas of research in the neurosciences are providing more specific information to develop individual differences in learning constructs for improved learning that consider more than the primarily cognitive aptitude perspective. The hegemony of the cognitive perspective is receding due to advances in neuroscience research.

"Considering the curiosity that the brain has inspired in scientists for a very long time, it is perhaps surprising that a model of learning based on neural function has taken so long to influence pedagogy." (Leamnson, 2002, p. 75). Recent advances in the neurosciences warrant a new look at interpreting how the brain learns.

As Zull (2001) suggests, "without biology, the learning cycle is theoretical." Needed are measurable psychological constructs based on proven or evolving biology-centered models that help researchers (a) isolate brain activity (input, processes, and responses) as primary sources for learning differences, (b) measure related underlying psychological factors and interactions, and (c) explain the impact of specific factors (e.g., conative, affective, cognitive, and social factors) on more successful learning and performance.

In working towards a more comprehensive human learning theory, educators need to identify strategies that can help learners take the difficult steps in the learning cycle that lead to creating new ideas and taking risks. "Acquisition of complex knowledge and skills requires extended learner effort and guided practice. "Without learners' motivation to learn, the willingness to exert this effort is unlikely without coercion" (Board of Educational Affairs, American Psychological Association, 1997).

Scientists often discuss the four areas of the brain's cerebral cortex shown in Figure 1 when they discuss learning and memory.

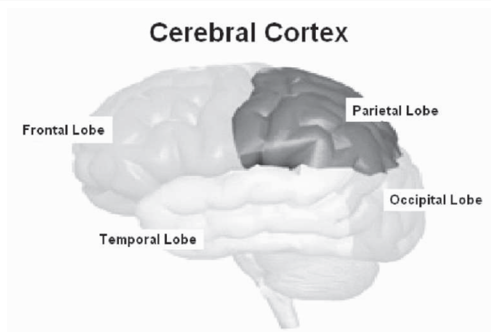

Figure 1. Brain Structure of the Cerebral Cortex

The parietal lobe is typically described as responsible for the brain's ability to sense stimuli (e.g., through taste, vision, feeling, or hearing).

The occipital lobe is typically described as responsible for the brain's ability to recognize stimulus and connect to what we already know (e.g., in long-term memory) to establish meaning.

The temporal lobe is typically described as responsible for the brain's ability to interpret, process, and plan to create new meaning.

The frontal lobe is typically described as responsible for the brain's ability to reason, create new meaning, problem solve and commit to action.

Educators for years have often used a learning cycle model as a tool for planning instruction. Kolb

(1984)described four steps, including concrete experience, observation and reflection, the formation of abstract concepts, and testing in new situations. Kolb (1984) used these four steps to describe a framework for a continuous or repetitious learning process that supports practice and feedback towards more experiential learning. Similarly, McCarthy (2000) provided a 4-step teaching model for curriculum development using experiencing, reflecting, abstracting, and acting. Educators can begin using recent advances in the neurosciences to find evidence that empirically recognize a natural learning cycle. Zull (2002) overlays Kolb's 4-step learning cycle (similar to those shown in Figure 2) to roughly estimate and match what we know about the 4-part brain structure to demonstrate how the entire brain engages in learning and memory.

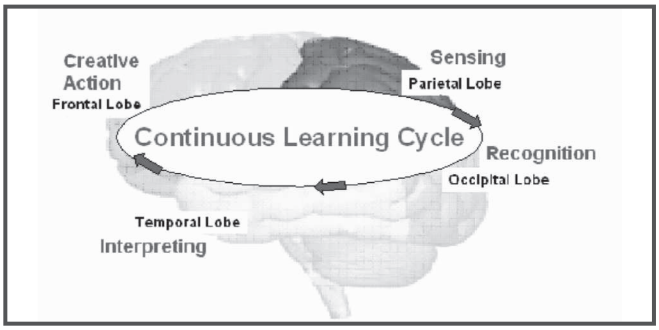

Figure 2. Connecting the Brain to Kolb's 4-Step Learning Cycle

Zull (2002) describes the learning process by discussing the brain connections that change data into knowledge. They represent the brain's ability to (1) receive signals via the senses, (2) recognize, connect, and reflect, (3) abstract the information, and (4) generate a plan for action as the occasion requires.

Thousands of signals are received simultaneously each competing for the individual's attention and response. Also in Figure 2, the learning appears in two sections: (1) Sensing and recognition in the "back cortex" area to illustrate the reception and transformation of signals into meaning connecting to long-term memory and (2) interpretation and creation in the "front cortex" area to illustrate the planning, abstracting, and creation of new ideas and action.

Zull (2002) suggests that we can imagine a Transformation Line (shown in Figure 3) between the "back" and "front" cortex areas that once bridged creates a change in the learner from a receiver to a producer or from a passive to a more active learner. It is the ability of the learner to move past this imagined transformation line that influences the individual's more successful learning ability.

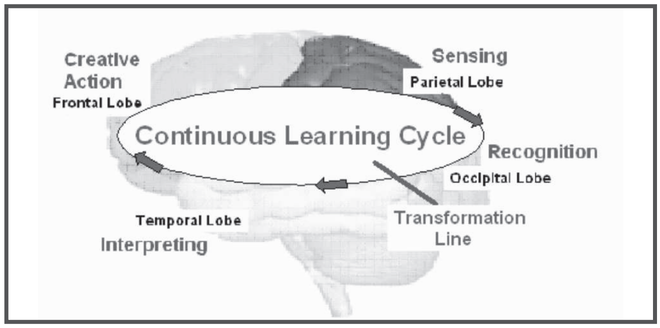

Figure 3. Transformation Line

Research also proposes that any progress in learning and thinking engages the "emotional center" and acts as the mortar to the brain's structure (Damasio, 1999; Ledoux, 1996, 2002; Zull, 2002) and a source for driving the learning cycle.

As educators, we can use this newer understanding of brain structure and natural learning cycles to help learners bridge or manage the transformation line that presents challenges to many learners. With more efficient measures and targeted interventions recognizing individual differences in learning, we can begin to implement targeted strategies for more productive, active, or successful learning.

To address the challenges discussed, this paper considers how to apply the multidisciplinary body of research to implement practical solutions that help learners tap into emotions and intentions to develop, manage, and apply more effective learning cycles (i.e., improve creativity, higher-order cognitive processing ability, executive control, and motivation). Tomorrow's research-based pedagogical models and tools will need to consider the deep psychological sources (identified by the neurosciences) that influence successful learning or impede academic success.

INDIVIDUAL DIFFERENCES IN LEARNING

To discuss individual differences in learning, this paper uses the Learning Orientation theory (Martinez, 2000, 2001, 2003) to (a) highlight recent brain research that point towards the impact of emotions on learning. (b) explore conative (will) and affective (emotions) aspects as a dominant learning influence, and (c) describe strategies to support individual differences in learning.

Appropriating relevant neurobiology of learning and memory research, the learning orientation theory serves as a foundation for exploring education practice and understanding, predicting, and managing specific individual learning processes--for instructors, learners, and designers. In this paper, the hypothesis is that learning orientation is a component of learning ability (e.g., examining holistic thinking, goal orientation, learner control, and one's passion to learn).

The learning orientation research describes the role of emotions and intentions and offers a perspective that explores variables that may be more dominant than most cognitively or metacognitively represented aptitudes, learning strategies, styles, preferences, and skills. The learning orientation research suggests the need for exploration of a general domain describing learning ability. This domain is independent of any curricular context and contributes to how well individuals learn in different disciplines. Research has shown that "students respond to the learning environment in different ways based on their stage of intellectual development, their orientation, the context of the course, the program and methods of assessment" (McDonald, 2002).

"To help students develop the thinking processes they need to meet these challenges [for academic success], we need a framework for learning that takes into account the role of disciplines or domains of knowledge yet goes beyond the acquisition of knowledge to encompass ways of constructing and using it in the disciplines" (McDonald, 2002).

Understanding the learning ability domain in context of the discipline's domain will help researchers support how instructors teach and how learners can more efficiently approach different disciplines with different learning abilities. Such a framework will help determine gaps in skills and target interventions. Table 1 presents a conceptual model of a part of the domain of learning ability using conventional measures, typically used in the field of education and psychology.

Table 1. Conceptual Model for Learning Ability

Attributes	Low	Med	High
Locus of Control			
Critical Thinking			
Goal Orientation			
Stress Arousal			
Non Verbal Ability			
Learning Strategies			
Creative Thinking			

LEARNING ORIENTATION RESEARCH

The learning orientation research (Martinez, 2000, 2001, 2003) describes a whole person perspective to consider successful learning attributes and patterns and understand sources for individual learning differences.

The *Learning Orientation Construct* examines how, to varying degrees, learners understand, know how, and can (1) focus emotions and intentions, (2) commit and self-manage effort and progress, and (3) set and accomplish short- or long-term goals. For further information about this research program, see: http://www.trainingplace.com-/loq/pop_construct1.htm.

The learning orientation perspective represents learners as complex human beings with sometimes subtle or implicit and sometimes obvious, compelling differences in their proclivity to learn. This perspective is more robust than typical, primarily cognitive or metacognitive (thinking) explanations (such as, learning styles), because it discusses the interplay between a set of key, complex psychological factors including emotions. The learning orientation model uses the three-factor construct to describe four specific *Learning Orientations--categorizing* an individual's general orientation or disposition to learn (shown in Table 2).

Table 2. Four Learning Orientations

Transforming Learners	Performing Learners	Conforming Learners	Resistant Learners

Learning orientations describe how individuals, with varying beliefs and levels of ability, will intentionally and emotionally approach, commit and expend effort to some extent, and then experience learning to progress and attain goals. In other words, learning orientations describe how an individual typically wants and chooses to manage their brain structure to learn or not learn.

Transforming Learners are highly goal-oriented, holistic thinkers who value learning ability, committed, persistent, and assertive effort to learn, abstract theories, creative strategies, and positive expectations to self-manage and accomplish personal goals successfully. These learners seldom rely heavily on schedules, deadlines, expected compliance, or others for support.

These learners, who may find routine activities boring, enjoy taking responsibility and control of their learning and willingly become actively involved in managing the learning process (high internal locus of control). They typically tap into stimulating, intrinsic influences, such as passions, personal principles, beliefs, and desires to self-direct intentional achievement of challenging, long-term goals.

These learners learn best in open, discovery, or challenging learning environments that encourage innovation, expertise building; risk-taking; mentoring relationships; complex, problem-solving situations; high learning standards, and long-term personal accomplishments and change. This group of learners can improve by not overlooking important details and increasing focus on practical applications, implementation, and task completion.

Performing Learners are task-oriented, more often extrinsically motivated, and prefer avoiding risks and mistakes. They are less comfortable with abstract theories and more often focus on details, processes, principles, grades, rewards, and normative achievement standards. They are often ready to rely on instructors, external resources, and social interaction to accomplish tasks. They may selectively use self-regulated learning skills and committed effort to learn topics and skills that they find particularly interesting and beneficial.

Often, these learners will clearly acknowledge that they want to limit or constrain effort (for example, they do not have enough time or interest) by only meeting stated objectives, getting the grade, or avoiding exploratory steps beyond requirements. They value and learn best in semi-structured learning environments that add competition, fun, and coaching to foster motivation (i.e., both intrinsically and extrinsically). These learners improve by practicing more holistic, abstract, and critical thinking skills.

Conforming Learners value security, structure, and routine. They are deeply influenced by an awareness of the social aspects of learning and the external resources that motivate them. They more passively accept knowledge, store it, and reproduce it to conform and complete assigned tasks. These learners are less complex learners, and struggle using initiative, abstract thinking, critical thinking, making mistakes, and meeting challenging goals. In other words, these learners struggle with the transformation line (shown in Figure 3) and often need additional support to succeed.

In comfortable, uncomplicated learning communities, conforming learners will, with scaffolded support and explicit guidance, successfully work to achieve progressively difficult goals. This group of learners can improve, over time with targeted support, social intervention, and by learning how to take increasingly greater risks in learning.

Resistant Learners may deal with either short-term (temporary) or long-term (permanent) resistance. They may doubt that: (1) they can learn or enjoy achieving any goals set by others (2) compulsory academic learning and achievement can help them achieve personal goals or initiate desired changes, and (3) their personal values, interests, and goals can benefit from academic objectives. Too often these learners will suffer repeated, long-term frustration from conflicting values, expectations, and goals, misunderstandings, perceived academic or social inadequacy, disappointment, or instruction that confuses or lacks value.

Table 3. Learner-Difference Attributes for Four Learning Orientations

Construct 1 Emotional/Intentional Motivational Aspects	Construct 2 Self-Directed Strategic Planning & Committed Learning Effort	Construct 3 Learning Autonomy
A transforming learner: Focuses strong passions and intentions on learning. Is an assertive, expert, highly self-motivated learner. Uses exploratory learning to transform to high, personal standards.	*A transforming learner:* Sets and achieves personal short- and long-term challenging goals that may or may not align with goals set by others; maximizes effort to reach important, long-term personal goals. Commits great effort to discover, elaborate, build, and apply new knowledge and meaning.	*A transforming learner:* Assumes learning responsibility and self-manages goals, learning, progress, and outcomes. Experiences frustration if restricted or given little learning autonomy.
A performing learner: Focuses emotions/ intentions on learning selectively or situationally. Is self-motivated when the content appeals. Meets above-average group standards only when the goal/benefit appeals.	*A performing learner:* Sets and achieves short-term, task-oriented goals that meet average-to-high standards; situationally minimizes efforts and standards to save time. Will reach assigned or negotiated standards. Selectively commits measured effort to assimilate and use relevant knowledge and meaning.	*A performing learner:* Will situationally assume learning responsibility in areas of interest but willingly gives up control in areas of less interest. Prefers coaching and interaction for achieving goals.
A conforming learner: Focuses intentions and emotions cautiously and routinely as directed. Is a low-risk, modestly effective, extrinsically motivated learner. Uses learning to conform to easily achieved group standards.	*A conforming learner:* Follows and tries to achieve simple task-oriented goals assigned and guided by others, then tries to please and conform; maximizes efforts in supportive relationships with safe standards. Commits careful, measured effort to accept and reproduce knowledge to meet external requirements.	*A conforming learner:* Assumes little responsibility, manages learning as little as possible, is compliant, wants continual guidance, and expects reinforcement for achieving short-term goals.
A resistant learner: Focuses on not cooperating. Is an actively or passively resistant learner.	*A resistant learner:* Considers lower standards, fewer academic goals, conflicting personal goals, or no goals; maximizes or minimizes efforts to resist assigned or expected goals either assertively or passively. Chronically avoids learning (apathetic, frustrated, unable, discouraged, or disobedient).	*A resistant learner:* Assumes responsibility for not meeting goals set by others, sets personal goals that avoid meeting formal learning requirements or expectations.

Note: In determining learning orientation, we must allow for the possibility of “situational performance or resistance.” Learners may temporarily approach learning situations more positively or negatively based on conditions. For example, in different situations transforming learners may also temporarily respond in a performing, conforming, or resistant manner. Similarly, a performing learner may temporarily respond in a conforming or resistant manner, and a conforming learner in a resistant manner. Nevertheless, their temporary disposition does not necessarily impact their general disposition to learn.

PERSONALIZED LEARNING

Successful learners are most often described as individuals who are highly self-motivated and ready to learn and accomplish challenging learning goals. For the rest, if instructional design strategies for ensuring social activities, direction, and increasing motivation (similar to any instructor's task) are not considered, then learner motivation and progress may suffer and require additional intervention. The learning orientation research suggests that learners can be intrinsically driven (self-motivated to some degree) or extrinsically influenced and supported, (externally motivated to some degree) to improve learning. Nevertheless, this research also suggests that we generally place too much emphasis on extrinsic motivation and not enough emphasis on fostering intrinsic or self-motivation toward learning more successfully. For example, transforming learners are generally very self-motivated to learn and manage their own learning. They have a lesser social dependence on the environment or external resources. They naturally foster their own drive to set and accomplish goals, expend learning effort, and improve or innovate. Giving them an environment that they can control, explore, and manage as they prefer to learn best, greatly nurtures their intrinsic motivation. In contrast, conforming learners are less self-motivated to learn and transform their environment. They have a greater dependence on the environment or external resources for their self-motivation or drive to learn. Giving conforming learners a more transforming solution may overwhelm or frustrate since these learners prefer a safe and secure environment that provides less complex solutions. Giving conforming learners a scaffolded environment in which they can succeed fosters greater intrinsic motivation, achievement, and satisfaction.

PRACTICAL APPLICATIONS

You recognize that your learners like to be supported as individuals, but how can you do it efficiently and cost effectively? In Table 4 is a simple 3-step approach to help you with your audience analysis and to provide more personalized attention. Table 4 shows the four learner types (top row) and four design elements (left column) for a hypothetical learning audience. The designer fills in the blank boxes to specify objectives and activities that work towards enhancing learning. The key is to tap into the common dispositions, values and interests that drive your audience.The first step is to identify the critical success attributes that are important to your learning audience. Primarily, this means identifying the common values and emotions that will motivate your audience to learn (that is, define the common deep-seated psychological factors that drive your audience). The second step is to examine your common learner types using a framework that considers at least four key design elements, including (1) learning environments, (2) presentation of instruction, (3) social relationships, and (4) expected outcomes. Use these four elements to identify key attributes for your learning audience. That is, you determine underlying values and then use this information to find drivers that will match an individual's disposition to learn. Once you identify what drives your audience (i.e., common learner types), in the third step, you can begin to specify objectives and activities that will continue to drive your audience towards improvement and continual success. With this blueprint, you can also evaluate how well you accomplished your instructional objectives.

Table 4. Elaborating the Instructional Blueprint for Four Learning Orientations

Key Design Elements to Consider	Learner Type 1 Assertive, Low Maintenance, Self-Directed, Holistic, Independent Learner (e.g. Executive)	Learner Type 2 Focused, Med Maintenance, Project, Detail, Hands-On, or Task Oriented Learner (e.g., Manager)	Learner Type 3 Dependent, Low Risk Learner who is dependent on external resources and support	Learner Type 4 Resistant Learner who is not interested in what "you" have to offer; it conflicts with their Values
	Transforming	Performing	Conforming	Resistant
Learning Environments	A. How can I independently explore and discover meaningful information to accomplish my goals?	A. How can I interact and get specific information that I can practice and apply to create meaningful projects?	A. How can I practice and work through the tasks in a guided, structured environment with continual feedback?	A. What is in it for me?
	B. Specify Objectives and Features that encourage discovery and application:	B. Specify Objectives and Features that use principle, procedures, process, and creative application:	B. Specify Objectives and Features that scaffold problem solving and creative application:	B. Specify Objectives and Features integration and involvement:
Presentation of Instruction	A. Make it quick and give me the Big Picture First, minimize the details until I need to know them.	A. Make it quick and give me the details and procedures, i.e., spare me too much of the big picture and theories.	A. Make it step-by-step with explicit instruction and repetitive tasks. Please minimize the risk taking/problems.	A. Why should I learn this?
	B. Specify Objectives and Activities that encourage discovery and application:	B. Specify Objectives and Activities that use principle, procedures, process, and creative application:	B. Specify Objectives and Activities that scaffold problem solving and creative application:	B. Specify Objectives and Activities integration, interest, and involvement
Social Relationships	A. I like low Involvement, unless I have fast or passionate learners that learn like me. I like mentoring relationships.	A. I like competitive, team or project-oriented involvement in my area of interest with coaching relationships.	A. I like group involvement with those that learn at a similar, stepwise pace. I like to depend on guiding, supportive relationships and explicit feedback.	A. Why should I interact or collaborate?
	B. Specify Objectives and Activities that foster mentoring relationships:	B. Specify Objectives and Activities that foster coaching relationships:	B. Specify Objectives and Activities that foster guiding relationships:	B. Specify Objectives and Activities that foster involvement:
Expected Outcomes	A. I like to focus on achievements that show improvement, a challenging degree of difficulty, and holistic, and complex problem solving.	A. I like to focus on achievements that show a hierarchy of completed tasks and projects, and some external rewards.	A. I like to focus on achievements that show visible progress, simple next steps, and social rewards.	A. I like to focus on tapping into values that may encourage my involvement in any future learning activities.
	B. Specify Objectives and Activities to achieve challenges:	B. Specify Objectives and Activities to achieve standards:	B. Specify Objectives and Activities to achieve tasks:	B. Specify Objectives and Activities to achieve personal goals:

CONCLUSION

Clearly in the past we have not fully understood the brain's structure and have not thoroughly understood how to regulate or measure emotion. Fortunately, today's more sophisticated research and technology is ready to provide educators the learning and thinking tools based on measured brain activity and biological mechanism. Neuroscientists are quickly filling the void by revealing the brain's triggering neural stimulus, proceeding to emotional responses, and concluding with responses influenced by our feelings, values, and beliefs. Taking advantage of their progress, educators can use relevant brain research and findings from the learning sciences to determine possible implications and build new frameworks (Bruer, 1997) for learning and instruction. We can no longer afford the luxury of overlooking the significant impact of emotions and other relevant psychological factors (e.g., intentions) on learning (Byrnes, 2001). As we take a more evidence-based approach in considering multiple learning variables, triggers, and emotional impact on learning, we can design instruction and implement environments, predict and seek outcomes, and establish social relationships with greater sophistication and better, more cost effective results. The missing link is the instructional design perspective that understands brain structure and the impact of emotions and intentions and embraces a truly personal understanding of how individuals want or intend to learn differently.

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