

5

The chapter examines how the brain uses experience as a basis for learning and how learning changes the brain.

Teaching with the Brain in Mind

Kathleen Taylor, Annalee Lamoreaux

I would have the experience but . . . I left the learning *behind* somewhere. During the course, I realized that the learning really *was* there, I just never *accessed* it. . . . So once I started to realize, through writing the papers, that it was *there* . . . [I was] able to go internally and access it, and link it up with thinking. And I can actually use it now.

—LM, a forty-eight-year-old Caucasian woman

I started looking at myself and what was going on and in the world around. I just started looking at everything a little differently. . . . Where was I going? What was the point of certain things that I was doing? My job started becoming a real problem too . . . because when you start examining yourself, you examine the whole world around besides yourself.

—JH, thirty-eight-year-old African American woman

As adult educators, we are committed to learning that encourages adults to see themselves and the world around them in more complex ways. We have therefore focused our practice on teaching with development in mind (Taylor, 2000; Lamoreaux, 2005). Recently, however, a colleague (Johnson, 2003) pointed us to a body of research that examines how the brain changes as it learns. We found it offered us a new and valuable perspective on teaching and learning. This chapter therefore describes aspects of brain function that suggest ways to teach with the brain in mind.



The Essential Brain

The brain's task is to preserve the organism by monitoring what goes on in and around the body, such as blood pressure, heart rate, and glucose levels as well as all data coming in through the senses, in order to continuously make adjustments intended to keep the body safe and functioning effectively. When faced with danger, the survival response releases hormones that prepare the body to fight or flee. The pleasure response encourages reproduction, maternal care of infants, and consumption of high-calorie foods.

Though these internal responses are not under conscious control, we can learn to choose the resulting behaviors—which is just as crucial to our long-term survival. When, for instance, someone accidentally bumps into us, we can ignore the rush of adrenaline and calm down rather than fight or run. When offered a delicious fat-and-sugar confection, we can politely decline and perhaps go for a walk instead.

Though all other cells in the body are regularly replaced, we are born with most of the brain cells (neurons) we will have. Rather than replacement, neurons “get changed by learning . . . [which changes] the way they connect with others” (Damasio, 1999, p. 144). Barring injury, disease, or the eventual breakdown that occurs as cell replacement slows with age, other organs continue to function as usual. Learning, however, changes how the brain functions, increasing our capacity for innovative, flexible responses to external conditions.

Anatomy and Memory. Memory enables individuals to reconsider previous experience when dealing in the present or planning for the future. To explain, we will greatly simplify the anatomy of a neuron.

Imagine a child's sketch of a tree: roots, thick base, slender trunk, and leafy branches. In the brain, an electrochemical signal starts at the “roots” (dendrites), flows to the “base” (cell body), up the “trunk” (axon), and then to the “branches” (axon terminals). The signal then passes across a space (synapse) from one of the branches to the roots or base of another tree, creating a web of interconnections. “When the organism is exposed to a new pattern of signals from the outside world, the strengths of the synaptic contacts (the ease of signal passage between neurons) . . . gradually change” leading to more complex connections throughout the brain; *“this represents learning as we understand it today”* (Goldberg, 2001, p. 29, italics added). Repeatedly activated connections become stronger; they “fire together, [therefore] wire together.” They also grow “bushier” dendrites, leading to more connections that may shrink synaptic spaces, resulting in a more tightly woven pattern of neurons (Goldberg, 2001; Siegel, 1999). By contrast, fewer follow-up experiences may lead to looser connections. Thus experience leads to changes in neural networks throughout the brain, including how information is “encoded.”

This encoding is not typically what we think of when referring to “a memory,” however; rather than being something stored in a particular *place* in the brain, memory is a *process*.

Memories are *constructions assembled* [from various places in the brain] *at the time of retrieval*, and the information stored during the initial experience is only one of the items used in the construction; other contributions include information already stored in the brain, as well as things the person hears or sees and then stores after the experience. [LeDoux, 2002, p. 203; italics added].

What comes into conscious awareness is therefore affected by the individual’s filters or frames of reference: “Memory is modified each time it is remembered” (Cozolino, 2002, p. 103).

When storing new sensory input, the brain “looks for” connections to earlier information. New data that can be related to existing patterns appear to “make sense” and are therefore more likely to be remembered. But confronted with ideas for which their brains can find no related prior experience, and therefore no meaningful links to existing patterns, learners may find them difficult to retain. If adults are further stressed as by an impending exam, rather than working to create new connections they may try to memorize—“knowledge” that, as educators know, rarely lasts.

Complexity of Mind. The brain uses analogy to connect new input to existing patterns: How is the current experience like some earlier experience? Being able to use the past to evaluate present situations is an evolutionary advantage that no doubt came in very handy each subsequent time our cave-dwelling ancestors faced things with fangs and claws. Even more significant, the brain’s “rules” (algorithm) for analyzing connections between new and old patterns become more complex over our lifetime. The phenomenal power of the human mind derives in large part from the fact that the brain learns to change its own algorithm to account for variations, contrasts, and more integrative metaphors, leading to more inclusive, creative, and flexible responses to unfolding experience (Cozolino, 2002).

For example, consider changes over the lifespan in how people make sense of others’ needs. A toddler will often grab something from a playmate, insisting it is “mine.” School-aged children can usually be induced to share, even if unwillingly. By late adolescence, some young adults respond to their peers’ needs or desires without sufficient regard for their own well-being. A mature adult, however, is likely to examine the situation from various perspectives and choose actions in keeping with his or her value system. Unfortunately, these capacities—for objective analysis of both situation and self—are not evenly developed among adults (Kegan, 1994).

Take the effectiveness of phrases such as “cut and run” or “stay and pay” in forming public opinion about the Iraq war. By triggering existing

neural networks, these superficial analogies can evoke in many adults predictable responses that are not conscious, hence unavailable for reflection. A primary task for adult educators may therefore be to create learning environments that encourage adults' brains to be less susceptible to such manipulation. Learners who can recognize the speaker's intentions and also examine their own assumptions have developed capacities that Mezirow and associates (2000) relate to "liberated person[s]" who are better able to take charge of their own lives (p. 26).

Plasticity. Plasticity refers to the brain's capacity to "rewire" or modify existing neural networks.

The growth and connectivity of neurons is the basic mechanism of all learning and adaptation. Learning can be reflected in neural changes in a number of ways, including the growth of new neurons, the expansion of existing neurons, and changes in the connectivity between existing neurons. All of these changes are expressions of plasticity, or the ability of the nervous system to change [Cozolino, 2002, p. 20].

Children's brains are extremely plastic, to allow adaptation to their environment. Though the plasticity of adults' brains diminishes with age, some losses are compensated by gains from the elaboration of neural networks generated by more experience (Siegel, 1999).

Meaning Making and Constructing Knowledge

At the cellular level, learning is about creating lasting neural patterns that can be effectively accessed. But this could apply to rote learning, skill development, or stimulus-reward behavioral training. As described earlier, our intentions for our adult learners go beyond mastering behavioral skills or informational content. We focus on what we consider meta-objectives of adult higher education, such as "the understanding that knowledge is neither given nor gotten, but constructed; the ability to take perspective on one's own beliefs; and the realization that learning and development are worthy life-long goals" (Taylor and Marienau, 1997, p. 233). This accords with Langer's definition of *mindful learning*: "the continuous creation of new categories; openness to new information; and an implicit awareness of more than one perspective" (1997, p. 4).

Adults who develop these more complex capacities are also likely to respond more effectively to what Kegan (1994, 2000) describes as the demands of modernity. For example, changing family structures require new ways of thinking about gender-related roles as well as what constitutes healthy partnerships, appropriate communication, and wise parenting. In the social milieu, increasing diversity calls for openness to others' ideas and beliefs, even when they are startlingly different from one's own. In many

workplaces and educational settings, employees and learners are increasingly expected to question institutional assumptions as well as demonstrate greater capacity for critical self-reflection.

Developmental intentions also accord with the constructivist notion that meaning is made in the mind-brain of the learner, rather than merely received from the mind-brain of the teacher or author of the text. This is not to discount the social elements of meaning construction (Vygotsky, 1978), but rather to acknowledge that “though there is an indispensable social aspect to the construction of meaning, there is also an irreducible individual element” (Caine and Caine, 2006, p. 54).

Learning, Teaching, and the Brain

There is no one right way to teach adults. Nevertheless, student learning may be enhanced if educators align practice with how the brain functions (Cozolino, 2002; Johnson and Taylor, 2006; Zull, 2002). For example, the steps of Kolb’s learning cycle (1984)—*concrete experience*, *reflective observation*, *abstract conceptualization*, and *active experimentation*—parallel how signals flow in the brain, from sensory input through various integrative functions to finally result in motor output. Zull (2002) terms these steps *experience*, *reflection*, *abstraction*, and *testing* and identifies them as the “four pillars of learning” (pp. 14–18).

Experience. For the brain to notice something, it must respond to signals traveling along nerve cells. Initially, however, “experiences don’t happen to us, events happen to us” (Brookfield, 1998, p. 129). Sensory data are events that the brain turns into experience. Events are filtered physically (the brain cannot process all the simultaneous stimuli) and psychologically (we unconsciously choose which data we will attend to on the basis of sociocultural and other prior experiences). The brain’s physical responses to the sensory data are recorded—literally, embodied—as experience, hence accessible to reconstruction as memory; without such physical responses, there is no basis for constructing meaning (Sheckley and Bell, 2006).

Current and prior experiences interact when new activities are unconsciously filtered through what the learner already “knows”—or thinks she does, which can lead to misinterpretation. Given that adults usually have some experience related, however tenuously, to course content, it is important that educators give these learners opportunities to make conscious connections.

For example, as experts in our fields most of us tend to introduce new material by framing it as we best understand it. In a course on adult development, we might provide an overview of various theories as they emerged in the latter part of the twentieth century, thus—we believe—laying a foundation for students to later read and analyze several theoretical viewpoints.

Another approach, however—one more likely to build on embodied experience—could first ask a diverse group of adults to individually note down significant personal and social milestones in each of their lives. Then, in small groups organized by age and gender, they could look for similarities and differences in these life-patterns. Finally, all the groups' discoveries would be synthesized, illuminating patterns of changes in gender- and age-related roles over time. When this group of learners then turns to the readings, their conscious connection to the theories can make subsequent analysis more meaningful. Zull (2002) is explicit: "A teacher must start with the existing networks of neurons in a learner's brain, because they are the physical form of her prior knowledge" (p. 8).

Listening to lectures and reading texts are valuable learning experiences, but the learners likely to derive the most benefit are those who can also draw on related prior experience. Caine and Caine (2006) explain: "More than reading is needed to make adequate sense of what is being read. At some stage, there is a need for physical and sensory participation or recall of sensory and physical events if full meaning is to emerge" (p. 55).

This suggests that offering concrete examples, analogies, and experiential activities, thus helping learners create meaningful connection, is—from the brain's perspective—a more effective approach to teaching and learning than focusing primarily on how we, as educators and experts, understand the issue.

Reflection. Reflection begins with the brain's association between new and past events, a physical process of searching for connections that leads to assembling and categorizing richer, more meaningful images and eventually, more complex neural networks (Zull, 2002). Reflection is therefore a key to *reframing*—that is, to reinterpreting past experiences in light of newer ones—because it can alter neural connections and therefore the meaning we make on the basis of those connections.

When new experiences do not readily fit existing patterns—an unsettling experience Mezirow (1990) calls a *disorienting dilemma*—the brain has an opportunity to forge new connections and therefore make new meaning that is "inclusive, discriminating, and integrative of experience [as well as open] to alternative perspectives" (p. 156). In their analysis of the importance of reflection to learning, Boud, Keogh, and Walker (1985) appear to have anticipated current understandings of brain function:

Why is it that conscious reflection is necessary? Why can it not occur effectively at the unconscious level? . . . [Because] unconscious processes do not allow us to make active and aware decisions about our learning. It is only when we bring our ideas to our consciousness that we can evaluate them and begin to make choices about what we will and will not do [p. 19].

From a practitioner's perspective, journaling is an effective way to encourage reflection. Walden (1995) describes various low-stress assignments

designed for adult learners unaccustomed to self-reflection in an academic setting.

We consider self-assessment as a specialized form of journaling. According to MacGregor (1993), potential outcomes for self-assessment include adults seeing “learning as a transaction between self and world . . . [which strengthens] their capacity to see themselves as agents of effective action” (p. 11). Boud, however, sees self-assessment as “a range of different practices in which learners take responsibility for making their own judgments about their work” (Taylor, Marienau, and Fiddler, 2000, p. 64).

In our practice, we tend to downplay the evaluative and judgment aspects of self-assessment and focus instead on asking adults to examine their *process* of learning itself—how they are engaging with the content, with one another, and with the various assignments. A journal entry reveals what can happen when adults reflect not just on course content but also on who they have been (and perhaps, are becoming) as learners:

Are truths absolute? Are values situational? Should one ever question the church . . . ? Even more controversial, is it a sin to question God? In the few short weeks that I have been in this class I have come to ask myself these questions. There was a time when asking these types of questions was taboo for me. Even if the only place these questions were being asked was in the mind. Today, I am not as threatened by these thoughts. In fact, I believe that these thoughts will enlighten me and strengthen my beliefs, even though some of my beliefs may change [JC, a forty-two-year-old Hispanic man].

Over time, we find such reflections foster in adults greater competence and self-confidence in dealing with their strengths and weaknesses, and therefore more effective learning. For Zull (2002), “The art of directing and supporting reflection is part of the art of changing a brain . . . [and] leading a student toward comprehension” (p. 164).

Abstraction. Zull (2002) terms this *creating* and includes planning and problem solving. Such activities occur in the most recently evolved part of the brain: the front cortex or “executive brain” (Goldberg, 2001). These processes—making sense of things, solving problems, and deciding on courses of action—go on continuously—entirely unrelated to formal learning. We human beings make meaning as easily as we breathe—and we perish in the absence of either.

Meaning is, in its origins, a physical activity (grasping, seeing), a social activity (it requires another), a survival activity (in doing it, we live). Meaning, understood in this way, is the primary human motion, irreducible. It cannot be divorced from the body, from social experience, or from the very survival of the organism [Kegan, 1982, pp. 18–19].

But requiring learners to make conscious meaning on demand is a different sort of task, and one that involves both emotion and cognition. The cognitive activity includes manipulating and categorizing information in both long-term storage and working memory as well as relating between them, thus elaborating existing neural networks. The role of emotion, according to Damasio (1999), appears to be “a support system without which the edifice of reason cannot operate properly” (p. 42).

The tasks and assignments most supportive of abstract, creative thinking are, like real-life problems, “ill-structured” (Schön, 1983). Grappling with ambiguous problems depends on an integrative brain process that Goldberg (2001) calls *adaptive decision making*, which requires examining issues from multiple perspectives: “Resolving ambiguity . . . depends on my priorities at the moment, which may change depending on the context. . . . Very different [cognitive] processes [are] involved in solving strictly deterministic situations” (pp. 78–79).

In contrast to adaptive decision making, tasks such as solving deterministic or veridical problems (those with clear right-and-wrong answers), taking tests that assess short-term memory, and writing papers that focus on repeating what experts have said lead to much less complex meaning construction.

In school we are given a problem and must find the correct answer. Only one correct answer usually exists. The answer is hidden. The question is clear-cut. But most real-life situations, outside of the narrow realm of technical problems, are inherently ambiguous. The answer is hidden, and so is the question. Our purposes in life are general and vague [Goldberg, 2001, p. 77].

In general, the “best way to help students develop and engage their executive [brain] functions is to adopt a constructivist approach to teaching and learning” (Caine and Caine, 2006, p. 57). When learners are challenged to make meaning—which is at the heart of constructivist practice—their brains are stimulated differently than when they are asked to focus on meaning already made.

Testing

Putting new meaning to the test can reveal that the brain’s process of association and categorization was inadequate or faulty. Ideally, this discovery becomes the starting point for another turn of the learning cycle leading toward clarification and correction.

Converting [an image] into the precise form required for language helps us see the details in our image, or it makes us invent those details . . . and we may notice that something is missing, a gap in our thought that we would

never have seen without converting our abstraction into [testable] form [Zull, 2002, p. 208].

“Testing” in this context does not refer to exams, which create such anxiety in most adults that they may inhibit neural connections. Moreover, the most prevalent type, multiple-choice, gives learners little support in identifying or revising flaws in their thinking. Far better are assignments that involve synthesizing ideas learned at different times during a course (or program), working and thinking with other learners, and (as Sheckley and Bell, 2006, have done) situating course activities in settings other than the classroom.

Dialogue is also an effective tool for examining one’s meaning making. A learner who reads actively, with her own thoughts in mind, is in dialogue with the text. Journals or self-assessments written with explicit attention to multiple perspectives (Walden, 1995) enable a learner to dialogue with the self. Dialogue with classmates (or, for that matter, anyone who wants to listen and talk about what is being learned) as well as the more formal interaction Mezirow (2000) calls *discourse* are yet another opportunity. Finally, formative feedback, a form of dialogue in which an educator both affirms and questions the learner’s presentation of her ideas, also encourages learners to examine and possibly revise their thinking.

Role of the Adult Educator

Adult educators who want to teach with learners’ brains in mind need also to recognize the emotional context of learning and therefore seek the most effective balance of support and challenge.

When mature, often-accomplished learners describe youthful experiences of deep shame following a schoolteacher’s comments, it is evident that such emotions can inhibit learning well into adulthood. A high level of hormones associated with trauma and the survival response can negatively affect both memory and learning (Perry, 2006).

Furthermore, many adults are returning learners precisely because they were not able to complete their degrees earlier. Even those who had rewarding learning experiences as children may fear academic failure or have anxiety about their skills (Perry, 2006). They are further challenged if the learning on which they will be assessed dismisses their maturity, knowledge, and experience, relying instead primarily on their ability to absorb printed and lectured material. Though too much stress greatly inhibits learning, insufficient challenge can also have a negative impact; a bored brain stops attending.

The most successful learning environments from the perspective of developmental intentions are those that provide high support *and* high challenge (Daloz, 1987). Scaffolding is an effective strategy that offers both.

A scaffold is a temporary structure that enables builders to work beyond a level that is mostly formed in order to start construction of the next, higher level. Similarly, when adult learners construct new meaning, scaffolding enables them to operate beyond their certainties, at what Daloz calls their *growing edge*. The combination of high support and high challenge may be the “optimal” stress that enhances production of dendrites, which are the parts of neurons most responsible for the “connectedness” of neuronal patterns (Cozolino, 2002).

Conclusion

Until recently, philosophy was the primary way to explain *mind*, anatomy and physiology to explain *brain*, and psychology to explain *self*. Now that we can observe the brains of living persons, these understandings have begun to converge. Current brain imaging techniques reveal not only the architecture of the brain but how its functions create “thought,” “personality,” and “consciousness”—and how the brain changes itself. Though this research is still in its infancy, we feel it offers powerful support to educators who wish to facilitate the particular changes in the brain called learning.

References

- Boud, D., Keogh, R., and Walker, D. (eds.). *Reflection: Turning Experience into Learning*. London: Kogan Page, 1985.
- Brookfield, S. “Against Naïve Romanticism: From Celebration to the Critical Analysis of Experience.” *Studies in Continuing Education*, 1998.
- Caine, G., and Caine, R. “Meaningful Learning and the Executive Functions of the Brain.” In S. Johnson and K. Taylor (eds.), *The Neuroscience of Adult Learning*. New Directions for Adult and Continuing Education, no. 110. San Francisco: Jossey-Bass, 2006.
- Cozolino, L. *The Neuroscience of Psychotherapy: Building and Rebuilding the Human Brain*. New York: Norton, 2002.
- Daloz, L. *Effective Teaching and Mentoring*. San Francisco: Jossey-Bass, 1987.
- Damasio, A. *The Feeling of What Happens: Body and Emotion in the Making of Consciousness*. Orlando: Harcourt Brace, 1999.
- Goldberg, E. *The Executive Brain: Frontal Lobes and the Civilized Mind*. New York: Oxford University Press, 2001.
- Johnson, S. “Facilitating the ‘Self’ of Adult Learners Moving Through Mid-Life Transition.” Doctoral dissertation, Walden University, 2003. *Digital Dissertations*, AAT3095120.
- Johnson, S., and Taylor, K. (eds.) *The Neurophysiology of Adult Learning*. New Directions for Adult and Continuing Education, no. 110. San Francisco: Jossey-Bass, 2006.
- Kegan, R. *The Evolving Self*. Cambridge, Mass.: Harvard University Press, 1982.
- Kegan, R. *In over Our Heads: The Mental Demands of Modern Life*. Cambridge, Mass.: Harvard University Press, 1994.
- Kegan, R. “What Form Transforms? A Constructive-Developmental Approach to Transformational Learning.” In J. Mezirow and Associates (eds.), *Learning as Transformation*. San Francisco: Jossey-Bass, 2000.

- Kolb, D. A. *Experiential Learning: Experience as the Source of Learning and Development*. Upper Saddle River, N.J.: Prentice-Hall, 1984.
- Lamoreaux, A. "Adult Learners' Experience of Change Related to Prior Learning Assessment." Doctoral dissertation, Walden University, 2005. Digital Dissertations AAT3180108.
- Langer, E. J. *The Power of Mindful Learning*. Cambridge, Mass.: Da Capo Press, 1997.
- LeDoux, J. *The Synaptic Self: How Our Brains Become Who We Are*. New York: Penguin Books, 2002.
- MacGregor, J. (ed.) *Student Self-Evaluation: Fostering Reflective Learning*. New Directions for Teaching and Learning, no. 56. San Francisco: Jossey-Bass, 1993.
- Mezirow, J. *Transformative Dimensions of Adult Learning*. San Francisco: Jossey-Bass, 1990.
- Mezirow, J., and Associates. *Learning as Transformation*. San Francisco: Jossey-Bass, 2000.
- Perry, B. "Fear and Learning: Trauma-Related Factors in the Adult Education Process." In S. Johnson and K. Taylor (eds.), *The Neuroscience of Adult Learning*. New Directions for Adult and Continuing Education, no. 110. San Francisco: Jossey-Bass, 2006.
- Sheckley, B., and Bell, S. "Experience, Consciousness, and Learning: Implications for Instruction." In S. Johnson and K. Taylor (eds.), *The Neuroscience of Adult Learning*. New Directions for Adult and Continuing Education, no. 110. San Francisco: Jossey-Bass, 2006.
- Schön, D. *The Reflective Practitioner: How Professionals Think in Action*. New York: Basic Books, 1983.
- Siegel, D. *The Developing Mind*. New York: Guilford Press, 1999.
- Taylor, K. "Teaching with Developmental Intention." In J. Mezirow and Associates (eds.), *Learning as Transformation*. San Francisco: Jossey-Bass, 2000.
- Taylor, K., and Marienau, C. "Constructive-Development Theory as a Framework for Assessment in Higher Education." *Assessment and Evaluation in Higher Education*, 1997, 22(2), 233–243.
- Taylor, K., Marienau, C., and Fiddler, M. *Developing Adult Learners: Strategies for Teachers and Trainers*. San Francisco: Jossey-Bass, 2000.
- Vygotsky, L. *Mind in Society: The Development of Higher Psychological Processes*. Cambridge, Mass.: Harvard University Press, 1978.
- Walden, P. "Journal Writing: A Tool for Women Developing as Knowers." In K. Taylor and C. Marienau (eds.), *Learning Environments for Women's Adult Development: Bridges Toward Change*. New Directions for Adult and Continuing Education, no. 65. San Francisco: Jossey-Bass, 1995.
- Zull, J. E. *The Art of Changing the Brain*. Sterling, Va.: Stylus, 2002.

KATHLEEN TAYLOR is professor in the graduate Educational Leadership Program, Kalmanovitz School of Education, Saint Mary's College of California.

ANNALEE LAMOREAUX is chair, prior learning assessment and adult development, Saint Mary's College of California.

Copyright of *New Directions for Adult & Continuing Education* is the property of John Wiley & Sons, Inc. / Education and its content may not be copied or emailed to multiple sites or posted to a listserv without the copyright holder's express written permission. However, users may print, download, or email articles for individual use.