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Keywords
Learning cycles, Brain research, Transformative learning, Curriculum design

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Lighting Up The Mind:
Transforming Learning Through The Applied Scholarship of Cognitive Neuroscience

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Abstract
“I am as sick of boring presentations as you are” admitted Medina (2008, p. 93), explaining how the typical academic lecture embodies the antithesis of scholarly, brain-rich teaching and learning. In contrast to what Kohn (1999, p. 218) decried as the “mind numbing” monotony of even the most well intended academic monologues, Medina explained that brains retain lessons learned through concrete experiences with emotionally cogent and relevant stimuli. Are such research-based insights the sort Boyer (1990) was invoking in Scholarship Reconsidered, which made the case for a new standard of scholarly teaching and learning? Thinking so, this essay synthesizes existing learning cycle theories and emerging cognitive neuroscientific insights to extend the discussion of research-based options for lighting up learners’ minds through the scholarship of 21st century brain-compatible teaching and learning. This essay concludes by illustrating a constructivist curriculum model for illuminating students’ minds by transforming learning through cognitive neuroscience.

Key words: learning cycles, brain research, transformative learning, curriculum design

Introduction
“I am as sick of boring presentations as you are” admitted Medina (2008, p. 93), as he explained how the typical 50 minute academic lecture embodies the functional antithesis of a brain-rich environment. In contrast to what Kohn (1999) called the “mind numbing” monotony of a semester full of even the most well meaning of academic monologues, Medina explained that brains favor and retain the lessons learned through concrete experiences with emotionally cogent and relevant stimuli.

As an educator who aspires to light up students’ minds through the scholarship of teaching and learning, I can’t help but wonder, even lament, So where were Medina’s candor and cognitive neuroscientific insights when I was earning my teacher licensure a decade and a half ago? And why were these research findings—veritable sparks of mental illumination—not the very foundation upon which we as new teachers learned to construct curriculum?

Were these brain-based insights the ones that Boyer (1990) was invoking in his seminal Scholarship Reconsidered, which made the case for a new standard of scholarly teaching and learning in higher education? While these insights were certainly burgeoning in scholarly journals, and may have even framed the professional ethos of my most sophisticated colleagues, for new teachers like me, such insights remained outside of the professional discourse and methods that shaped our teaching.

And now, after fifteen years of missing thousands of opportunities, and delivering countless boring lectures, I think I may just be stealing my first glimpses of the scholarship of
teaching and learning that so moved Boyer and colleagues. Consequently, I couldn’t be more excited about the insights that arise from serious inquiry into the lessons that 21st century brain research hold for those who, sickened by the boring presentations that have long dominated our teaching, commit to learning to reconsidering the scholarship of their teaching.

This essay, which introduces, reviews, and synthesizes longstanding learning cycle theories and emerging cognitive neuroscientific research is offered in a spirit of collegial dialogue about our teaching profession’s unparalleled opportunity to supplant our well earned reputation for boring presentations and instead become facilitators of mental illumination. For these reasons, this essay extends the discussion of research-based options for lighting up learners’ minds through the scholarship of 21st century brain-compatible teaching and learning. This essay concludes by offering a constructivist curriculum model that invites educators to light up students’ minds by engaging and transforming learning through cognitive neuroscience.

**Lighting Up The Mind**

In contrast to suffering through the lost opportunities of another boring lecture, when was the last time our minds were alight with wonder, excitement, and learning? Why? What was taking place? And how often are our students’ minds lit up with engagement and transformative learning? And when so, what creates such illumination?

For millennia, scholarly teachers have theorized about the phenomenology of the sort of learning that lights up the mind. From Confucius to Aristotle, from Whitehead to Kolb to Mezirow, deep, meaningful, and lasting learning has long been understood as constructed through cycles of experience, reflection, conceptualization, and application. And for millennia, because the human mind has historically been perceived as a mysterious source of illusive cognition, the scholarship of teaching and learning tended to be driven more by theoretical speculation than from empirical evidence.

But in recent decades, much has changed, unveiling fresh insights into the cognitive neuroscience of learning. This proliferation of brain research has revealed remarkable symmetry between learning cycle theories and optimal brain function. This symbiosis between cognitive neuroscience and learning theories suggests powerful new insights that guide those who teach and learn with scholarly intention into lighting up the minds of twenty first century learners.

Moved by the power of such evidence, this paper seeks to contribute to the scholarship of lighting up 21st century learners’ minds through analysis of time-honored learning cycle theories in relationship to current brain research. In doing so, this paper synthesizes major themes in experiential, transformative, and cognitive neuroscientific learning theories, so that educators might, with increasing success, light up learners’ minds through cycles of curricular engagement and perspective transformation.

**Literature Review**

In order to better illustrate the powerful relationship between experiential learning theories and current brain research, this essay briefly reviews selected experiential learning theories proceeding from the work of teacher-scholars including Confucius, Socrates, Whitehead, Kolb, Mezirow, Gardner, and Zull.
The Early Scholarship Of Lighting Up The Mind

“I hear and I forget. I see and I remember. I do and I understand,” is attributed to the great contemplative Confucius. His sparing yet lucid fifth century B.C.E. insight into learning may be among the earliest recorded articulations of the relationship between concrete action and deep understanding. Similarly, a century later, Aristotle asserted, “the things we have to learn before we do them, we learn by doing them” (Stonehouse, Allison, Carr, 2010). Together, these teacher-scholars emphasized that enduring learning, characterized by deep understanding, emanates from experience that engages multiple senses and learning modalities. In their view, experience turns impressions into insights. From these ancient foundations, 20th and 21st century understandings of cyclical learning have taken shape.

The Twentieth Century Scholarship Of Lighting Up The Mind

“The rhythm of education,” claimed Whitehead (1927), arising from the “natural cravings of human intelligence,” reflects a complete, organic, and threefold cycle fueled by passion and curiosity (p. 31). The first stage originates in romantic discovery, in which subject matter has what Whitehead described as “vividness, novelty, unexplored connections, and possibilities half disclosed and half concealed” (p. 18). Constructed upon this passionate inquiry is the precision phase, in which the mind is lit up with the challenge of formulating conceptual exactitude. Yet, efforts toward precision, warns Whitehead, are rendered “barren without a previous stage of romance” (p. 18). In the subsequent generalization phase of Whitehead’s rhythmic cycle, is the work of “shedding details in favor of active application of principles” into the “active freedom of application” in order to “create the environment of a larger knowledge and a firmer purpose” (pp. 37-40).

Reflecting insights from Confucian, Aristotelian, and Whitehead’s learning cycles, Kolb (1984) suggested, “knowledge is created through the transformation of experience” (p. 41). His subsequent experiential learning model proposed that concrete experiences with subject matter are the ideal objects of reflective observation, enabling learners to synthesize and analyze personal experiences in relationship to other sources of information, thus positioning an individual in an optimal situation from which to actively experiment with newly informed action. “Experiential learning theory,” explained Kolb (2000), “provides a holistic model of the learning process and a multilinear model of adult development, both of which are consistent with what we know about how people learn, grow, and develop” (p. 2). Kolb’s experiential learning model, which serves as a foundation for scholarly and transformative teaching via brain research, is illustrated in Figure 1.
Encompassing Confucian and Aristotelian understandings as well as Whitehead’s, and Kolb’s insights into lighting up the mind, transformative learning theory, as explained by Mezirow (2000), proceeds from cycles of experience, reflection, discourse, and action. Mezirow (2009) defined transformative learning as “the process by which we transform our taken-for-granted frames of reference to make them more inclusive, discriminating, open, emotionally capable of change, and reflective so that they may generate beliefs and opinions that will prove more true or justified to guide action” (p. 8). Perspective transformation as described by Herber (1998), Brookfield (2000), Cranton (2006), and Mezirow and Taylor (2009), proceeds from the cognitive dissonance of disorienting trigger events, followed by critical reflection on one’s assumptions, rational discourse, and renewed committed action. Like Kolb’s experiential cycle, Mezirow’s transformative learning model is central to the scholarly teaching that brain research suggests lights up 21st century minds, and is illustrated in Figure 2.
**Figure 2. Mezirow’s (2000) Transformative Learning Cycle**

![Diagram of Mezirow's Transformative Learning Cycle]

**The Twenty-First Century Scholarship Of Lighting Up The Mind**

“With the advent of neuroimaging techniques...that can detect the effect of [interventions] on neural organization,” observed Gardner (2004), the scholarship of learning “is evolving into a science” (p. 200). “When one treats the brain as a black box,” he observed, theories about how learning takes place “operate at a purely behavioral level” (p. 200). In contrast, 21st century cognitive neuroscience enables the “links between brain changing and mind changing to become a matter of knowledge, rather than speculation, prayer, luck, or idiosyncratic artistry” (p. 201).

Moreover, “the claim that learning is change” explained Zull (2006) “is more than a metaphor. It is a physical statement. The brain changes physically as we learn” (p. 4). “Thus,” continued Zull, “learning is powerful and long-lasting in proportion to how many neocortical regions [in the brain] are used. The more regions of the cortex used, the more change will occur. Thus, learning experiences should be designed to use the four major areas of the neocortex (sensory, back integrative, front integrative, and motor). This,” according to Zull, “leads to identification of four fundamental pillars of learning: gathering, reflecting, creating, and testing” (p. 5).

Gardner’s advocacy of the importance of using brain research to inform the science of learning reflects a profound opportunity provided by the cognitive neuroscientific research community--that the relationship between brain form and mental function should inform the scholarship of 21st century teaching and learning. As such, when viewed through physiological and phenomenological lenses, the biology of the brain appears to be
wonderfully compatible with the time-honored understanding of learning as a cycle of experience, introspection, analysis, and application. Zull (2002) illustrated this in noting the striking alignment between the sensory cortex and the concrete, experiential stage of inquiry learning. Once sensed, information is carried by neuronal networks to the temporal cortex, where it is associated with pre-existing and novel meanings. This reflective process is akin to the reflective dimensions of experiential learning. After associative regions interpret sensory information for meaning, these meanings are transported through neuronal networks to the analytical frontal cortex where abstract conceptualization and rational metacognition take place. Then, these rational thoughts from the frontal cortex are sent to the motor cortex, where they take the form of active experimentation and directed action. Thereafter, upon encountering additional novel stimuli, this learning cycle repeats itself in the human brain (Zull, 2006). See Figure 3.

**Figure 3.** Zull’s (2000) Cognitive Neuroscientific Learning Cycle

Glimpsing Into The Black Box: The Scholarship of Cognitive Neuroscience
While Zull’s (2002) discussion of the alignment between experiential learning and the brain’s cortices is among the most comprehensive of applied brain research and scholarship models to inform 21st century teaching and learning, Zull’s findings are part of a larger cognitive neuroscience movement that is gaining momentum. “We have learned more about the brain in the last decade,” exclaimed Restak (2009), “than we did in the previous two hundred years” (p. 5). And so the first decade of the 21st century has produced research-based insights (e.g. Doidge, 2007; Gardner, 2008; Jensen, 2008; Lehrer, 2007;
Medina, 2008; Pink, 2006; Restak, 2009; Siegel, 2010; Sousa, 2006; Sylwester, 2005; Zull, 2002) that empirically support the understanding that deep learning follows from cycles of rich sensory experience, reflective meaning interpretation, analytical thought, and directed action. In fact, beyond informing professional insights, cognitive neuroscientific research points to pathways for faculty to light up learners’ minds by constructing curricular engagement based upon emerging understandings about brain form and function.

**Findings**

While these research findings may be novel and interesting, at the end of the day, so what? What do these have to do with lighting up student’s minds? What role, if any, might 21st century brain research play in redirecting higher education’s well intended but mind-numbing tendency to blather on ad nauseam in a seemingly endless series of boring lectures? In what ways, if any, might cognitive neuroscientific insights into lighting up the mind catalyze a new era of scholarly 21st century teaching and learning?

Well, for starters, Elmore’s (2007) research on reforming learning from the inside out explained that for teaching and learning to improve, most of us will need some new learning, prompted by what Medina (2008) called “emotionally competent and relevant stimuli” (p. 91) to problematize our current practices. Following Mezirow’s (2009) designs for fostering transformative learning, we’ll need to be supported in engaging in critical assessment of our own assumptions about teaching and learning. Then, dialogue and conceptualization are appropriate. And finally, opportunities for committed action must temper our experiential development as faculty.

These findings are offered in alignment with Elmore’s (2007) research-based claim that people—educators included—want to do well, and when they’re not doing well, it’s typically an issue of not knowing how to meet the demands of the situation. In this case, argued Elmore, reformers are responsible for establishing relationships of what Elmore called “reciprocity” wherein any expectation for change must be accompanied by teaching that individual how to accomplish such change (p. 66). These aims and this format will guide the Findings section of this paper.

**Scholarly Teaching Through Early Insights**

In light of cognitive neuroscientific research findings, to what extent should Confucian insights inform scholarly 21st century teaching and learning?

Confucius noted, “I hear and I forget.” Understood through brain research, the act of hearing consists of mapping out sound sensations in the auditory cortex, after which the information is “transmitted to the frontal lobe where the sound can be linked to emotion, thoughts, and past experiences” (Sousa, 2006, p. 222). While hearing is one route to knowing, its power for long term recall or behavior change is limited if not partnered with metacognition and deliberate action. This is where many lectures go wrong. As they’re characterized by one person speaking, many hearing, and minimal structured metacognitive action, they result in little meaningful encoding, recall, or retention (Medina, 2008).

Confucius continued, “I see and I remember.” In order to understand how seeing creates memorable experiences, Sylwester (2005) suggested, “think of your eyes as the projector lens that registers the rapid sequence of sunlight-to-starlight still pictures it has received from your retina--still pictures that it translates into a continuous mental motion picture.
Think of your frontal lobe neurons [or brain cells] as the audience watching, interpreting, and responding to the film” (p. 147). The memorability of this process is increased as the degree of associative, interpretive, and analytical interactions within the brain increases.

“I do and I understand,” concluded Confucius. Doing, or exercising volition upon an object or situation, generally engages and demands more brainwork than does receiving sensory impressions. And so the intensive and discursive work of doing, which Zull (2002) described as coordinating one’s sensory (stimuli registering), temporal (or meaning making), frontal (analytical), and motor (action) cortices may be thought of as transforming experience into understanding. Moreover, because as Doidge (2007) pointed out, “neurons that fire together, wire together,” taking action enables one’s body to establish deep procedural familiarity with informed doing— or situational understanding. Furthermore, because “the body and the brain are part of the same continuous organism, and what happens to the body happens to the brain, these dual stimuli create a more detailed map for the brain to use for storage and retrieval” (Jensen, 2005, p. 136).

As Confucian wisdom is analyzed through the lens of brain research, we find that lectures require limited cognitive processing and result in minimal long-term illumination. While visually-rich lectures, if accompanied by relevant and emotionally moving stimuli, are increasingly memorable (Heath & Heath, 2008), experiential learning engages more enduring illumination, as taking action requires sensory, temporal, frontal, and motor cortices to work in conjunction.

So to what extent do our curricula support, enable, and construct such illumination?

**Scholarly Teaching Through Twentieth Century Insights**

In light of brain research findings, to what extent might Kolb’s experiential learning model inform scholarly 21st century teaching and learning?

Analyzing Kolb’s (1984) experiential learning model through brain research suggests a great deal of educational value in concrete experiences—which register as visual, auditory, olfactory, taste, and tactile impressions in the brain’s sensory cortex. These impressions move from neuron to neuron by virtue of synapses and neurotransmitters. Such sensory data, which when present in multiple modalities are stronger and more memorable than when perceived individually. These data are transported through neuronal pathways and become the physiological embodiment of learning which connects the brain’s sensory and association regions. The association regions, according to Zull (2006), categorize and label sensory impressions in reflective meaning making processes. After concrete experiences have registered in the sensory cortex and then been reflectively observed and interpreted in the temporal cortex, neuronal networks carry these data to the frontal cortex for abstract conceptualization, analytical thought, judgment, and related decision making. Decisions which are constructed through a sequence of sensory, temporal, and frontal cortex work become the impetus for active experimentation to be carried out by the brain’s motor cortex. The brain’s motor cortex, when active, sends signals to the body to exert volition— or take action—based upon frontal cortex decisions. Such action, which stimulates the brain stem, generates a protein called brain-derived neurotrophic factor, which fosters further neurogenesis, or brain cell development and fertilization (Doidge, 2007; Medina, 2008; Restak, 2009).

In short, brain research suggests that learning which involves the entirety of Kolb’s (1984) experiential cycle appears to be nearly the ideal embodiment of cognitive neuroscientific principles for teaching and learning.
Well, almost the ideal—with the exception of a larger, unanswered question: what kind of learning might teaching through Kolb’s experiential cycle promote? Likely conscientious action, one may expect, given the probable integrity of learner, teacher, and theorist. But because even individuals with great integrity have figurative blind spots that proceed from unexamined assumptions, taken-for-granted habits of mind, and socially-normed action, might this experiential learning cycle also unintentionally propagate inaccurate and problematic thoughts, attitudes, and behaviors? What in this experiential cycle is to prevent one’s sensory, temporal, frontal, and motor cortices from interpreting and acting in good faith on inaccurate or flawed premises? While this question may seem trivial, is not the 20th century—as well as much of human history—ripe with effectively learned and efficiently executed ideological cataclysms?

If so, what preferable alternatives arise from which to construct scholarly and transformative 21st century teaching and learning?

The research points to the promise of frontal-cortex-rich critical reflection, which plays a central role in transforming learning. Educators engaged in fostering such transformation structure opportunities for learners to sojourn into environments that trigger supported cognitive dissonance. Therein, students’ sensory cortices register impressions that are interpreted as mixed messages in temporal associative and frontal integrative cortices. In the presence of this powerful dissonance, scholarly teachers model and then facilitate critical reflection, or “questioning the integrity of deeply held assumptions and beliefs based upon prior experience . . . . [and] examining the presuppositions underlying our knowledge of the world” (Taylor, 2009, pp. 7-8).

As learners’ assumptions and beliefs are through various means experientially acquired, they remain present and influential in the brain in the form of neuronal networks—which are the physiological embodiment of knowledge. Fostering critical reflection is, of course, difficult because doing so requires existing gray matter to be repurposed through neuroplasticity or new neurons to be experientially developed through neurogenesis. Yet, the literally transformative result of such teaching and learning is that doing so constructs new neuronal networks to support, sustain, and model critical reflection, rational discourse, and committed action. These networks become the neuronal pathways that thereafter with increasing facility meet disorienting sensory stimuli with critically reflective and rational temporal and frontal integrative thought followed by committed action coordinated by the motor cortex.

Discussion

What then, are the larger implications for assisting educators in lighting up the 21st century mind through the scholarship of cognitive neuroscientific teaching and learning?

Twenty-first century brain research appears to be confirming the relationship between experiential, cyclical theories of learning and rich, deep cognition that may be traced back to Confucian and Aristotelian insights. Constructed upon cycles of concrete and multi-sensory experience followed by reflection, analysis, and action, this relationship, suggests an emergent model by which to light up 21st century minds through a scholarly sequence of learning experiences.

Figure 4 suggests that transformative 21st century learning can be constructed by fostering concrete, dissonance-creating experiences that engage multiple senses in learners’ brains. Doing so establishes powerful sensory experiences that both register with and yet extend beyond one’s existing neuronal networks. In the presence of concrete, experiential cognitive dissonance, learners are ideally positioned to proceed to reflective observation of the multiple, conflicting interpretations that are present in the temporal, associative regions of the brain. Conflicting interpretations become the subjects of critical reflection upon assumptions, and this rational thought and meaning construction takes place in the frontal integrative cortex. The concomitant active experimentation that emerges from this cycle that transforms experiences into insights is directed by the brain’s motor cortex. And then, the transformative learning cycle begins again as committed action situates the learner in the midst of new, novel, increasingly complex, and again conflicting concrete experiences. See Figure 4.

Figure 4. Lighting Up The Mind: The Synthesized Scholarship Of Experiential, Transformative, and Cognitive Neuroscientific Learning Cycles
Conclusion

As time-honored learning theories become further informed by current cognitive neuroscientific insights, teachers and learners alike should rightly expect to collaborate in the active construction of mental illumination through cycles of brain-based, transformative learning.

Twenty-first century educators who teach in order to foster illumination and transformation rather than to habituate simple recall will do well by their learners to construct curriculum cycles that that engage multiple senses, structure critical reflection, advance rational conceptualization, and require active experimentation. Such “balanced use of all parts of the brain is essential for the kind of learning” that provides individuals with new behavioral choices, explained Zull (2002, p. 32). Learning of this nature is sustained through “long term potentiation,” which Jensen (2005) described as when a neuron’s response to another neuron has increased, or has learned to respond, in which case “each future event requires less work to activate the same memory network” (p. 16). Moreover, Doidge (2007) expressed this thus: “Neurons that fire together wire together; neurons that fire apart wire apart” (p. 159). So the implication for rich learning is clear: cycles of multi-sensory stimulation, critical reflection, situated analysis, and active experimentation create neuronal networks adept at further whole-brained learning.

Given such immense possibilities, might the responsibility be ours to ask, How often are our students’ whole minds lit up with engagement and transformative learning? And when so, what is transpiring? Isn’t anything less—such as another boring lecture—indicative of the missed opportunities that typify much of education history rather than reflective of the transformative power of scholarly 21st century teaching and learning?

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