Article

Journal of Experiential Education
1–23

DOI: 10.1177/1053825914547153
jee.sagepub.com

Evolving Kolb: Experiential Education in the Age of Neuroscience

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Abstract

In pursuing a refined Learning Styles Inventory (LSI), Kolb has moved away from the original cyclical nature of his model of experiential learning. Kolb's model has not adapted to current research and has failed to increase understanding of learning. A critical examination of Kolb's experiential learning theory in terms of epistemology, educational neuroscience, and model analysis reveals the need for an experiential learning theory that addresses these issues. This article re-conceptualizes experiential learning by building from cognitive neuroscience, Dynamic Skill Theory, and effective experiential education practices into a self-adjusting fractal-like cycle that we call Co-Constructed Developmental Teaching Theory (CDTT). CDTT is a biologically driven model of teaching. It is a cohesive framework of ideas that have been presented before but not linked in a coherent manner to the biology of the learning process. In addition, it orders the steps in a neurobiologically supported sequence. CDTT opens new avenues of research utilizing evidenced-based teaching practices and provides a basis for a new conversation. However, thorough testing remains.

Keywords

experiential learning theory, constructivism, educational neuroscience

In experiential education, David Kolb's work is ubiquitous, with more than 17,800 citations (as measured with a Google search on July 16, 2012) and is part of many experiential programs. In *Experiential Learning*, Kolb (1984) purported to integrate the work of Jean Piaget, Kurt Lewin, and John Dewey (for a critique, see Miettinen,

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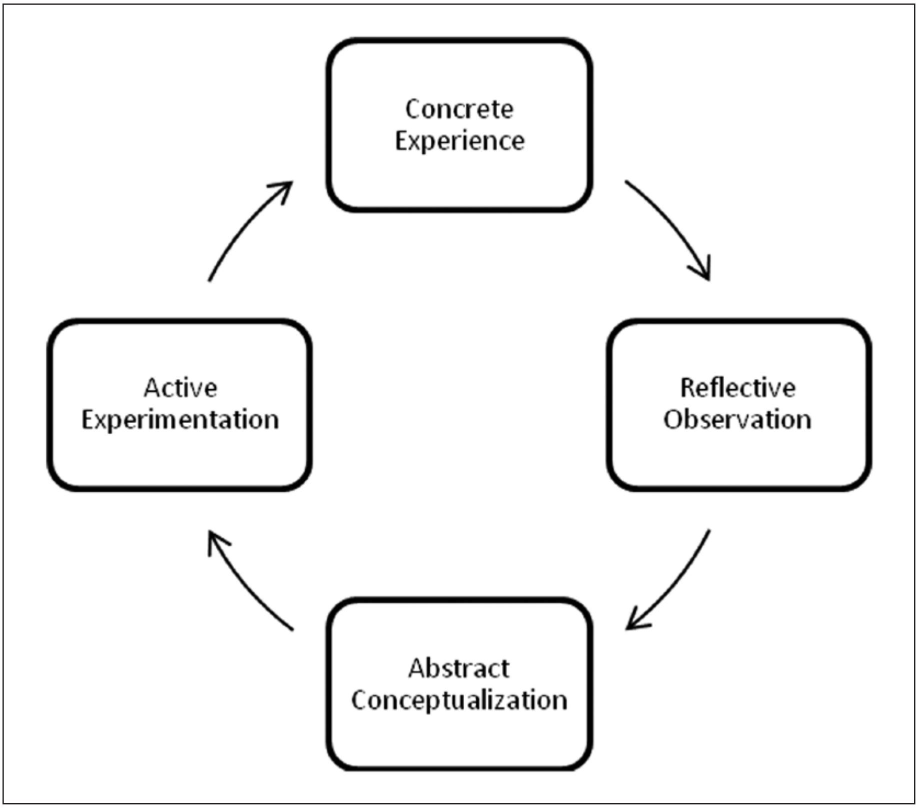

Figure 1. Kolb's experiential learning theory.
Source. Adapted from D. A. Kolb (1984).

2000). In his experiential learning theory, D. A. Kolb (1984) argued that learning is "the process by which knowledge is created through the transformation of experience, [and] knowledge results from the combination of grasping and transforming experience" (p. 41). A major tenet of Kolb's experiential learning theory (KELT) is comprised of *concrete experience, reflective observation, abstract conceptualization*, and *active experimentation*, where a learner "touches all bases" (p. 41) in a cycle (see Figure 1).

KELT is broadly embraced by experiential educators (e.g., Stavenga de Jong, Wierstra, & Hermanussen, 2006; Svinickl & Dixon, 1987), business managers (e.g., Akella, 2010), and computer programmers (e.g., Beard, Wilson, & McCarter, 2007). Furthermore, Kolb supports the adoption of learning styles across many fields (A. Y. Kolb & Kolb, 2005). However, as learning research increasingly uncovers biological correlates (Schenck, 2011), pushing to reinstate a separation of the tools of education from the goal of education, critiques of Kolb have appeared (e.g., Bergsteiner, Avery,

& Neumann, 2010; Coffield, Moseley, Hall, & Ecclestone, 2004). Critiques of Kolb range from the philosophical (e.g., Fenwick, 2003; Seaman, 2008) to the psychological (e.g., Heron, 1992), and throughout adult education (e.g., Rogers, 1996; Vince, 1998). Sweller, Kirschner, and Clark (2007) specifically reject Kolb's theoretical foundation, arguing from psychobiological evidence that "we have not evolved to effortlessly acquire the biologically secondary knowledge . . . that are characteristically taught in educational institutions. That information passes through working memory and so requires conscious effort. It must be explicitly taught" (p. 121). Critiques of Kolb's assumptions in the Learning Styles Inventory (LSI) did yield revisions in 1985 and 1999 (A. Y. Kolb & Kolb, 2005).

The first part of this article re-evaluates KELT in light of basic cognitive concepts and emerging neuroscience evidence, both supportive and refuting, and examines KELT as a descriptor of learning and the concepts it promotes. The second part of this article proposes a new conceptualization of experiential education theory, Co-Constructed Developmental Teaching Theory (CDTT). As there is great variability in every person, every brain, every context, and every learning event, we propose a theory of teaching rather than one of learning. Furthermore, because CDTT is not a learning theory, different types of learning theories may be utilized under the single framework of the model. Finally, this model provides direction in that it demonstrates both reasonable expectations and neurobiological limitations of instructional strategies that are empirically testable.

Epistemology: Concepts of Learning

D. A. Kolb (1984) originally described his model as "a four stage cycle involving four adaptive learning modes" (p. 40), and updated that description in 2005, stating,

> Experiential learning is a process of constructing knowledge that involves creative tension among the four learning modes that are responsive to contextual demands. This process is portrayed as an idealized learning cycle or spiral where the learner "touches all bases"—experiencing, reflecting, thinking, and acting—in a recursive process that is responsive to the learning situation and what is being learned. (p. 194)

Kolb sought one model as both a cycle of the learning process and a description of modes to which learners give preference. Kolb suggested that the combination of modes creates a learning cycle.

Conceptually, Kolb interchanges learning cycle *stages* with learning style *modes*. This is an epistemological contradiction because the difference between learning *modes* and learning *stages* is fundamental. For example, if an individual scores higher as a "reflective observer" on the LSI, this says nothing about their conceptual reasoning, only the *mode* of input. This is the basic conflation between the "what" and "how" of learning (Kirschner, Sweller, & Clark, 2006). Using "learning styles" or "learning modes" interchangeably with "learning theory" is dubious, suggesting no universal learning processes, thus undermining the concept of a learning *cycle*. Either KELT describes a universal process for learning, or it proposes itself as a topographic inventory of learning styles, but not both. Learning style modes describe only a method of input; it does not tell you how the learning is progressing. Because LSIs lack sequential order through which the learning moves, statistically, there is no method of predictability. Consequently, the LSI has been unable to yield valid predictions on performance (Pashler, McDaniel, Rohrer, & Bjork, 2008).

Kolb's epistemological contradictions have created a lack of rigor and statistic viability, making KELT untestable. The LSI's reliability was examined by Iliff (1994) with a meta-analysis, which concluded that the LSI lacked predictive validity and therefore studies based upon it are not statistically verifiable. Furthermore, Kirschner et al. (2006) found that the four stages are not sequential or cyclical, and overall, KELT and LSI are not accepted as useful for research purposes, resulting in feeble support for experiential education compared with more rigorously measured educational models (see also Ruble & Stout, 1993).

Kolb's philosophy limits KELT, stating, "Learning is not one universal process, but a map of learning territories" (A. Y. Kolb & Kolb, 2005, p. 200). However, neuroscience has demonstrated that some processes *are* universal to learning. The brain learns from the environment that surrounds it, and has evolved dynamic systems, including perception, attention, affect, and memory, all significant to learning and each with overlapping neural networks (Rose, 2010).

Neuroscience Research

Through neuropsychology, cognitive neuroscience, and brain imaging, we know much more about memory processes (Baddeley, 2003), attention (Cohen, Romero, Servan-Schreiber, & Farah, 1994; Posner & Boies, 1971), and the developmental pathways of learning (Fischer, 1980), resulting in the redesign of many models of learning. For example, disproven assumptions (neuromyths) include only using 10% of our brain or being "left or right-brained" (Goswami, 2006; Organisation for Economic Co-Operation and Development [OECD], 2007). Rigorous evidence also suggests that the learning styles concept is seriously if not fatally flawed (Pashler et al., 2008).

Neuroscience does support KELT in areas of novelty (new or different experiences), holistic learning, active learning, and emotional connection. Emerging neuropsychological evidence demonstrates that certain types of learning involve both pre-frontal lobes and brain stem activity (Immordino-Yang, 2011). Experiential learning integrates different neural networks during the learning event (Piaget, 1950/2001), resulting in multiple memory pathways (Hebb, 1949) and connections between abstract concepts. For example, having students provide personal explanations or demonstrations of the concepts through multiple modalities produces higher retention (Craik & Tulving, 1975). Elaboration through a number of modalities creates more linkages, unlike learning styles, which is often interpreted to suggest that an individual learns better and can perform better when their "learning style" is accommodated (Pashler et al., 2008).

Experiential learning also addresses the student's need for an emotive connection with the physical world (LeDoux, 1997), which triggers a release of dopamine,

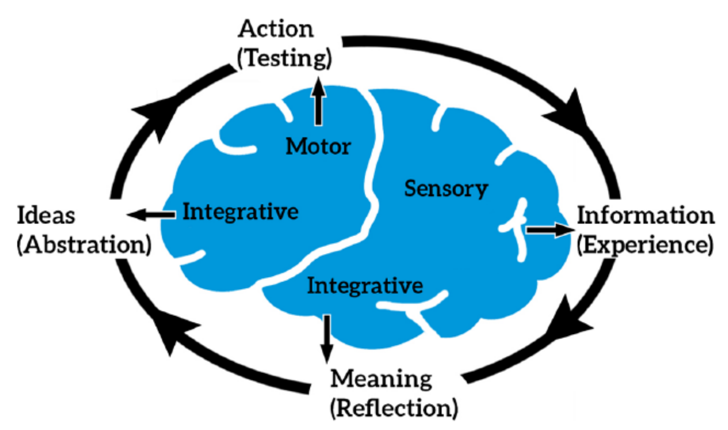

Figure 2. KELT overlaid with the cerebral cortex.
Source. Adapted from Zull (2002).
Note. KELT = Kolb's experiential learning theory.

significant to memory formation (Gazzaniga, Ivry, & Mangun, 2002). Experiential learning provides novel experiences, stimulating attention, and limbic/emotional systems, which facilitates memory formation (Gazzaniga et al., 2002).

KELT neglects other cognitive foundations, such as salience, the hierarchical shape of learning abstractions, cognitive load theory, and priming. These were not well known at the time Kolb originally wrote his theory in 1984, but for the last 15 years they have exhibited considerable importance yet remain unaddressed. The little neuroscience Kolb has included drastically oversimplifies the brain's learning. Recent publications suggest an a priori process of taking neuroscience research, presenting misinformation, and adapting it to KELT. For example, A. Y. Kolb and Kolb (2005) quote Zull (2002, pp. 18-19) and provide a misleading diagram of KELT with a brain (see Figure 2).

> The figure illustrates that concrete experiences come through the sensory cortex, reflective observation involves the integrative cortex at the back, creating new abstract concepts occurs in the frontal integrative cortex, and active testing involves the motor brain. In other words, the learning cycle arises from the structure of the brain. (A. Y. Kolb & Kolb, 2005, p. 194)

This figure is grossly misleading and implies that only certain cortical lobes of our brain are active based upon the type of learning activity. Such a priori methodology can lead to neuromyths. However, a full critique of Kolb's neurobiological misrepresentations and misconceptions is beyond the scope of this article.

Regarding cognitive foundations, KELT does not address the learner's need for salience, or determining what information is important (Baddeley, 2003). The brain cannot manage the deluge of information from the environment. Instead, it has evolved methods of prioritizing information and channeling resources. Interconnected networks, such as the limbic system, determine salience and sort information, retaining some while ignoring other data (Cowan, 1988; Dehaene, Posner, & Tucker, 1994; LeDoux, 1997), all at a non-conscious level. In addition, salience affects motivation; a lesson personally unimportant decreases motivation (Dweck & Leggett, 1988). Salience is addressed by using priming, goal setting, and framing.

Salience involves a student's cognitive load, which is how much information the brain can process before working memory is overwhelmed (Cowan, 1988). Performance drops when a student must focus on both the "what" of the topic and the "how" of problem-solving (Kirschner et al., 2006). Contrary to KELT, the brain focuses on only one aspect of a lesson at a time, leaving few resources to concurrently process and analyze the remaining information. This bottleneck is overcome by instructional methods that address salience. Students do not naturally identify all of the lesson's salient points, hence the need for methods such as review and guided reflection.

Model Analysis

Neuroscience evidence discussed above supports some of D. A. Kolb's (1984) original claims. For example, D. A. Kolb (1984) proposed that the learner goes through each stage of a*cquisition, specialization*, and *integration* where knowledge increases in complexity. Earlier Piaget (1950/2001) proposed hierarchical learning stages, but Kolb broke from Piaget, suggesting that learning is multilinear, not unilinear. Fischer bridged this with Dynamic Skill Theory, postulating hierarchical learning proceeding along multiple converging and diverging paths (Fischer, 1980, 2008; Fischer & Bidell, 2006). Neuroeducation uses dynamic systems modeling of learning that includes complexity, but KELT moves away from dynamic processes to a more limited two-dimensional model of learning contained in the LSI.

KELT focuses on polar points (see Figure 3), through which a learner might pass in an unspecified order. Miettinen (2000) strongly disputed Kolb's assumptions, noting Kolb's use of separate, unlinked phases as modes of learning. Bergsteiner et al. (2010) also found that KELT's two-dimensional nature contributed to major contradictions and inconsistencies, thus impeding reliable research using KELT. Conversely, Dynamic Skill Theory (Fischer, 1980) and Dynamic Systems Theory (Spencer, Thomas, & McClelland, 2009) provide robust evidence that different learning processes, as well as the environment, are linked to one another in fractal patterns. Cognition displays dynamic fractal patterns (see Figures 4 and 5) that may also appear like an interconnected, spiral cycle (Thelen & Smith, 1994), not a disconnected, two-dimensional learning process.

Ultimately, learning styles are an ill-defined construct whose measurable effects are highly questionable. Learning *preferences* exist, possibly contributing to motivation, but research is lacking. Rohrer and Pashler (2010) demonstrated that learning styles relate to *feeling* successful while studying, not which strategies *actually* yield greater learning.

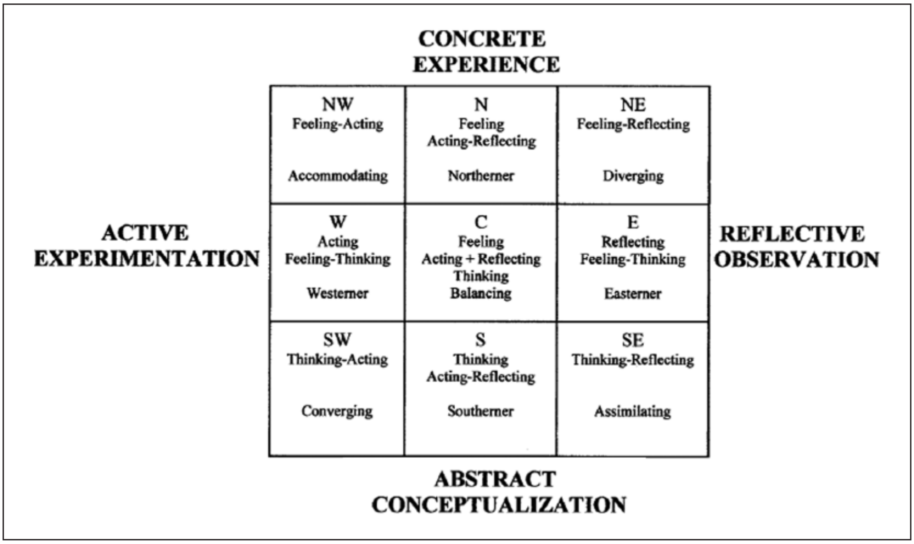

Figure 3. The nine regions of the experiential learning theory learning space.
Source. Adapted from A. Y. Kolb and Kolb (2005).

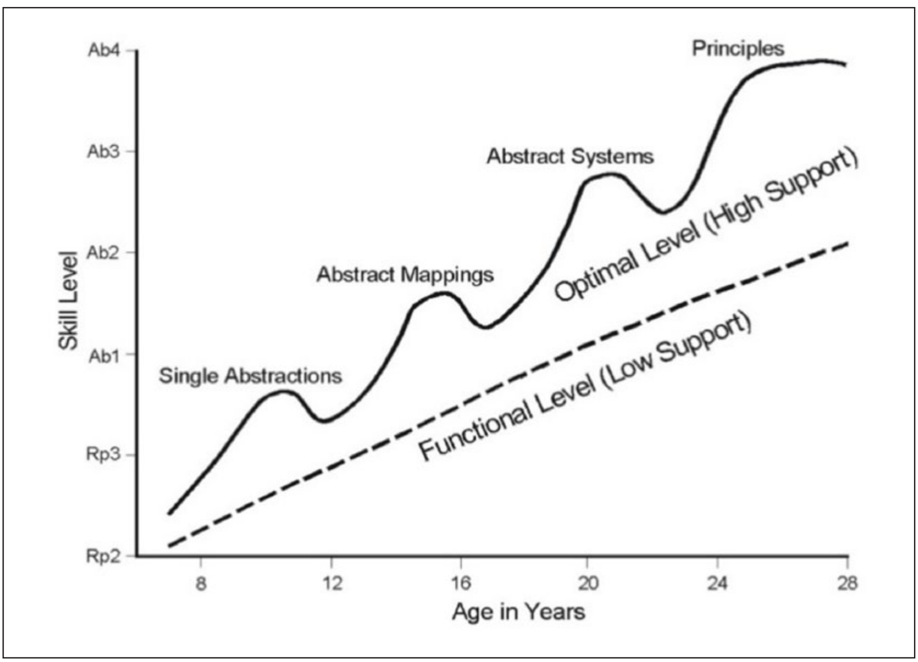

Figure 4. An interpretation of Fischer Developmental Skill Theory (Fischer, 1980) illustrating dynamic phases in cyclic-like reiterations.

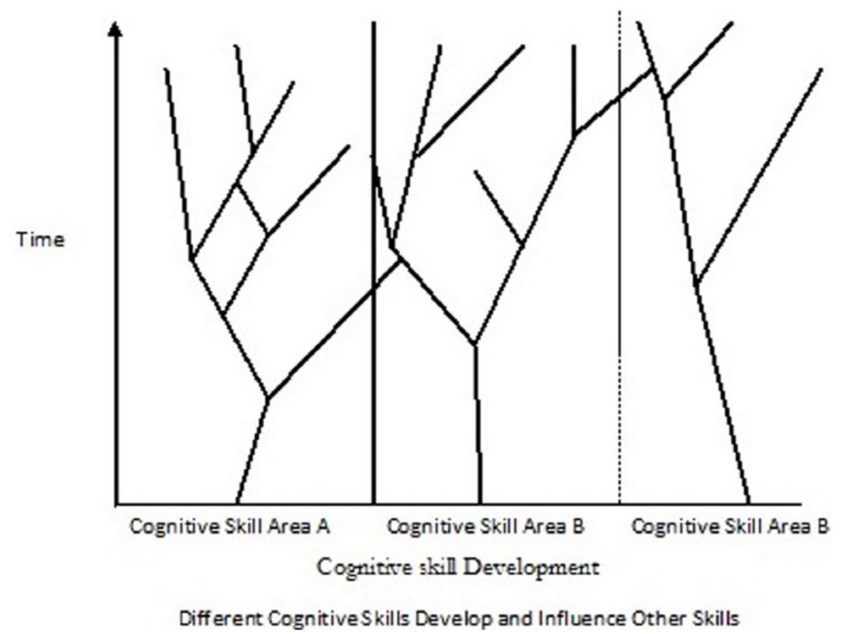

Figure 5. An interpretation of Fischer and Rose's (2001) web of skills, as cited in Schenck (2011).

Need for a New Model

Models express complex concepts and serve as visual metaphors that can bootstrap advances in understanding. However, models that cannot incorporate new significant studies can end up impeding progress and learning. The need for a new model of experiential learning is clear. We would argue that it needs to be grounded in current neuroscience research and able to facilitate predictable learning, yet adaptable as new understandings emerge. The model should address valence from a holistic, neuroscience perspective, and simultaneously address KELT's neuroscience gaps, such as salience, priming, cognitive growth cycles and the hierarchical shape of learning.

The model needs to facilitate explicit learning goals, not implicit. The field has known for a while that it is folly to assume that self-guided reflection yields intended conclusions and a greater grasp of content (Boud, Keogh, & Walker, 1985). To continue this, the new model needs to integrate student engagement (the non-conscious systems, front-end of learning), with experiential learning's focus on reflection to build understanding (the conscious systems or the back-end of learning).

The model's adaptability should be testable in other cultures to determine if there are differences in learning. Ideally, it should have dynamic, cyclic iterations at different scales (Rose & Fischer, in press). Finally, it should adapt to the context of the learning environment using feedback loops allowing for self-adjustment in a constructivist approach, taking into account the seminal work of both Vygotsky (1978) on the role of the social environment in learning, and Piaget (1950/2001) on developmental stages where learning is limited by biology.

To be a significant participant in the current education discourse and develop new conversations, experiential education needs to continue to increase qualitative and quantitative research (Roberts, 2002). For example, by using a more verifiable model of experiential learning, experiential education could begin a valuable conversation with the highly respected International Mind, Brain, and Education Society (IMBES). IMBES could provide research methods, empirical grounding, and potential funding to experiential education programs, along with field professionals working to vet the science of learning. Such a collaboration could potentially create the research schools Dewey envisioned and IMBES champions (Fischer, 2009), becoming a significant force in education.

Emergence of a Neuroscience-Based Teaching Model

Much ground has been gained since Bruer's (1997) argument that a direct brain–behavior–education link was a "bridge too far." Research discoveries in the mind and cognitive psychology are building that bridge (Coch, Fisher, & Dawson, 2007; Immordino-Yang, Christodoulou, & Singh, 2012; Tokuhama-Espinosa, 2010), bypassing the creation of neuromyths, such as right or left brain dominance, exercises that cross the midline, and Baby Einstein (Goswami, 2006; OECD, 2007). The last two decades of research call us to re-examine what we know about learning and education (Roberts, 2002). This new model is the result of our review of research across many fields, including neurobiology, cognitive psychology, gaming, chaos and complexity theory, experiential education, educational psychology, behavioral psychology, and developmental psychology, as well as 8 years of field testing. It is comprised of evidence-based phases of intentional facilitation set out in a progressive order with inherent feedback loops at all levels. This model, based upon the aforementioned fields, has a completely different foundation than other models, such as KELT, or those described by Boud et al. (1985). The similarities of this model to others are those portions that appear to be supported in cognitive research. The research also infers differences, which are introduced here.

Research Background and Philosophical Basis of CDTT

Constructivism theory is well established in educational neuroscience (Mareschal et al., 2007), experiential education (Fenwick, 2003), social-emotional learning (Immordino-Yang, McColl, Damasio, & Damasio, 2009) and is now finding considerable neurobiological support (Damasio, 2012). While these have been discussed as competing theories in past reviews of experiential education foundations (i.e., Fenwick, 2003), research uncovering the interdependent brain processes of social, situational, and cultural interaction has led to the reformation of the theory into neo-constructivism where learning is embodied, en-culturated, contextual, conscious as well as non-conscious, developmentally dependent, and dynamic (Mareschal et al., 2007). CDTT continues in the same vein of neo-constructivism. It relies heavily on past and current life experiences of all participants (including the teacher) to facilitate instruction through the learning event. Those experiences are the foundation for the inherent feedback loops, which manifest both neurobiologically (Immordino-Yang, 2011) and psychologically (Dweck, 2008). We conceive of learning as based on relationships: between all parties in the room, the individual's relationship with themselves, the environment, with the context of learning, and relationships with the content. A good facilitator is aware of these dynamics, and orchestrates them accordingly.

Development and Shape of Learning in Dynamic Systems

In 1980, Kurt Fischer introduced Dynamic Skill Theory, building on Piaget's hierarchical description of learning. Piaget (1950/2001) described children's learning as limited by their cognitive development. In Dynamic Skill Theory, Fischer re-envisioned Piaget's ideas, making a few significant alterations. Fischer described the shape of learning as a series of oscillating s-shaped curves, finding a progression of competence as increasingly abstract concepts were understood, demonstrating order and hierarchy. Another significant finding were dips in competence where the mind seems to regress in understanding as it neurologically reorganizes the concept and constructs a new understanding (see Figure 4).

Fischer experimentally demonstrated the reorganization repeats every time a person learns something completely new. The s-shaped curves are linked in a continuous learning process, starting with simple concepts and developing to higher levels of complexity. The limit on how fast and high an individual develops is set biologically. Like height, one cannot speed up the brain's growing. Critically, however, is the difference between what a student understands on their own in an unsupported environment, and in a highly supported environment with a teacher facilitating their experiences. Vygotsky (1978) noted in his Zone of Proximal Development (ZPD) that the environment can significantly affect learning (see also Boud et al., 1985). The student's ZPD is the gap between an unsupported and supported environment (Fischer, Rose, & Rose, 2007; Rose & Fischer, 2009). Fischer also found that learning does not progress in a step-ladder fashion as Piaget described and as many experiential educators assume (Seaman, 2008), but is rather a web-shaped fractal (Fischer & Rose, 2001; see Figure 5). This "web of skills" illustrates learning converging and diverging, where individual differences describe the distinctive paths of the web. Two may arrive at the same end (i.e., both can read), but they do not arrive by the same paths because of the specific challenges encountered (Fischer & Bidell, 2006).

CDTT also includes psychology's Self-Determination Theory (SDT) of innate human needs (Deci & Ryan, 2000; Ryan & Deci, 2000). In SDT, motivation ranges from extrinsic to intrinsic, where intrinsic motivation is facilitated by addressing the need for autonomy, competency, and relatedness. This, and Maslow's (1943) hierarchy of needs, suggests that individuals are constantly appraising their environment and their relationships with it at a non-conscious level (Lazarus, 2006). Also, included is Immordino-Yang's research, which demonstrates the overlapping and interdependent systems of intrinsic motivation, autobiographical memory, and imagining possible futures (Immordino-Yang et al., 2009). Finally, Csikszentmihalyi's (1978, 1991) Flow Theory, where a person performs and learns through feedback that creates a harmonious state between himself or herself and their environment, overlaps with portions of SDT and Immordino-Yang's work. Furthermore, these theories individually consider the importance of dynamic states in learning, but Dynamic Systems Theory provides natural and thorough linkages.

Dynamic Systems Theory

The brain is the most complex system in the known universe (Fischbach, 1992; Koch & Laurent, 1999). By comparison, self-evolving smart systems computers are simpler. The brain has chemical and electrical pathways, thresholds, genetic controls, previous and outside information, information in context, highly used and rarely used pathways. Its complexity makes it very difficult to study. The development of Dynamic Systems Theory provides a mathematical means that helps explain and predict such complexity. In dynamic systems, similar patterns repeat at scales large and small but never repeat exactly. The patterns may appear to be cyclic, but actually oscillate and change phases (Mainzer, 1996). Slight changes in initial conditions can produce large changes later, the so-called "butterfly effect" (Lorenz, 1963). These relationships can be visually expressed as fractal patterns. When Rose and Fischer (in press), in their elaboration of Piaget, applied these to the brain, the Dynamic Skills Theory emerged.

The *Easy* versus the *Hard* Part of Learning

Philosophically and neurobiologically, learning is a natural process upon which our survival depends. Our brains evolved to learn. One does not need to be told, "Walking is important to learn, you will need to remember it later." However, guidance and processing are usually necessary for examining multiple facets of the experience and for creating intentional connections to other concepts. A limiting factor in learning seems to be the use of glucose to fuel the mind (Cowan, 2005; Kimball & Holyoak, 2000; Sapolsky, 2004). Energy efficiency is the rule when understanding the fundamentals of brain processes. This understanding has led us to conceive of a learning model that is a spiraling fractal (Figure 6) and has two parts: the energy-efficient front-end of learning and the energy-demanding back-end.

The front-end of learning involves non-conscious systems of appraisal, attention, and affect. The appraisal system uses peripheral vision and the body's relationship with the environment to evaluate a situation. The attention system manages all the incoming stimuli, identifies and directs your attention to what is important. The affect system is the ebb and flow of emotional states that course through you right now in a milieu of electrical signals and neurochemicals. Thoughts and sensations are encoded

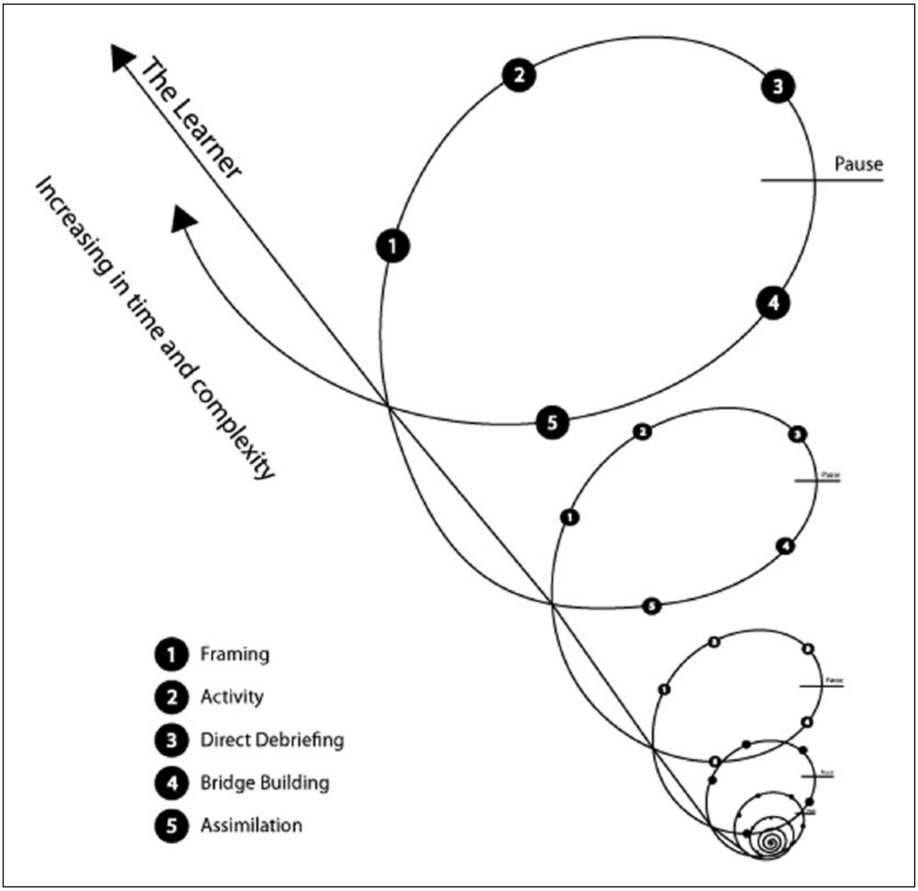

Figure 6. Co-Constructed Developmental Teaching Theory.
Note. The process is re-iterative at different scales producing a fractal spiral. Not shown are the feedback loops that connect the different phases at different scales in time and place, or sub-iterations of the CDTT cycle that occur as part of a larger iteration. The spacing of the points along the spiral is variable and not to scale. The spacing does not infer a set measure of time. Fractals are extremely common throughout nature, occurring from the molecular level upward to galaxies. CDTT = Co-Constructed Developmental Teaching Theory.

with emotion as they come and go, meaning that a person's emotional state is emergent and fluid.

These processes happen below the surface of consciousness and are regulated/modulated with lower energy consumption compared with full processing at a consciousness level (Gazzaniga et al., 2002; Stanovich, 2009). Addressing and intentionally influencing these processes as a teacher/facilitator can preserve energies needed to carry students through the back-end, or the hard part of learning.

The back-end of learning is more challenging in that while non-conscious systems still need to be considered and stewarded, this second part of the process happens above the level of consciousness. In it, new connections are being made. Neural growth is stimulated through the actions of the learning event and requires more energy. This back-end of learning does not always happen spontaneously, and therefore, learning is most effective when guided and facilitated by a teacher (Fischer, Yan, & Stewart, 2002; Parziale & Fischer, 1998).

By stewarding a student's non-conscious systems well, there should be more energy (i.e., glucose) for the neural growth of long-term memory. Reducing barriers to learning should allow more energy for deeper processing of concepts, permitting us to take a student farther through the learning process. Future research into this area could elucidate these assumptions.

The "Co" in CDTT

We have argued the need for a new model that incorporates theories capable of reflecting a learner's multiple dynamic states, in different contexts, at different scales in a re-iterative fractal-like process. CDTT starts and finishes with the whole person and purports learning as an embodied, *in situ* process.

Whole Person

CDTT conceptualizes the learner holistically and seeks to meet them where they are, whatever their background, where variability is the norm. To address the myriad of variables, CDTT *frames* the learning event using an explicit psychological goal, cognizant of the learner's needs, and systems of attention, motivation, appraisal/affect.

Framing. The initial part of the CDTT process has been called different things, depending on the field of study. It draws from research in neuroscience, cognitive psychology and education on priming, framing, and frontloading, respectively. We have chosen to use the term *framing* because the actions, words, and considerations a facilitator makes starting at this part of the CDTT cycle are targeted at stewarding non-conscious and psychological processes. These forms of pre-activity interaction are not novel to the field of experiential education. Work has been done in frontloading, specifically in the domain of therapeutic practices (Gass, 1995; Priest & Gass, 1994), as well as general facilitation practices (Estes, 2004). CDTT builds on that strong foundation by connecting these practices to their corresponding mind/brain functions and long-term memory processes. By knowing *why* these practices have such efficacy, facilitators can be more thorough and intentional in their use, as well as connect them appropriately to post-activity meaning-making.

Foundationally, the human mind is goal-oriented with overlapping non-conscious processes, including attention, motivation, and appraisal/affect (Dweck, 1986; Dweck & Leggett, 1988). To engage these, CDTT uses an explicit psychological goal to frame the learning event, setting the initial conditions critical to dynamic processes (Lorenz, 1963). Differences in learners are seriously considered, not by identifying each person's attentional and motivational milieu, but by tapping into the mind/brain's goal orientation to engage learners. This idea, borrowed from gaming research, seems to be more efficient than individual tailoring. Tailoring through differentiated instruction is used to guide a learning event, not start it.

The teacher/facilitator uses framing to start the lesson with an awareness of non-conscious processes and manages/stewards them throughout the learning event, potentially freeing more cognitive energy for later processing. The mind is goal-oriented, and when the goal is achieved, it will stop "learning" efficiently preserving energy (Rose, 2010). The mind's effort is likely to shut down even if the learning event is not completed. When goals are set at a higher psychological level, the brain's goal-oriented systems are more likely to remain engaged (with careful stewardship) recruiting more resources until the goal is reached. This creates a cognitive reserve to carry a learner through the conscious/hard part of the learning event.

Examples of the framing process include both verbal and non-verbal portions, which, together, facilitate the over goal of managing the non-conscious processes.

Field example of non-verbal portion of framing. Some factors include facilitator awareness and management of the impact of the physical and emotional environment, stress states, students' working memory capacity, students past histories with instructor, group, content and environment. Framing may also include other non-verbal adjustments such as in difficulty or speed of the learning event. These factors are often managed outside of the students' awareness.

Field example of verbal portion of framing. The learning event may be a trust-building activity, framed in part by reminding the group to "pay attention to how you are trusting today—how you are trusting others, the equipment or climbing shoes, even how you are trusting yourself" (Cruickshank & Doenges, 2012, p. 54).

Coupled with the initial *Framing* is the *Activity*, traditionally considered the actual lesson. However, CDTT extends far beyond such a limited perspective.

Activity. The activity is a forum, not an end. The activity uses social-emotional skills to loop back and re-iterate framing points. During the learning event, all aspects of neuroeducation come into play as the teacher/facilitator seeks to direct the non-conscious systems of attention, motivation, and appraisal/affect. To maintain attention, information and activities must be neither too much, nor too fast to avoid overloading working memory. An overloaded brain drops in performance; it does not multitask (Charron & Koechlin, 2010; Klingberg, 2009; Ophir, Nass, & Wagner, 2009). The activity should have short, clear, attainable goals, rapid natural feedback and within the range of the student's abilities, which facilitates motivation. This is the Goldilocks test, getting the challenge level just right (Schenck, 2011). Feedback goes to both student and instructor, permitting adjustments, before formal reflection. This feedback allows the instructor, leadership, and program to improve performance if attention is paid to the dynamics of the learning. Feedback, at all levels, creates a highly responsive system (Spencer et al. 2009). When these systems proceed in harmonious concert, a flow state could potentially be achieved (Csikszentmihalyi & Nakamura, 2010).

Field example of activity. Rock climbing is used to focus on a psychological goal of trust building. During a student's initial exposure to climbing, many personal security fears and assumptions are revealed. They confront whether they trust their belayer, their shoes, the rope, or themselves, creating many teachable moments where the facilitator can point back to the framing question of trust (Can I do this? Does anyone care how I feel?).

The rest of the fractal-like cycle, starting with debriefing, involves the hard part of learning, and is significant (Dewey, 1897; Schooler, 2011). Experiential educators often break down debriefing into "what, so what, now what" (Borton, 1970) to facilitate adapted reflection. This corresponds to Phases 3 to 5 in CDTT; however, we extend the debriefing process over time and with added points of intentionality. Neuroscience points toward slowing down the debriefing process to avoid cognitive overload and allow for neuron growth to create a long-lasting change (Cowan, 2005; Ratey, 2008).

Direct debriefing. Direct debriefing double checks what students take away from the activity and what is still needed to reach the psychological goal. During the direct debriefing, issues salient to each learner and the group are discussed. Like Gibbs (1988), valence is included (what was painful or enjoyable), and its significance discussed. Unlike Gibbs, the facilitator guides the debrief in terms of the goal presented in the original framing of the learning event. If flow (Csikszentmihalyi, 1991) is achieved, it should be explored. Many existing debriefing techniques are utilized. However, the facilitator should be cognizant of which questions pertain to direct debriefing and which should be saved for bridge-building and assimilation.

Field example of direct debriefing. After an activity, such as rock climbing, the direct debriefing should include questions that recap how that activity was framed. Examples include: "When did you trust during this activity? What did you see that built trust? What did you see that took away trust?" The questions focus on the activity and points you want students to take away. Avoid the temptation to go deeper, rather make sure the debrief is thorough, giving each student a chance to share and point out what they saw.

This phase is similar to the "Label" segment in EELDRC (Enroll, Experience, Label, Demonstrate, Review, Celebrate) identified by Deporter, Reardon, and Singer-Nourie (1999), but CDTT divides up the remaining phases differently, specifically to enhance long-term memory and later assimilation. CDTT also incorporates as integral a "pause" in the learning cycle. This aspect of CDTT stems from observation and is the most likely to be improved by research. Research currently underway is looking into the phenomenon of the inherent "pause" in spontaneous and unfacilitated deep processing (Immordino-Yang et al., 2009).

"Pause." The "pause" refers to a significant break (may include sleep) in debriefing that allows for internal reflective states to consider and personalize the learning experience. Field observations, pedagogical arguments for reflection (Boud et al. 1985; Schooler, 2011), and clinical observations indicate that a "pause" is considerably important to both learning and even human development (Immordino-Yang, 2008). Research has demonstrated that it takes time for the memory of the learning event to stabilize (Hebb, 1949; Schenck, 2011). At this time, it is unknown how long the "pause" should be for optimal learning. For example, some evidence suggests that a "pause" of only a few seconds can result in limited deep processing (Immordino-Yang et al., 2012).

Field example of "pause." SROM incorporates the "pause" into their curriculum in a few different ways. First, each day has down time after the activity's direct debriefing. This can be personal time and even extend into dinner. After dinner, the next phase picks up with Bridge-Building. When looking at the whole course itinerary, a "pause" can be built in as longer personal time, or even a solo activity. When building the "pause" into the itinerary, consider making it on the same time scale as the whole course. For example, on SROM's 40 Day, 40 Night course the "pause" is a 48-hr solo (Cruickshank & Doenges, 2010).

The circumstances illuminating and surrounding the "pause" may end up proving to be of great significance to both education and social-emotional processing (Immordino-Yang et al., 2012).

Bridge-building. This phase is the most difficult part, and the student must be intentionally guided. Overt connections are made with concepts encountered during the activity and extended to new situations during bridge-building. As students look for patterns through their newly acquired lens, in keeping with Dynamic Skills Theory, the facilitator needs to help steer them as they begin to connect their prior experience to these patterns. New perspectives, new connections in memory are somewhat unstable at this time and malleable (Loftus & Ketchum, 1994). The new attitude (which is really a newly established memory network) and memories of the learning event continue to stabilize as they are retrieved, discussed, explored, and used (Butler, Karpicke, & Roediger, 2008; Rohrer & Pashler, 2010). As the students become more proficient in the application of their new skills/knowledge and construct their own understanding, they increase their autonomy and become more self-directed.

Field example of bridge-building. Questions to ask may include the following: What do they think about the activity now, in light of the goal of the learning event? Why was that important to you? What perspectives or relationships changed? What further insights have been achieved? What did they see that was similar or different from their past experiences?

However, to successfully transfer and solve new problems, *all* the relevant new skills and knowledge must be practiced in association with each other because students are reaching a new complexity level in understanding (Fischer 1980; Schenck, 2011). If only some skills are practiced, transfer may not occur. New skills, knowledge, and attitudes are first applied under guidance, but as students practice toward automaticity, the task may become less effortful. However, we cannot assume that a student will spontaneously see the connections. Intentional guidance and checking is necessary.

Assimilation. The learning event, debriefing experiences, bridges to understandings, applications, and memory stabilization all synthesize and find direction/purpose in *assimilation*. All phases meld into a learner's personal history (Dere, Pause, & Peitrowsky, 2010; Dweck & Master, 2009). The person and learning are connected through multiple systems, and learning becomes part of their autobiographical memory. These different but overlapping memory networks comprised of procedures, knowledge sets, and emotions, which affect future thoughts and actions (Baddeley, 2003; Craik & Tulving, 1975). The learning event and psychological goal are integrated in the person's autobiographical memory indicating a state known as transference.

Field example of assimilation. The goal of the learning event is tied to a person's life and future when the individual chooses what and how they are going to do things differently because of their new experience. It should be a personal application of skill or knowledge. For example, questions to consider are: What are you going to do differently when you go home? How has your perspective changed? What is something new you discovered about yourself and what is going to change in your life as a result?

A Framework of Learning and Teaching

Using a biological approach and understanding that even social and psychological processes have neurobiological correlates, one can uncover processes that are ubiquitous to learning. The CDTT model framework describes a teaching process, not a curriculum. This means any curriculum or teaching schedule can use the process whether for leadership training of corporate executives, teaching knot tying, or introducing subtraction. The framework guides the learning event.

CDTT can be applied at many different levels; it has dynamic but repeating patterns at different levels of complexity (fractals) as Fischer and Rose (2001) demonstrated. In nature, fractal patterns of complexity are extremely common, not just in the mind's processing. Tree branches or streams illustrate the fractal where a single branch forks, each in turn dividing further depending upon their initial conditions. CDTT's repeating fractal patterns at different levels of complexity make the model scalable, both up and down. For example, feedback can inform up and down in scale with environmental conditions informing the learner, and between the learner and instructor (both ways), or between instructors and program leaders and management. All feedback is affected by the initial conditions of that level (Lorenz, 1963) and helps reframe any particular level, permitting self-adjustment. The CDTT model describes a fractal, not a cobbled together cycle, allowing its natural application to many forms of training while simultaneously permitting it to adapt and self-adjust.

Empirical Testing: Questions to Still Be Answered

Unlike previous models of experiential learning, CDTT allows for empirical testing, a deficiency in existing experiential models (Seaman, 2008). Each phase is specifically defined and described in terms of quantifiable cognitive psychological and neurobiological processes. This allows for testing for null hypotheses, such as *Does the order of the cycle matter or can phases be skipped? What is the optimal length of the "pause?" Does the pause coming in the right sequence, or are there multiple "pauses?" What changes or adaptations need to be made to accommodate cultural difference in internally reflective states?*

Furthermore, given that the model is based on empirical research and defined terms, it can evolve as our understanding of the mind/brain systems evolves, permitting other forms of empirical testing as neuroscience explores the brain interactions with culture. One question is how adaptable is this model to varying contexts or cultures, and whether it creates usable knowledge (Fischer, 2009).

Moving Forward: The Need for Objective and Empirical Evaluation

As experiential education continues to move forward in terms of empirical research and evidence-based practices, there will be a continued necessity for well-grounded theories that are able to predict and accommodate new findings. CDTT has portions superficially similar to other models that are sound in terms of neuroeducation and neurobiological research, but it combines many "best-practices" into a more encompassing and deeper framework. As all learning takes place in the brain and affects the mind that emerges, having a better understanding of the neurobiological processes permits us to get beyond the trial and error approach to using a testable neuroeducation approach. This provides direction in that it demonstrates both reasonable expectations and neurobiological limitations of instructional strategies. Failure or success can be heavily influenced by the natural mind–brain processes without curricular or instructional leadership ever being aware, leaving them susceptible to neuromyths and inappropriate "brain-based education" marketing. Experiential learning is powerful. However, we need to better inform ourselves about the mind–brain processes that affect experiential learning. When one understands *why* something works and can articulate that, it can be replicated in other contexts. In turn, this facilitates the potential application, not only in experiential education but also in other fields of learning.

Clearly, there is a need for a new teaching model for experiential learning, one that is grounded in research, practically usable, adaptable to new research, and testable to determine validity. The CDTT model presented and described has both a research foundation and extensive theoretical underpinnings. The intent is that this model will initiate a new conversation and lead to new research questions. Granted, one day in the future, a better model may emerge. Until that day comes, CDTT is respectfully submitted for consideration.

Declaration of Conflicting Interests

The author(s) declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

Funding

The author(s) received no financial support for the research, authorship, and/or publication of this article.

References

Akella, D. (2010). Learning together: Kolb's experiential theory and its application. *Journal of Management & Organization*, *16*, 100-112.

Baddeley, A. (2003). Working memory: Looking back and looking forward. *Nature Reviews*, *4*, 829-839.

Beard, C., Wilson, J. P., & McCarter, R. (2007). Toward a theory of e-learning: Experiential e-learning. *Journal of Hospitality, Leisure, Sport & Tourism*, *6*(2), 3-15.

Bergsteiner, H., Avery, G. C., & Neumann, R. (2010). Kolb's experiential learning model: Critique from a modelling perspective. *Studies in Continuing Education*, *32*, 29-46.

Borton, T. (1970). *Reach, touch, and teach: Student concerns and process education*. New York, NY: McGraw Hill.

Boud, D., Keogh, R., & Walker, D. (1985). *Reflection: Turning experiences into learning*. London, England: Kogan Page.

Bruer, J. T. (1997). Education and the brain: A bridge too far. *Educational Researcher*, *26*(8), 4-16.

Butler, A. C., Karpicke, J. D., & Roediger, H. L., III. (2008). Correcting a metacognitive error: Feedback increases retention of low-confident correct responses. *Journal of Experimental Psychology*, *34*, 918-928.

Charron, S., & Koechlin, E. (2010). Divided representation of concurrent goals in the human frontal lobes. *Science*, *328*, 360-363. doi:10.1126/science.1183614

Coch, D., Fisher, K. W., & Dawson, G. (Eds.). (2007). *Human behavior, learning, and the developing brain: Typical development*. New York, NY: Guilford Press.

Coffield, F., Moseley, D., Hall, E., & Ecclestone, K. (2004). *Learning styles and pedagogy in post-16 learning: A systematic and critical review*. London, England: Learning and Skills Research Centre.

Cohen, J. D., Romero, R. D., Servan-Schreiber, D., & Farah, M. J. (1994). Mechanisms of spatial attention: The relation of macrostructure to microstructure in parietal neglect. *Journal of Cognitive Neuroscience*, *6*, 377-387.

Cowan, N. (1988). Evolving conceptions of memory storage, selective attention, and their mutual constraints within the human information-processing system. *Psychological Bulletin*, *104*, 163-191.

Cowan, N. (2005). *Working memory capacity*. New York, NY: Psychological Press.

Craik, F. I., & Tulving, E. (1975). Depth of processing and the retention of words in episodic memory. *Journal of Experimental Psychology-General*, *104*, 268-294.

Cruickshank, J., & Doenges, J. (Eds.). (2012). *SROM instructor manual* (5th ed.). Laramie, WY: Solid Rock Outdoor Ministries.

Csikszentmihalyi, M. (1978). Attention and the holistic approach to behavior. In K. S. Pope & J. L. Singer (Eds.), *The stream of consciousness* (pp. 335-358). New York, NY: Plenum.

Csikszentmihalyi, M. (1991). *Flow: The psychology of optimal experience*. New York, NY: Harper Perennial.

Csikszentmihalyi, M., & Nakamura, J. (2010). Effortless attention in everyday life: A systematic phenomenology. In B. Bruya (Ed.), *Effortless attention: A new perspective in the cognitive science of attention and action* (pp. 179-189). Cambridge, MA: MIT Press.

Damasio, A. (2012). *Self comes to mind: Constructing the conscious brain*. New York, NY: Pantheon.

Deci, E., & Ryan, R. (2000). The "what" and "why" of goal pursuits: Human needs and the self-determination of behavior. *Psychological Inquiry*, *4*, 227-268.

Dehaene, S., Posner, M. I., & Tucker, D. M. (1994). Localization of a neural system for error detection and compensation. *Psychological Science*, *5*, 303-305.

Deporter, B., Reardon, M., & Singer-Nourie, S. (1999). *Quantum teaching*. Needham Heights, MA: Allyn & Bacon.

Dere, E., Pause, B. M., & Peitrowsky, R. (2010). Emotion and episodic memory in neuropsychiatric disorders. *Behavioural Brain Research*, *215*, 162-171.

Dewey, J. (1897). My pedagogical creed. *The School Journal* (Vol. LIV (3). January 16, 1987, pp. 77-80).

Dweck, C. S. (1986). Motivational processes affecting learning. *American Psychologist*, *41*, 1040-1048.

Dweck, C. S. (2008). Can personality be changed? The role of beliefs in personality and change. *Current Directions in Psychological Science*, *17*, 391-394.

Dweck, C. S., & Leggett, E. (1988). A social cognition approach to motivation and personality. *Psychological Review*, *95*, 256-273.

Dweck, C. S., & Master, A. (2009). Self-theories and motivation; Students' beliefs about intelligence. In K. R. Wenzel & A. Wigfield (Eds.), *Handbook of motivation at school* (pp. 123-140). New York, NY: Routledge.

Estes, C. A. (2004). Promoting student-centered learning in experiential education. *Journal of Experiential Education*, *27*, 141-160.

Fenwick, T. J. (2003). *Learning through experience: Troubling orthodoxies and intersecting questions*. Malabar, FL: Krieger.

Fischbach, G. D. (1992, September). Mind and brain. *Scientific American*, p. 4857.

Fischer, K. W. (1980). A theory of cognitive development: The control and construction of hierarchies of skills. *Psychological Review*, *87*, 477-531.

Fischer, K. W. (2008). Dynamic cycles of cognitive and brain development: Measuring growth in mind, brain, and education. In A. M. Battro, K. W. Fischer, & P. J. Lena (Eds.), *The educated brain* (pp. 127-150). Cambridge, UK: Pontifical Academy of Science and the Cambridge University Press.

Fischer, K. W. (2009). Mind, brain, and education: Building a scientific groundwork for learning and teaching. *International Mind, Brain, and Education*, *3*, 3-16.

Fischer, K. W., & Bidell, T. R. (2006). Dynamic development of action and thought. In W. Damon & R. M. Lerner (Eds.), *Theoretical models of human development: Handbook of child psychology* (6th ed., Vol. 1, pp. 313-399). New York, NY: John Wiley.

Fischer, K. W., & Rose, L. T. (2001, November). Web of skill: How students learn. *Educational Leadership*, pp. 6-12.

Fischer, K. W., Rose, L. T., & Rose, S. (2007). Growth cycles if mind and brain, analyzing developmental pathways of learning disorders. In *Mind, brain and education in reading disorders* (pp. 101-132). Cambridge, NY: Cambridge University Press.

Fischer, K. W., Yan, Z., & Stewart, J. (2002). Cognitive development in adulthood: Dynamics of variation and consideration. In J. Valsiner & K. Connolly (Eds.), *Handbook of developmental psychology* (pp. 491-516). Thousand Oaks, CA: SAGE.

Gass, M. A. (1995). *Book of metaphors* (Vol. 2). Dubuque, IA: Kendall Hunt.

Gazzaniga, M. S., Ivry, R. B., & Mangun, G. R. (2002). *Cognitive neuroscience*. New York, NY: W.W. Norton.

Gibbs, G. (1988). *Learning by doing: A guide to teaching and learning methods*. Boston, MA: Oxford Polytechnic Further Education Unit.

Goswami, U. (2006). Neuroscience and education: From research to practice? *Nature Reviews Neuroscience*, *7*, 2-7.

Hebb, D. (1949). *The organization of behavior: A neuropsychological theory*. New York, NY: John Wiley.

Heron, J. (1992). *Feeling and personhood: Psychology in another key*. London, England: SAGE.

Iliff, C. (1994). *Kolb's Learning Style Inventory: A meta-analysis* (Unpublished Doctoral dissertation). Boston University, MA.

Immordino-Yang, M. H. (2008). Smoke around the mirror neurons. *Mind, Brain, and Education*, *2*, 67-73.

Immordino-Yang, M. H. (2011). Me, my "self" and you: Neuropsychological relations between social emotions, self awareness, and morality. *Emotion Review*, *3*, 313-315.

Immordino-Yang, M. H., Christodoulou, J. A., & Singh, V. (2012). Rest is not idleness: Implications of the brain's default mode for human development and education. *Perspectives on Psychological Science*, *7*, 352-364.

Immordino-Yang, M. H., McColl, A., Damasio, H., & Damasio, A. (2009). Neural correlates of admiration and compassion. *Proceedings of the National Academy of Sciences*, *106*, 8021-8026.

Kimball, D., & Holyoak, K. (2000). Transfer and expertise. In E. Tulving & F. Craik (Eds.), *The Oxford handbook of memory* (pp. 109-122). New York, NY: Oxford University Press.

Kirschner, P. A., Sweller, J., & Clark, R. E. (2006). Why minimal guidance during instruction does not work: An analysis of the failure of constructivist, discovery, problem-based, experiential, and inquiry-based teaching. *Educational Psychologist*, *41*, 75-86.

Klingberg, T. (2009). *The overflowing brain: Information overload and the limits of working memory*. New York, NY: Oxford University Press.

Koch, C., & Laurent, G. (1999). Complexity and the nervous system. *Science*, *284*, 96-98.

Kolb, A. Y., & Kolb, D. A. (2005). Learning styles and learning spaces: Enhancing experiential learning in higher education. *Academy of Management Learning & Education*, *4*, 193-212.

Kolb, D. A. (1984). *Experiential learning: Experience as the source of learning and development*. Englewood Cliffs, NJ: Prentice Hall.

Lazarus, R. S. (2006). Emotions and interpersonal relationships: Towards a person-centered conceptualization of emotions and coping. *Journal of Personality*, *74*, 9-46.

LeDoux, J. (1997). *The emotional brain*. New York, NY: Putnam.

Loftus, E. F., & Ketchum, K. (1994). *The myth of repressed memory: False memories and allegations of sexual abuse*. New York, NY: St. Martin's.

Lorenz, E. (1963). Deterministic nonperiodic flow. *Journal of Atmospheric Sciences*, *20*, 130-141.

Mainzer, K. (1996). *Thinking in complexity: The complex dynamics of matter, mind, and mankind*. New York, NY: Springer-Verlag.
Mareschal, D., Johnson, M. H., Sirois, S., Spratling, M. W., Thomas, M. S., & Westermann, G. (2007). *Neuroconstructivism* (Vol. 1). New York, NY: Oxford University Press.
Maslow, A. H. (1943). A theory of human motivation. *Psychological Review*, *50*, 370-396.
Miettinen, R. (2000). The concept of experiential learning and John Dewey's theory of reflective thought and action. *International Journal of Lifelong Education*, *19*, 54-72.
Ophir, E., Nass, C., & Wagner, A. (2009). Cognitive control in media multitaskers. *Proceedings of the National Academy of Sciences*, *106*, 15583-15587.
Organisation for Economic Co-Operation and Development. (2007). *Understanding the brain: The birth of a science of learning-executive summary*. Paris, France: Author.
Parziale, J., & Fischer, K. W. (1998). The practical use of skill theory in classrooms. In R. J. Sternberg & W. M. Williams (Eds.), *Intelligence, instruction, and assessment: Theory into practice* (pp. 95-110). Mahwah, NJ: Lawrence Erlbaum.
Pashler, H., McDaniel, M., Rohrer, D., & Bjork, R. (2008). Learning styles: Concepts and evidence. *Psychological Science in the Public Interest*, *9*, 105-119.
Piaget, J. (2001). *The psychology of intelligence*. New York, NY: Routledge. (Original work published 1950)
Posner, M. I., & Boies, S. J. (1971). Components of attention. *Psychological Review*, *78*, 391-408.
Priest, S., & Gass, M. (1994). Frontloading with paradox & double binds in adventure education facilitation. *Journal of Adventure Education and Outdoor Leadership*, *11*, 8-10.
Ratey, J. (2008). *Spark: The revolutionary new science of exercise and the brain*. New York, NY: Little, Brown.
Roberts, J. W. (2002). Beyond learning by doing: The brain compatible approach. *Journal for Experiential Education*, *25*, 281-285.
Rogers, A. (1996). *Teaching adults* (2nd ed.). Buckingham, UK: Open University Press.
Rohrer, D., & Pashler, H. (2010). Recent research on human learning challenges conventional instructional strategies. *Educational Researcher*, *39*, 406-412.
Rose, L. T. (2010). *Educational neuroscience class lecture*. Cambridge, MA: Harvard Graduate School of Education.
Rose, L. T., & Fischer, K. W. (2009). Dynamic development: A neo-Piagetian approach. In U. Muller, J. I. Carpendale, & L. Smith (Eds.), *Cambridge companion to Piaget* (pp. 400-422). New York, NY: Cambridge University Press.
Rose, L. T., & Fischer, K. W. (in press). Dynamic Systems Theory. In R. A. Shweder (Ed.), *Chicago companion to the child*. Chicago, IL: Chicago University Press.
Ruble, T. L., & Stout, D. E. (1993). Learning styles and end-user training: An unwarranted leap of faith. *Management Information Systems Quarterly*, *17*, 115-117.
Ryan, R. M., & Deci, E. L. (2000). Self-determination theory and the facilitation of intrinsic motivation, social development, and well-being. *American Psychologist*, *55*, 68-78.
Sapolsky, R. (2004). *Why zebra's don't get ulcers*, New York, NY: Henry Holt.
Schenck, J. (2011). *Teaching and the adolescent brain: An educator's guide*. New York, NY: W.W. Norton.
Schooler, J. (2011). Introspecting in the spirit of William James: Comment on Fox, Ericsson, and Best (2011). *Psychological Bulletin*, *137*, 235-350.
Seaman, J. (2008). Experience, reflect, critique: The end of the "learning cycles" era. *Journal of Experiential Education*, *31*, 3-18.

Spencer, J., Thomas, M., & McClelland, J. (2009). *Towards a unified theory of development*. New York, NY: Oxford University Press.

Stanovich, K. (2009). *What intelligence tests miss: The psychology of rational thought*. New Haven, CT: Yale University Press.

Stavenga de Jong, J. A., Wierstra, R. F., & Hermanussen, J. (2006). An exploration of the relationship between academic and experiential learning approaches in vocational education. *British Journal of Educational Psychology*, *76*, 155-169.

Svinickl, M. D., & Dixon, N. M. (1987). The Kolb model modified for classroom activities. *College Teaching*, *35*, 141-146.

Sweller, J., Kirschner, P. A., & Clark, R. E. (2007). Why minimally guided teaching techniques do not work: A reply to commentaries. *Educational Psychologist*, *42*, 115-121.

Thelen, E., & Smith, L. (1994). *A dynamic systems approach to development of cognition and action*. Cambridge, MA: MIT Press.

Tokuhama-Espinosa, T. (2010). *Mind, brain, and education science: A comprehensive guide to the new brain-based teaching*. New York, NY: W.W. Norton.

Vince, R. (1998). Behind and beyond Kolb's learning cycle. *Journal of Management Education*, *22*, 304-319.

Vygotsky, L. S. (1978). *Mind in society: The development of higher psychological processes*. Cambridge, MA: Harvard University Press.

Zull, J. (2002). *The art of changing the brain: Enriching teaching by exploring the biology of learning*. Sterling, VA: Stylus.

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