SPi	MBE	MBE_12176	B	Dispatch: August 11, 2018	Journal: MBE	CE: Yuvaarthi/Suresh
	Journal Name	Manuscript No.		Author Received:	No of pages: 10	TS: suresh

Creative Engagement: Embodied Metaphor, the Affective Brain, and Meaningful Learning

Q2 Ross Anderson[1]

Q1

ABSTRACT— In this commentary, I build on recent interdisciplinary models for embodied cognition with additional perspectives from affective neuroscience, educational psychology, creativity theory, and science education. I invoke William James and John Dewey, pioneers of an embodied philosophy of mind, alongside recent affective neuroscience theory about the role of bodily emotional response in learning. I present educational implications of the need for meaning-making through body–mind and affective interaction with a social-learning environment. I reformulate the problem of learner engagement in school to look beyond the need for autonomy, belonging, and competency to include the need for creative meaning-making in learner engagement. To provide context, I explore the experience of adolescent students using a drama-based pedagogical tool to learn an abstract science concept. This example illustrates how embodied, creative learning rich with metaphor shapes meaning-making in science learning. I conclude by elaborating further on a proposed model of creative engagement.

> The trouble lies not so much in the solutions, as in the factors which determine statement of the problem. If this be so, the way out of the snarl is a reconsideration of the conceptions in virtue of which the problem exists. (Dewey, 1925, p. 194)

American philosopher, John Dewey, proposed that the issue in philosophy of mind was not the inadequate solutions but rather the poor conception of the problem to which philosophy responded (Dewey, 1925). More than 100 years later, solutions to pervasive challenges in education respond to problems formulated in err—based on a philosophy of knowledge and reasoning that upholds the problematic body–mind dichotomy that Dewey criticized so adamantly. In response to that continued challenge, an interdisciplinary approach to conceptualizing and investigating embodied cognition in learning has taken shape (Osgood-Campbell, 2015). Within science education, for instance, researchers have related the living body as a sensorial medium of aesthetic appreciation and creative self-fashioning (Shusterman, 2008) that can explore and express the meaning of physics concepts, gesturally (Scherr et al., 2013). However, those innovations continue to be limited in scope and scale.

In this commentary, I build on recent interdisciplinary models for embodied cognition (e.g., Delafield & Adie, 2016; Osgood-Campbell, 2015) with additional perspectives from affective neuroscience, educational psychology, creativity theory, and science education. I invoke William James and John Dewey, pioneers of an embodied philosophy of mind, alongside recent affective neuroscience theory about the role of bodily emotional response in learning. I present educational implications of embodied meaning-making in a social-learning environment. I reformulate the problem of learner engagement in school (Eccles & Roeser, 2011) to look beyond the needs for autonomy, belonging, and competency, suggested by dominating theories in educational psychology (Fredericks, Blumenfeld, & Paris, 2004), to include the need for creative meaning-making in learner engagement. To provide context, I explore the experience of adolescent students using a drama-based pedagogical tool, called *tableaux vivants*. That example aims to illustrate how creative engagement in learning, rich with embodied metaphor, can shape meaning-making for the learner. After this illustration, I

[1]Inflexion, University of Oregon,

Address correspondence to Ross Anderson, Inflexion, 1700 Millrace, Eugene, OR 97405; e-mail: ross.anderson@inflexion.org

connect affective neuroscience perspectives with student engagement and creativity to conceptualize an interdisciplinary model of creative engagement.

A LIVING PICTURE

Dewey (1925) described experience as *dramatic enactment* and William James' (1890) conceived mind to be *pulses of thought*; as such, tableaux vivants, or living picture, provides a fitting illustration of how to make meaning of abstract concepts through artistic, embodied metaphor. Tableaux vivants directly challenges the pervasive idea inherited from analytic philosophy of linguistics and knowledge that meaning must be tied to words (Shusterman, 2008). In its enacted form tableaux vivants requires one or more actors to create a scene for an audience, remaining silent and motionless (Anderson & Beard, 2018). Actors can create and move through a sequence of static scenes; the silence generates a sensory deprivation that draws on other rich modalities to grasp, produce, and share meaning without a reliance on words.

Actors use tableaux vivants to express the sights, smells, sounds, textures, and tastes that signify a concept or an idea. Actors create an environment of meaning through a multisensory enactment of the nuances of the concept. Tableaux vivants compositions include creative and aesthetic choices for proximity of actors, facial expression, implied motion, shape/flow, contrasting levels, focal points, bodily gesture, and orientation to audience, among other possible textures (see Figure 1 for photograph examples; Anderson & Beard, 2018). The tableaux vivants form can be used in a variety of contexts and purposes in education. For instance, high school teachers might use tableaux to generate greater empathy and understanding around sensitive social topics, such as sexual consent, where students can play out different roles and personas in various contexts. Students can enact historical scenes as everyday characters living in ancient times to deepen their understanding of how people lived and what they may have felt (Anderson & Beard, 2018). Students can pull catalytic moments from chapters in a novel and create tableaux frames to portray the characters' experience. Beyond these applications for literary, social, or historical dramatization, students can also represent inanimate objects and abstract ideas in math and science through gestural metaphor to deepen their grasp.

Teachers and students both report that integration of tableaux vivants into academic content creates emotionally evocative learning and rich opportunities for shared meaning-making (Anderson & Beard, 2018). As I explore further in the following pages, theories from neuroscience reinforce the potential benefits of a practice like tableaux vivants, where multisensory systems are at work and emotions are aroused in the construction of meaning. Theoretically, this heightened potential of neural bindings in the brain should strengthen the relation of meanings, values, and purposiveness of actions and thoughts (Damasio, 2010; Delafield & Adie, 2016; Immordino-Yang & Yang, 2017; Osgood-Campbell, 2015).

METAPHOR AND THE MAKING OF MEANING

> We think; and as we think we feel our bodily selves as the seat of the thinking. If the thinking be *our* thinking, it must be suffused through all its parts with that peculiar warmth and intimacy that makes it come as ours. (James, 1890, p. 242)

In *The principles of psychology* William James (1890) emphasized the overlooked role of the body in sensing the different types of self that we experience in relation to the environment and others. In *Nature and experience*, John Dewey (1925) went further to establish the inseparable nature of body–mind[1] in how we experience consciousness, self, and meaning in life. According to James and Dewey, experience is owned by an individual and builds on a unique history with the environment—inextricably natural and social. Selves are simply processes of experiences; experiences establish new potentials for meaning; meaning is the foundation of understanding mind; and mind is no way distinct from body. The difference, then, between meaning and knowledge is ontological. The idea that knowledge can be broken down into componential facts does not necessarily make knowledge more real than the meaning that an individual creates. Meaning is emergent not static and knowledge held by a knower contributes to meaning. Theories in neuroscience (Damasio, 2010; Edelman, 2004) suggest that meaning of an object is different than the mental representation—recalled, perceived, or anticipated—of an object in the environment. Meaning arises from the interaction of the *bodily organism* (the learner) and the environment through connections, images, felt qualities, emotions, and patterns, which are mostly nonconscious (Johnson, 2007a). In essence, meaning relates the past to present and future experiences.

Dewey (1925) stressed that meaning does not draw on what an interaction or object *immediately is* but rather what it *makes possible*. In this way, meaning is both relational to the qualities and structures of past situations, including ancient value systems that shape our motivations (Damasio, 2010), and instrumental to our future actions and thoughts. To recover the deep process of meaning-making requires going beyond the purely propositional structure of meaning in language using other means, such as movement (Delafield & Adie, 2016). For instance, to make meaning of the scientific process of evaporation requires the conceptual coding of

Fig. 1. Textured photographs of original tableaux vivants produced by middle school students. Tableaux vivants compositions include creative and aesthetic choices for proximity of actors, facial expression, implied motion, shape/flow, contrasting levels, focal points, bodily gesture, and orientation to audience, among other possible textures.

related characteristics, such as vapor, molecules, and water cycle. An embodied interactionist perspective (Goodwin, 2000) suggests that the formation of meaning around those characteristics will always be social where "communicative interactions and shared language ... [are] the means of exploring the meaning of things" (Johnson, 2007b, p. 266).

Imagine the experience of a sixth grade learner conceiving a tableaux vivants with several peers aiming to express the heat energy required for the chemical reactions of evaporation to take place. She reads about the characteristics of the process and shares her scientific understanding. She selects qualities and metaphorical representations to express in embodied forms (e.g., dried puddles, fog, sun, shrinking, shriveling, etc.). This physical simulation to visualize, interpret, embody, and experience nonhuman processes, such as heat particles, creates a spatial awareness of force sensations and visualizations of abstract concepts (Reiner & Gilbert, 2000). Generally, the integration of drama and science uses improvisational forms (Odegaard, 2003), requiring that learners build from felt qualities and act on immediate and suggestive interpretations. Johnson (2007b) proposed that this type of development of conceptual metaphor "is a nearly omnipresent part of the human capacity for abstract conceptualization and reasoning ... it permits us to use the semantics and inferential structure of our bodily experience as a primary way of making sense of abstract entities, relations, and events" (p. 280). In this way, any idea that there is a literal core to the concept of evaporation is a false pretense. If we accept that *meaning* goes far beyond a descriptive linguistic definition, evaporation will *mean* something different to each learner based on experience.

This hypothetical learning scenario aligns with the *invention* approach to science instruction proposed by Chase and Klahr (2017) that includes both direct instruction of science content and student-led inquiry and invention to make meaning of and apply content knowledge. Envisioning, embodying, and enacting a tableaux vivants scene of evaporation with peers also presents potentialities unique to the form. Even though we remain largely unaware, the engagement of myriad sensorimotor and cognitive systems results in greater potential for meaning (Damasio, 2010; Johnson, 2007a). Lakoff and Johnson (2008) proposed that all abstractions can be understood in terms of these basic sensorimotor experiences, such as object permanence and movement. We express ideas, like time, with embodied metaphors, instinctively. When we say we are “half way through” the year, we imply that the year has a spatial extent and we are moving relative to it. Through embodied and linguistic metaphor, meaning-making expresses felt qualities that emerge from our bodily organism changing constantly in response to the environment. In contrast to behaviorist and functionalist perspectives (Fodor, 1981), we are not disembodied thinking and knowing creatures governed by valueless and emotionless cognition.

A PALPITATING INWARD LIFE

> Understanding emotions is also (and perhaps even more critically) about the meaning that students are making—that is, the ways in which students and teachers are *experiencing* and *feeling* their emotional reactions and how feelings are steering thoughts and behaviors, consciously or not. (Immordino-Yang, 2015, p. 21)

In his work on understanding the origins of the self, neuroscientist Antonio Damasio (2010), suggested that the ultimate value to our body–mind processes is a homeostasis in dynamic equilibrium—what James (1890) called the “palpitating inward life” (p. 287). Dewey perceived homeostasis of our bodily systems through the idea that *everything is becoming*—growth in meaning holding the ultimate value. Both Dewey (1925) and James (1890) noted the feeling of tendency and sense of direction in consciousness. In this way, meaning-making relates the present moment to past and future experience in an anticipatory forward feeling sense of direction. The felt distinction between furtherance and hindrance, openness and skepticism, and fluidity and resistance emerges in the mind from emotional responses seated in the body’s viscera.

When the sixth grade learner faces the ambiguous task of constructing tableaux vivants of evaporation, the novelty of the experience may at first be felt as a hindrance. Perhaps she has never performed this before, does not know her peers well, or is not sure what the teacher really wants. Emotions of embarrassment and uncertainty contribute to a mild feeling of dread for both teachers and students new to tableaux vivants (Anderson & Beard, 2018); however, within this resistance, sharp analysis takes shape and new meaning is born, intimately connected with the bodily states experienced. The hindrance and furtherance for her peers will each be different based on individual history of their bodily organism but also commonly grounded in a phylogenetic ancestry that evaluates reward and risk in the environment (Packard & Delafield-Butt, 2014). In practice, thoughtfully structured experiences build comfort with tableaux vivants; any immediate sense of dread can transform into enthusiasm (Anderson & Beard, 2018).

Once she enacts the tableaux vivants representing kinetic energy of heat and water vapor, the felt qualities of evaporation take on far more meaning than just the linguistic string of words signifying the concept. As James (1890) envisioned, the conceptual topography of evaporation forms a web of meaning—a fishnet with a focal point and a fringe of unconscious, faint feelings, and memories. Based on an ever-changing bodily response, evaporation will never take on identical meaning, even in two consecutive moments of thought. In a process that Edelman (2004) termed degeneracy, the brain never employs the identical set of neural maps and connections twice to obtain to the same outcome (e.g., the concept of evaporation). As Edelman (2004) clarified, “... the reentrant circuitry underlying consciousness is enormously degenerate. There is no single circuit activity or code that corresponds to a given conscious ‘representation’” (p. 106). In the term *reentrant circuitry*, Edelman referred to the reciprocal connections and communications across different systems in the brain. Each system contains functionally segregated activities that work together to build perceptual maps. In light of this theory, concepts generalize using this same process when meeting ambiguous or novel inputs from the world. If the meaning will never be identical for one person twice, then of course it will never be the same for two individuals even if they were part of the same tableaux vivants scene after reading the same material on the scientific process of evaporation. This learning experience becomes latent with novelty for each learner, intimately woven with a unique emotional *palpitating inward life*.

To Dewey, meaning was the body–mind yearning to retain harmony in the midst of novelty in an environment in constant flux. In recognition that young learners face a constant barrage of novelty, Immordino-Yang (2015, p. 21) merged educator and neuroscientist perspectives to propose that emotional responses of the learner are simply another dimension of the cognitive skill that the learner works to grasp. Tableaux vivants, for instance, can be considered a tool that supports the strategy to recruit and manage relevant emotions in service of meaningful learning (Anderson & Beard, 2018). When the learner is aware of the environment—including an audience of her peers—the felt quality of her experience is heightened and the emotional cascade of anticipation, nervousness, excitement, and relief strengthens the neural mappings that represent the concept she works to grasp. According to Immordino-Yang (2015), these emotions, serve as a *rudder*, helping the learner recognize and call up knowledge. Moreover, the act of embodying the *feeling* of evaporation adds one more layer of emotion-based meaning and felt quality of the concept. The mostly nonconscious emotional reactions to the experience of performing evaporation become implicitly attached to cognitive scientific knowledge. With skilled guidance, those emotions can become visible to the learner herself. By integrating these embodied emotional reactions with cognitive processing, *skilled intuitions* are shaped by experience in the specific context, such as scientific understanding. These relevant intuitions steer thinking and actions to make the learner more efficient (Immordino-Yang, 2015).

To Dewey (1925), felt sense is imminent meaning. The emotional flux governing our body–mind process—need, effort to meet the need, and satisfaction of need met—occurs at all levels of meaning. Feelings are the affordances of the body medium within that value system in relation to the affordances in the environment. As the environment grows complex with learning, culture, and social influence, so do the potential feelings. In the tableaux vivants of evaporation, there is an inherent need to cultivate the meaning of evaporation to create a coherent and rich living scene. There is a need for openness from peers to new ideas and novel representations of meaning. Our student's idea that evaporation *feels* to her like shriveling, like a grape drying into a raisin, produces a felt quality to the meaning of the concept that can expand the reference to new situations for her peers. Language demarcates relations that shape the meaning of evaporation, but the felt quality, largely unnamable, places knowledge about the concept in context to help discriminate between similar scientific processes. This aid in discrimination is important given the documented struggle that many students have distinguishing between abstract science concepts (McDermott & Redish, 1999). Language can add distinguishable boundaries to meaning, permeable as they may be, but the felt quality is what shapes it (Dewey, 1925). Capacity for discriminating emotional qualities in both conscious and nonconscious processes is unquestionably critical to effective learning (Immordino-Yang, 2015), and learning in a social environment shapes awareness of those emotions (Immordino-Yang & Yang, 2017).

Embodied meaning-making in tableaux vivants connects emotional signals in various ways, especially through the incorporation of metaphor. Aziz-Zadeh and Gamez-Djokic (2016) and Lakoff (2016) build a strong case for the link between linguistic metaphor and emotion. For instance, when relating the feeling of disgust to different situations metaphorically, patterns of neural activation have been found to be very similar to those when a physical response to disgust is actually processed. The idea that most of our meaning-making of abstract concepts, such as evaporation, comes from affective experiences is gaining traction. In light of that point, meaning-making through tableaux vivants presents powerful potential. The learner may interpret the chemical change process as that of shriveling, communicating a felt quality through linguistic metaphor. Then, she embodies the meaning of a shriveling state of matter in enacted metaphor with expressive gesture. She interacts with her teachers and peers to expand this metaphor further with their own contributions. As a living sketch of the evaporation process, tableaux vivants enacts possibilities of meaning for the learner and her audience, anchored by an emotional and aesthetic experience.

THE BODILY SELF AS A CARTOGRAPHER

> … The signals from these 'self' systems report the relation of the body to both the inside and outside environments. Such signals include so-called proprioceptive, kinesthetic or somatosensory, and autonomic components. These components, which signal, respectively, the position of the body, the action of muscles and joints, and the regulation of the internal environment, affect almost every aspect of our being … The dynamic core, whose activities are enriched through learning, continues throughout life to be influenced by new processes of categorization connected to what might be termed the bodily self. (Edelman, 2004, p. 73–74)

Damasio (2010) and Edelman (2004) credited James' advances in philosophy of mind to conceptualize mind as a process that emerges from the automatic response patterns of the bodily self in the environment and the higher-order discrimination of felt qualities that arise from these interactions. Damasio (2010) presented the idea that the ultimate value of our bodily organism is the maintenance of a sensitive range of homeostasis in our internal milieu—"the chemical soup within which the struggle for life goes on uninterrupted" (p. 45). Damasio among others (Panksepp & Northoff, 2009) theorized that the primordial value system governed by our brain nuclei in the brain stem, hypothalamus, and basal forebrain is at the seat of our consciousness of Self. That system sends signals of our motivations and emotions to the rest of the brain, determining thoughts and moves in social, biological, and learning situations (Damasio, 2010; Immordino-Yang, 2015). These valuation processes go beyond survival for humans and relate directly "to the *quality* of that survival in the form of *well-being*" (Damasio, 2010, p. 51).

Damasio (2010) perceived images as the main currency in the mind but clarified that the images formed by the brain relate to the bodily value system and are not just visual. Such images are the mental patterns in any of the sensory modalities—touch, feel, taste, sight, and sound. After performing the tableaux depicting evaporation as a shriveling piece of fruit in the sun, the sixth grade science learner calls on a myriad of images when she sees the term evaporation on a test—including the darkness that descends as she slowly shrinks and shrivels inward closing her eyes. The majority of the images may remain on the fringe, nonconscious contributors to the whole, but they nonetheless play a role. The emotional arousal of performance may increase the value placed on these images. The images that form when recalling the meaning of evaporation contain physical characteristics as well as the somatic emotional markers. A web of perceptual maps whose relationships form a layered conceptual map represent the object at hand—the concept of evaporation (Damasio, 2010). As born *cartographers*, we build complex maps through interaction with the environment, maps that are mercurial through constant bodily motion.

The felt bodily response to any situation becomes *somatic markers* of emotion—skilled intuitions—that we use throughout living and learning, consciously or not, for the selection of images that come to mind. To Edelman (2004), the emotions that arise from this value system likely help to determine the strength and number of neural firings in our brains. Emotional responses do not require real-time external social or physical circumstances. As such, our capacity for intellectual reflection means that emotions can arise from internal beliefs or inferential imaginings (Immordino-Yang, 2010). The conscious or unconscious emotional recalls are the somatic markers on these maps where their connection to actions in the environment selects the most valued markers and mappings in the brain. By enacting a metaphorical milieu for evaporation—the hot sun, a grape shriveling into a raisin, and the upward motion of vapors rising—the multisensory experience shapes meaning, sustained deeply through somatic markers.

The saliency of images determines the selection process as meaning of evaporation continues to shape for the learner when recalled in future science tasks. Edelman (2004) succinctly explained that memory is always nonrepresentational. Concepts, such as the behavior of evaporation, are "the outcome of the brain mapping its own perceptual maps leading to generalities ... while memory and concepts are, together with value systems, necessary for meaning or semantic content, they are not identical to that content" (Edelman, 2004, p. 105). Our first-order maps are of the body and the environment, the primordial feelings, and the dynamic core; the second-order maps present an awareness of body changes. As Edelman suggested, this discrimination of the qualities felt in one moment is always in reference to other qualities. Made manifest in learning, this idea is powerful if we consider the difference between the learner enacting the felt meaning of evaporation compared to reading the definition within a symbolic language, only. In the language-only form, without strong somatic markers to aid the discrimination then or in the future, the possible qualities emergent in the meaning-making process may remain limited.

According to Immordino-Yang, repeated laboratory experiments conducted by Damasio and Adie (2016) have demonstrated that "emotional hunches accrue with experience and develop into 'skilled intuitions' that form the basis for implementing procedural knowledge" (p. 93). Patients with damage to the ventromedial prefrontal cortex, the area that links bodily feeling of emotion and cognitive strategies in learning, were not able to integrate their functional conscious knowledge, emotional response, and cognitive strategies to learn to play a risk-taking card game. Integrating this understanding, educators should consider how learning experiences (a) foster emotional connection to learning material, (b) develop transferrable skilled intuitions that undergird representation of concepts and content and (c) build a classroom social climate where task-relevant emotions are engaged consistently developing awareness and trust in emotional responses in learning. Immordino-Yang (2016) proposed "it is now becoming increasingly evident that emotion plays a fundamental role not only in the background processes like motivation for learning but also in moment-to-moment problem-solving and decision making" (p. 86). Gaining substantial support in the field of neuroscience and applied to a variety of studies (Venkatraman, Edlow, & Immordino-Yang, 2017), affective theories about the role of emotion and the brainstem in body–mind development provide new ways to conceptualize the objectives and strategies of typical classroom learning.

CREATIVE ENGAGEMENT IN EMBODIED LEARNING

For two decades, education psychology scholars have conceptualized learner engagement (Eccles, 2016; Fredericks et al., 2004; Ryan & Deci, 2000) as the composite outcome when three fundamental needs are met: *need for belonging*, *need for autonomy*, and *need for competence*. In light of the theory, research, and perspectives reviewed thus far, I propose that *the need for meaning* should be considered primary and supported by everyday creativity in the learning process alongside those other key needs. Figure 2 illustrates this idea within the concept of creative engagement. Across decades, some researchers have promoted creativity and learning as the same phenomenon (e.g., Guilford, 1967; Sawyer, 2012). Beghetto (2016) refreshed the idea of creative learning in a model that validates the individual interpretations and ideas that a learner may act on in everyday learning. That model built on past conceptualizations that viewed learning and creativity as entirely interdependent for the learner (e.g., Guilford, 1967; Piaget, 1972; Sawyer, 2012). Other models of creative learning have been situated in a pedagogical and curricular perspective (Sefton-Green, Thomson, Jones, & Bresler, 2011) or focused on creative learning as a process of

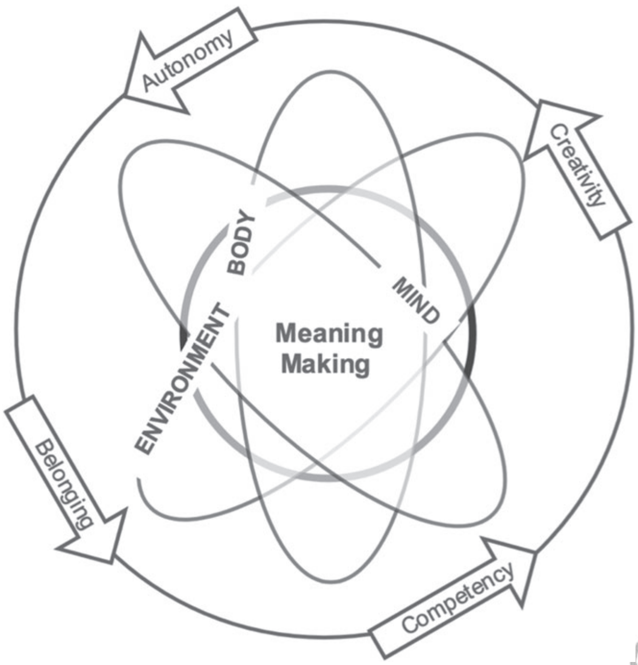

Fig. 2. A model of creative engagement for embodied meaning-making that links theories of creativity, engagement in learning, affective neuroscience, and embodied philosophy of mind.

problem-solving (Truman, 2011). Beghetto provided greater clarity by distinguishing two aspects of the creative learning process: *creativity-in-learning*, where personally meaningful interpretations are made, and *learning-in-creativity* where interpretation contributes to the meaning-making of others. To illustrate, our sixth grade learner's embodied metaphor of evaporation as the quality of a shriveling raisin shaped meaning for herself before it shaped the meaning of her peers. Her creative engagement of embodied metaphor contributed new possibilities seated in an emotional experience and grounded in knowledge and insight.

In science, for instance, research indicates that learners carry stores of intuition about the physical world, informed by their personal experience in the environment, cultural participation, schooling, and other knowledge-building activities (Dewey, 1938; Duckworth, 1996; Hammer, 2000, 2006). Some of these intuitions are *productive* and align with disciplinary norms in science fields (Hammer, 1996; Hammer, Goldberg, & Fargason, 2012; Harrer, Flood, & Wittmann, 2013). The creative experience of embodied metaphor in tableaux is a process of growth through which the seeds of learners' early ideas mature through experience to become more coherent, scientific, and personally meaningful and aesthetic. This conceptualization relates to many established theories about teaching and learning (e.g., Dewey, 1938; Montessori, 1978; Piaget & Inhelder, 1974; Vygotsky, 1986) and also reflects substantial evidence from research, including in science education (e.g., diSessa, Hammer, Sherin, & Kolpakowski, 1991; Metcalfe, Abbott, Bray, Exley, & Wisnia, 1984; Podolefsky & Finkelstein, 2007; Scherr et al., 2013; Scherr, Close, Close, & Vokos, 2012). That evidence suggests that full engagement in learning is a process of active, social, and embodied meaning-making personal to the learner and dependent on conditions in the learning environment.

Our sixth grade science learner first read about and discussed the process of evaporation and then considered possibilities through her feeling, gesture, and thought, barely conscious to the image selection taking place in her brain. In what may have seemed an instantaneous moment, the notion of a shriveling raisin formed in her body–mind based on past *felt* experience. Multiple emotional responses of her bodily organism in the environment determined how she moved forward with this idea to broaden the network of related percepts and emotions. Discrepant to her peers, but within an acceptable range, the meaning behind her idea solidified through both an embodied dramatic demonstration and semantic representation—*I am a shriveling raisin in the sun*. Within the practice of tableaux vivants, the communication of novel meaning need not be language-based; the enactment widens possibilities for her and her peers.

Lubart and Getz (1997) highlighted the central role of emotions in generating these kinds of creative metaphors. They also highlighted the fact that research seldom addresses the emergence of metaphor from source domains that are often unique to the individual's affective bodily response. One critical dimension of a creative idea is originality (Runco & Jaeger, 2012), which aligns with Edelman's (2004) theories of degeneracy and reentrant circuitry. Perceptual and conceptual mapping in response to the body's interaction with the environment will never be identical for two individuals but will always be socially constructed. In this light, the seeds of creativity—those personally meaningful interpretations that build from our individual embodied interaction with the world—are likely a natural aspect of neural processing and perceptual and conceptual mapping. Novel associations and ideas that arise from these embodied interactions make us human and unique. Importantly, affective neuroscience seats the emergence of mind and the Self at the brain stem, the corridor of communication from the body's value system of reward and motivation, to the brain's mind processes that construct meaning and conceptual mapping (Damasio, 2010; Edelman, 2004; Panksepp & Northoff, 2009). From this perspective, creative learning (Beghetto, 2016; Guilford, 1967; Truman, 2011) can grow more fully into a model of creative engagement where this value system of feelings and needs actively pursues novel meaning-making through the whole body–mind. Creative engagement moves creative learning from cognitive problem-solving, only, to a social and embodied experience of meaning-making.

Importantly, the term creative engagement has been used by scholars previously for varying purposes and with varying degrees of specificity. For instance, Edmonds, Muller, and Connell (2006) proposed a model of creative engagement for how interactive works of visual art engage viewers. Their model considers the engagement of an audience with an art work as an actively creative process. Craft, Chappell, and Twining (2008) used the term creative engagement broadly to reconceptualize the education system around learners' agency, voice, and creativity. An artist, a scholar, and an educator Eric Booth (2013) conceptualized creative engagement as "making worlds we care about and exploring the worlds others have made" (p. 1). Booth's ideas about creative engagement align closely with those presented in this essay.

At its core, novel interpretation of evaporation or other concepts is potential meaning. In the social classroom environment where a single convergent correct answer is most often rewarded (Glaveanu & Beghetto, 2017), the expression of something novel triggers the value system automatically—anticipation of risk and reward (Beghetto, 2016). If the emotional and creative act is internal meaning expressed outwardly interacting with an environment and audience, the audience must work to evaluate its meaning. That practice takes active and careful design of the learning environment (Anderson & Beard, 2018). When novel metaphor and interpretation are not enacted through outward expression, the opportunity may be lost to generate embodied and neural maps filled with emotional markers that generate new opportunity for meaning, recall, and application.

CONCLUSION: A MODEL FOR EMOTION-FILLED CREATIVE ENGAGEMENT

Integrating the fields of philosophy of mind, creativity, educational psychology, and affective neuroscience, I propose this model of *creative engagement* of the body–mind in learning as a path forward for what the education field may attend to in both instructional design and research. I have presented an embodied approach to meaning-making, briefly discussed some theories and evidence from neuroscience that support the embodied perspective, and anchored those discussions to an aesthetically integrated learning experience in a sixth grade science class. To conclude this commentary, I present several assertions that bridge elements of the psychosocial learner to an emotional and embodied maker of meaning.

In learning, the need for *autonomy* requires that a learner's body–mind be given time and space to *feel* and *think* through movement, gesture, and other modalities in the process of creative meaning-making. A learner has autonomy when they can connect emotionally with content and ideas freely. The need for *belonging* requires that a learner's body–mind be flexible and safe to make and express meaning with others who work to understand those novel interpretations. The need for *competency* requires that a learner's body–mind develop the skilled intuitions and habits that shape an emotional, embodied, and flexible cognitive orientation to the learning environment. Although unique to the individual, this flexibility has the common target of continuously furthering the body–mind capacity to discriminate at higher levels in meaning-making processes. The need for *creativity* requires that a learning environment provides space and time to access the embodied Self, build on skilled intuitions, and explore novel, personally meaningful possibilities about the world. Learners' creative resources—creative mindset, creative thinking, and creative behaviors—need to be leveraged in the learning process.

Some examples from the field can help to demonstrate creative engagement in practice. Project-based learning at the High Tech High network of schools uses four project design principles (i.e., equity, personalization, authentic work, and collaborative design) to ensure that students develop their own interest and commitment to the learning experience through artistic and socially engaged themes and practices (High Tech High, 2018). For instance, after one of their peers was killed, students drove the design of a project to explore the theme of gun violence in schools, conducting research and development to create a documentary film for the public. That project provided a sense of autonomy to pursue a meaningful topic, belonging to take part in a collaborative production, competency to deal with a complex topic, and the creative resources needed for successful film production. The San Francisco Unified School District has implemented restorative justice districtwide (Berkowitz, 2009) to create opportunities for students to become responsible citizens in their schools. Students learn to take the perspective of another and to express their feelings and the impact of their actions and the actions of others. Routines such as affective statements, restorative discussion, and proactive and responsive circles all provide opportunities for creative engagement that connect students to their emotional response, generate shared vulnerability, and tap into their creative resources to find novel solutions to social challenges. Arts integration practices across the artistic disciplines can leverage embodied creative engagement. For instance, the ArtCore project (ArtCore, 2018) integrated weaving of found materials along vertical and horizontal axes to learn how to plot objects mathematically, while allowing students to embody and express their understanding of geometric principles of a coordinate grid. These examples are just a few from the field that illustrate the wide range of approaches to produce creative engagement for students in schools.

To apply creative engagement in practice, schools can consider several immediate steps: (a) ensure that every lesson provides time for students to interpret content in a personally expressive or creative way, (b) develop student capacity to understand and build metaphors for complex and abstract concepts, using poetry, visualization, movement, and dramatic forms, (c) integrate drama-based or embodied practices, such as tableaux vivants, as a common classroom routine and learning tool, (d) create consistent opportunities for students to present or perform their novel metaphors and embodied representations for their peers in different modalities and teach effective audience participation, (e) discuss and normalize the spectrum of emotions experienced in learning within the classroom community and (f) obtain feedback from students about which experiences make learning most emotionally salient and effective. Those recommendations represent just a few strategies for educators to meet learner needs for creative engagement.

In this model of creative engagement, the feeling of autonomy, belonging, and competency arises out of the overarching *need for meaning* sought by a learner's body–mind interaction with the socially and culturally rich environment. Linked to the value system of motivations, the movement toward meaning contributes to global embodied, neural mappings of concepts and new possibility. These mappings reinforce future effort and anticipation toward creative generation and expression in meaning-making and draw on the diversity of a learner's creative resources. The ideas presented in this commentary integrate current considerations in creativity research, affective neuroscience, and the highly individualized and social process of meaning-making in learning. In the legacy of John Dewey and William James, pioneers of an embodied mind, these ideas aim to actualize conditions for more meaningful learning in schools.

Acknowledgments—This work was supported by the U.S. Department of Education under PR/Award number U351D140063.

NOTE

1 I use the term *body–mind* throughout this essay to refer to the complex and interconnected nature of a person's body, brain, and mind. I privilege *body* first in this coupling to emphasize the importance of the body to the formation of *mind* in embodied philosophy and theories of affective neuroscience.

REFERENCES

Anderson, R. C., & Beard, N. (2018). Envisioning, feeling, and expressing meaning: Training middle level educators to use tableaux vivants to engage students. In P. Howell, S. Faulkner, J. Jones & J. Carpenter (Eds.), *Preparing middle level educators for 21st century schools: Enduring beliefs, changing times, evolving practices*. Charlotte, NC: Information Age Publishing.

ArtCore (2018) *Weaving a coordinate grid*. Eugene, OR: Inflexion. Retrieved from. http://www.artcorelearning.org/modules-math-coordinategrid/

Aziz-Zadeh, L., & Gamez-Djokic, V. (2016). Comment: The interaction between metaphor and emotion processing in the brain. *Emotion Review*, *8*(3), 275–276.

Beghetto, R. A. (2016). Creative learning: A fresh look. *Journal of Cognitive Education and Psychology*, *15*.

Berkowitz, K. (2009) *Restorative practices whole-school implementation guide*. San Francisco, CA: San Francisco Unified School District.

Booth, E. (2013). *The habits of mind of creative engagement*. Retrieved from http://ericbooth.net/the-habits-of-mind-of-creative-engagement/

Craft, A., Chappell, K., & Twining, P. (2008). Learners reconceptualizing education: Widening participation through creative engagement? *Innovations in Education and Teaching International*, *45*(3), 235–245.

Damasio, A. (2010) *Self comes to mind: Constructing the conscious brain*. New York, NY: Vintage.

Delafield, J., & Adie, J. (2016). The embodied narrative nature of learning: Nurture in school. *Mind, Brain, and Education*, *10*(2), 117–131.

Dewey, J. (1925) *Nature and experience*. New York, NY: Dover.

Dewey, J. (1938). Experience and education. *Education*, *50*(3), 96.

diSessa, A., Hammer, D., Sherin, B. L., & Kolpakowski, T. (1991). Inventing graphing: Meta-representational expertise in children. *The Journal of Mathematical Behavior*, *10*, 117–160.

Duckworth, E. (1996) *"The having of wonderful ideas" and other essays on teaching and learning*. New York, NY: Teachers College Press.

Eccles, J. S. (2016). Engagement: Where to next? *Learning and Instruction*, 1–5.

Eccles, J. S., & Roeser, R. W. (2011). Schools as developmental contexts during adolescence. *Journal of Research on Adolescence*, *21*(1), 225–241.

Edelman, G. M. (2004) *Wider than the sky: The phenomenal gift of consciousness*. New Haven, CT: Yale University Press.

Edmonds, E., Muller, L., & Connell, M. (2006). On creative engagement. *Visual Communication*, *5*(3), 307–322.

Fodor, J. (1981). The mind-body problem. *Scientific American*, *244*(1), 114–123.

Fredericks, J. A., Blumenfeld, P. C., & Paris, A. H. (2004). School engagement: Potential of the concept, state of the evidence. *Review of Educational Research*, *74*, 59–109.

Glaveanu, V. P., & Beghetto, R. A. (2017). The difference that makes a "creative" difference in education. In R. A. Beghetto, & B. Sriraman (Eds.), *Creative contradictions in education: Cross discinplary paradoxes and perspectives*. (pp. 37–54). Basel, Switzerland: Springer.

Goodwin, C. (2000). Action and embodiment within situated human interaction. *Journal of Pragmatics*, *32*(10), 1489–1522.

Guilford, J. P. (1967). Creativity: Yesterday, today and tomorrow. *The Journal of Creative Behavior*, *1*(1), 3–14.

Hammer, D. (2000). Student resources for learning introductory physics. *American Journal of Physics*, *68*, S52–S59.

Hammer, D. (2006). Epistemological considerations in teaching introductory physics. *Science Education*, *79*(4), 393–413.

Hammer, D., Goldberg, F., & Fargason, S. (2012). Responsive teaching and the beginnings of energy in a third grade classroom. *Review of Science, Mathematics, and ICT Education*, *6*(1), 51–72.

Harrer, B. W., Flood, V. J., & Wittmann, M. C. (2013). Productive resources in students' ideas about energy: An alternative analysis of watts' original interview transcripts. *Physical Review Special Topics - Physics Education Research*, *9*(2), 023101-1-023101-5

High Tech High (2018) *Design principles*. San Diego, CA: High Tech High. Retrieved from. https://www.hightechhigh.org/about-us/

Immordino-Yang, M. H. (2010). Toward a microdevelopmental, interdisciplinary approach to social emotion. *Emotion Review*, *2*(3), 217–220.

Immordino-Yang, M. H. (2015) *Emotions, learning, and the brain: Exploring the educational implications of affective neuroscience*. New York, NY: WW Norton & Company.

Immordino-Yang, M. H., & Yang, X. F. (2017). Cultural differences in the neural correlates of social–emotional feelings: An interdisciplinary, developmental perspective. *Current Oinion in Psychology*, *17*, 34–40.

James, W. (1890) *The principles of psychology*. (Vol. *1*). New York, NY: Henry Holt and Company.

Johnson, M. (2007a). 'The stone that was cast out shall become the cornerstone': The bodily aesthetics of human meaning. *Journal of Visual Art Practice*, *6*(2), 89–103.

Johnson, M. (2007b) *The meaning of the body*. Chicago, IL: The University of Chicago Press.

Lakoff, G. (2016). Language and emotion. *Emotion Review*, *8*(3), 275–276.

Lakoff, G., & Johnson, M. (2008) *Metaphors we live by*. Chicago, IL: University of Chicago Press.

Lubart, T. I., & Getz, I. (1997). Emotion, metaphor, and the creative process. *Creativity Research Journal*, *10*(4), 285–301.

McDermott, L. C., & Redish, E. F. (1999). Resource letter PER-1: Physics education research. *American Journal of Physics*, *67*(9), 755–767.

Metcalfe, R. J. A., Abbott, S., Bray, P., Exley, J., & Wisnia, D. (1984). Teaching science through drama: An empirical investigation. *Research in Science and Technological Education*, *2*(1), 77–81.

Montessori, M. M. (1978) *The discovery of the child*. New York, NY: Ballantine.

Odegaard, M. (2003). Dramatic science: A critical review of drama in science education. *Studies in Science Education*, *39*, 75–102.

Osgood-Campbell, E. (2015). Investigating the educational implications of embodied cognition: A model interdisciplinary inquiry in mind, brain, and education curricula. *Mind, Brain, and Education*, *9*(1), 3–9.

Packard, A., & Delafield-Butt, J. T. (2014). Feelings as agents of selection: Putting Charles Darwin back into (extended neo-) Darwinism. *Biological Journal of the Linnean Society*, *112*(2), 332–353.

Panksepp, J., & Northoff, G. (2009). The trans-species core SELF: The emergence of active cultural and neuro-ecological agents through self-related processing within subcortical-cortical midline networks. *Consciousness and Cognition*, *18*(1), 193–215.

Piaget, J. (1972). Development and learning. In R. E. Ripple, & V. N. Rockcastle (Eds.), *Piaget rediscovered*. (pp. 7–20). Cornell, NY: Cornell University.

Piaget, J., & Inhelder, B. (1974) *The child's construction of quantities: Conservation and atomism*. London, England: Routledge.

Podolefsky, N. S., & Finkelstein, N. D. (2007). Analogical scaffolding and the learning of abstract ideas in physics: Empirical studies. *Physical Review Special Topics - Physics Education Research*, *3*(2), 20104, 1–16

Reiner, M., & Gilbert, J. (2000). Epistemological resources for thought experimentation in science learning. *International Journal of Science Education*, *22*(5), 489–450.

Runco, M. A., & Jaeger, G. J. (2012). The standard definition of creativity. *Creativity Research Journal*, *24*(1), 92–96. https://doi.org/10.1080/10400419.2012.650092

Ryan, R. M., & Deci, E. L. (2000). Self-determination theory and the facilitation of intrinsic motivation, social development, and well-being. *American Psychologist*, *55*(1), 68–78.

Sawyer, K. (2012) *Explaining creativity: The science of human innovation*. New York, NY: Oxford University Press.

Scherr, R. E., Close, H. G., Close, E. W., Flood, V. J., McKagan, S. B., Robertson, A. D., … Vokos, S. (2013). Negotiating energy dynamics through embodied action in a materially structured environment. *Physical Review Special Topics - Physics Education Research*, *9*(2), 020105, 1–18

Scherr, R. E., Close, H. G., Close, E. W., & Vokos, S. (2012). Representing energy. II. Energy tracking representations. *Physical Review Special Topics - Physics Education Research*, *8*(2), 020115, 1–11

Sefton-Green, J., Thomson, P., Jones, K., & Bresler, L. (Eds.) (2011) *The Routledge international handbook of creative learning*. London, England: Routledge.

Shusterman, R. (2008) *Body consciousness: A philosophy of mindfulness and somaesthetics*. Cambridge, England: Cambridge University Press.

Truman, S. (2011). *A generative framework for creative learning: A tool for planning creative-collaborative tasks in the classroom*. Retrieved from http://www.regents.ac.uk/media/448147/1101_generative_framework_truman.pdf

Venkatraman, A., Edlow, B. L., & Immordino-Yang, M. H. (2017). The brainstem in emotion: A review. *Frontiers in Neuroanatomy*, *11*, 15.

Vygotsky, L. S. (1986). The development of scientific concepts in childhood: The design of a working hypothesis. In A. Kozulin (Ed.), *Thought and language*. (pp. 146–209). Cambridge, MA: MIT Press.