LIVING SYSTEMS THEORY AND THE SYSTEMIC TRANSFORMATION OF EDUCATION

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Education is notoriously resistant to change. Much of the reason, I suggest, lies in a deeply held but inappropriate belief about how people learn, and corresponding views of what good teaching looks like. The orthodox and deeply embedded view is of learning as a largely mechanistic process and its corollary, an engineering and bureaucratic view of teaching and schools. It appears that this is the approach that undergirds the massive current effort to implement the No child Left Behind Act of 2001.

In my view, the system of education that we have is an excellent example of an emergent phenomenon, the consequence (in part) of the individual responses and behaviors of each element in the system based upon its own view of how people learn. That is why I argue that, for appropriate changes to occur in the system, the persistently held core view of how people learn must change. We need a commonly held understanding that is more in tune with the nature of life itself.

Many attempts, such as the work of Dewey (1965), have been made to offer and introduce an alternative view of learning and teaching. Perhaps most pervasive is the notion of constructivism.

Constructivism is a "view of learning in which learners use their own experiences to construct understandings that make sense to them, rather than having understanding delivered to them in already organized form…. Learning activities based on constructivism put learners in the context of what they already know, and apply their understanding to authentic situations.” (Kauchak & Eggen, 1998, p. 184)

Constructivism has had a fairly long and contentious history, and is the basis for a variety of concerns such as the following:

• Constructivism has multiple and not always mutually supportive roots. One strand is Piagetian (Piaget, 1976), and has to do with the development of conceptual thinking from the perspective of the individual, although all individuals are said to follow the same general route. Another strand is
Vygotskian (Vygotsky, 1978) and emphasizes the immense importance of social interactions in the development of cognitive capacities and of meanings.

- Some are concerned that the constructivist approach is ineffective because, they contend, it means that students are always inventing knowledge and do not and cannot avail themselves of what teachers already know (Bennett et. al., 2000).
- Another problem is seen in the difference between drill and practice and the systematic development of some structures, on the one hand, and learning for understanding on the other. Thus linguist Steven Pinker writes:

  *The ascendant philosophy of mathematical education in the United States is constructivism, a mixture of Piaget’s psychology with counterculture and postmodern ideology. Children must actively construct mathematical knowledge for themselves in a social enterprise driven by disagreements about the meaning of concepts.  
  ... Drill and practice, the routes to automaticity, are called mechanistic, and seen as detrimental to understanding. . . .  
  Constructivism has merit when it comes to the intuitions of small numbers and simple arithmetic that arise naturally in all children.  
  But it ignores the difference between our factory-installed equipment and the accessories that civilization bolts on afterward.* (1997, pp. 341-342).

- Although constructivism seems to have made a great deal of headway in the language that educators and researchers use, it seems not to be making much of a dent in current practice.

This paper is an attempt, in part, to give more vitality to the theory and practice of constructivism. I will suggest that constructivism is the view that is most consistent with the nature of life itself and with the ways in which people, as living systems, learn. Educators are dealing with the messy and dynamic nature of life in every direct and indirect interaction with every student at any time.
But education cannot improve until the ways in which people think about education matches and capitalizes on the natural ways in which people learn.

This is not to say that everyone needs to use the language of living systems, nor that there is only one way to teach. Rather, education - as society’s way of preparing students for life - must be grounded in philosophies and practices that resonate with the nature of life itself.

Thus, the objectives of this paper are:

1. To show that learning is a function of living systems.
2. To give more vitality to the theory and practice of constructivism.
3. To suggest some ways in which effective education can be grounded in the way that living systems learn.

**SYSTEM: A SENSE OF THE WHOLE**

A place to begin is with systems thinking because clearly human beings are systems of some sort. Although machines are systems, an intrinsic aspect of mechanical systems is that parts can be repaired and replaced without disturbing the whole. Yet sophisticated teachers (and parents and therapists and managers) know that human beings do not work in this simplistic way.

For instance, there is an embedded interconnectedness so that an intervention of some kind often has quite unexpected results. Moreover, reactions within a person and interactions with a context are nonlinear. Small events can have large consequences for the individual system while an apparently powerful intervention can leave the system unchanged. This phenomenon is known to every educator who has seen a chance remark change a student for life, while that same student manages to resist other repeated and ostensibly important inputs and information. The challenge is to make sense of, and work with, this dynamic and nonlinear interconnectedness.
When I first entered the world of education reform and professional development of educators, I took it for granted that body, brain and mind were interconnected. I was familiar with some of the origins of systems theory (e.g. Wiener, 1961, Von Bertalanffy, 1976) and some attempts to look for unification of body and mind (e.g. Bateson, 1979). However, much of what I concluded was a matter of inference from a variety of sources that seemed to say the same thing although coming from different contexts (e.g. stress as a systems phenomenon, Selye, 1978). In recent times the inherent interconnectedness of body, brain and mind is being substantiated by evidence from many disciplines, much of it from the neurosciences.

The human being as an interconnected system

The core point is that people are not just bits and pieces of muscles, tissues, blood and brain regions each with a separate function. In addition to that, the body and brain of each person forms a complete unity. In this unity, everything is interconnected to everything else and everything influences everything else in multiple ways. Thus the neuroscientist Damasio writes in *Descartes Error* (1994) that

(1) The human brain and the rest of the body constitute an indissociable organism. . .  (2) The organism interacts with the environment as an ensemble: the interaction is neither of the body alone nor of the brain alone (pp. xvi-xvii).

Some of the most powerful work to establish this interconnectedness was done by Candace Pert and others (1997). They discovered that a group of messenger molecules called peptides are the correlates of emotion. Most peptides are produced in the brain (where they function as neurotransmitters) as well as in other parts of the body. Peptides interconnect what used to be regarded as three separate systems: the nervous system, the immune system and the endocrine system so that in Pert’s view, the three should best be regarded as one single network. Thus she writes that “I can no longer make a strong distinction between the brain and the body” (1997).
Damasio puts it this way:

When I say that body and brain form an indissociable organism, I am not exaggerating. In fact, I am oversimplifying. Consider that the brain receives signals not only from the body but, in some of its sectors, from parts of itself that receive signals from the body! The organism constituted by the brain-body partnership interacts with the environment as an ensemble, the interaction being of neither the body or the brain alone. But complex organisms such as ours do more than just interact, more than merely generate the spontaneous or reactive external responses known collectively as behavior. They also generate internal responses, some of which constitute images (visual, auditory, somatosensory, and so on), which I postulate as the basis for mind. (1994, p.88)

For example, a person walking down the street may experience some sensory signals that result in a sense of apprehension. This is an emotional and cognitive response, with many physiological manifestations. Pupils will dilate, blood pressure will rise, rate of breathing will be affected, some processes such as digestion will slow down, muscle tension will change and so on. There is a clear focus of concern, but the individual responds as an indissociable organism.

Research fields such as psychoneuroimmunology and other recent hybrids such as social cognitive neuroscience (Azar, 2002) are emerging to describe this clearer understanding of the interconnectedness within the system and how outside environment interacts with internal states. Here are some examples:

- It used to be believed that cognition and affect are largely separated, but that is incorrect. Thus, Damasio points out in The Feeling of What happens (1999) that emotion is integral to reasoning, whether we like it or not. Lakoff and Johnson (1980) make the same argument by demonstrating the emotional tone that is a crucial aspect of the meaning of any metaphor.

- Learning is both conscious and unconscious and the processes of the cognitive unconscious operate at many levels. Joseph LeDoux, a leading researcher into the pathways of fear in the brain, points out that the layers of unconscious operation range from the ordinary ways in which our
sensory systems respond to the world, through much of memory and extend even to speaking grammatically and making moment to moment decisions (1996).

- The brain-mind is social because responding and reacting to others seems to be built into our bodies and brains.

  Recently, the neuropsychologist Giacomo Rizzolatti has found neurons in monkeys that fire both when the monkey carries out certain specific hand motions, and when it views those specific motions being carried out by someone else. . . Based on preliminary data, it is likely that mirror neurons will also be found for other gestures, including facial movements. (Brothers, 1997 p. 79).

The fact that we all seem to be biologically built to respond to others was confirmed in some research published as this paper was being written, that suggests that all human beings are “hard wired” for empathy (Singer, 2004).

The wholeness of the learner should no longer be in dispute. The consequence is that educators have to work with a paradox. On the one hand there are specific concepts, skills and processes to master and values that develop. On the other, each specific in some way engages the whole learner. So the question is how does one think of a system where many specifics and the whole are simultaneously engaged?

**LEARners As Living Systems**

Learners are not just systems. They are living systems, and they are human. Our task as educators is to deal with what someone once called the “squirming, active whole being of a child. Children and learners are whole organisms affected by, and responding to, events taking place in their immediate environments. Fortunately, we do not have to have a complete theory about the nature of life in order to deal with the issue. It is enough, to begin with, to grasp some key attributes of the human learner as a living system. Without going into detail, I
subscribe to the view that living systems are grounded in, but are more than, complex adaptive systems.

1. The whole is greater than the some of its parts.

   In a living system, parts are defined not in isolation from one another but in terms of their relations with each other and with the system as a whole. (Doll, 1993, p. 64)

All complex adaptive systems, and all living systems, are self-organizing wholes that are greater than the sum of their parts. One consequence is that the system as a whole has properties and capacities that would not be found in any of its elements, in the same way that a molecule of water has qualities that would not be found in nor predicted by the properties of its constituent atoms, hydrogen and oxygen. These “emergent properties” come into being from interactions within the system itself (Capra, 1996)

I suggest that learning, creativity, decision making, emotional and social intelligence and several other capacities and processes are actually functions and properties of the system as a whole. This was the view adopted by Georgi Lozanov, the Bulgarian psychiatrist who developed suggestopedia. Lozanov argued that he was seeking to release “hidden” or “nonspecific” mental reserves (1978). While specific skills and procedures can be “taught” (such as life skills or a particular curriculum), well developed system properties ultimately emerge as a result of the overall type of education and qualities of experience that a person has.

Thus school is never just about math or literature. School is about how a living organism interacts with its world and what happens to it as a result.

2. Living Systems have identity.

   Systems are much more than the sum of their parts. They have an identity and existence all their own. . . . The tendency to maintain identity is inherent in the very nature of organizations (Combs, 1999, p.4).
One system property, I suggest, is a sense of self or identity. While there is a
sense in which any complex adaptive system preserves and sustains itself, every
living system is intrinsically driven to defend, preserve and maintain itself. The
drive to survive can be illustrated by reference to the immune system, which
works to determine when a virus or bacterium is a foreign substance invading
the body, so that the body’s forces can be mobilized to attack the intruder. For
this to happen, the immune system cumulatively develops a sense of self - it
must know whether something is me or not-me.

The shift from the identity of, say, a snail to the psychophysiological identity of a
person, is vast because in a human being, identity emerges from body, brain and
mind working together. In terms of complexity theory I suggest that identity
exists far from equilibrium. On the one hand identity is stable and coherent, and
on other hand, it is subject to sudden and substantial change and development.

*We are always in a perpetual state of being created and creating ourselves.*
*We will never be the same, and we have never been quite the way we are
right at this moment... the self is perpetually being created.* (Siegel,
1999, p.221)

At every moment of the day, and in every class and course, there is an
underlying drive in learners to develop and maintain their identity. How any
subject or skill or relationship is dealt with is always filtered through a student’s
(and educator’s) sense of identity.

3. **Living systems make themselves.**

*A living system interacts with its environment through structural
coupling, that is, through recurrent interactions, each of which triggers
structural changes in the system.* (Capra, 1996, p. 219).

Living systems are not just sets of components that are created or replaced by the
environment. On the contrary, living systems are constantly involved in
producing their own components and developing their own processes that are
then used to grow themselves. They make themselves. For instance, cells are
constantly manufacturing the proteins that are used to build tissue and regenerate other cells.

The term coined by Maturana and Varela (1998) to describe the process of self-making is “autopoiesis.” In addition, the system does not simply replicate precisely what was there before, but is constantly making internal adjustments as it adapts to changes in its environment and in itself.

Adaptation in human beings involves adaptive decision-making.

priority based, adaptive decision making in ambiguous situations is central to our lives, and . . . the frontal lobes of the cerebral cortex of the brain are particularly important in such decision making. (Goldberg, 2001, p.79)

Adaptive decision-making is a complex process. It involves recognizing and interpreting what is going on, assessing and valuing events and behaviors in terms of what is personally relevant, accessing a repertoire of skills and responses and making a continuous series of small and large decisions with both short term and long term consequences. We do not come into the world ready equipped to do all this. So we have to learn.

LIVING SYSTEMS LEARN IN ORDER TO SURVIVE
The word “learn” is multiply ambiguous. In one sense, “to learn” means to remember or memorize. And indeed, many complex living systems do master some procedures by practicing what they are shown. Baby seals have to learn to swim. Baboons learn some aspects of being in a social group. And human beings have declarative and procedural memory systems which allow for rote memory (See e.g. Squire and Kandel, 1999). Classical and operant conditioning work to some extent because the system allows them to work. Thus, in this one sense of “learn”, survival depends on being able to implement some procedures and respond to some situations automatically and without thinking.
But there is more to learning. In another sense of the word, “to learn” means adapting by coming to see things differently. Learning is, therefore, a matter of developing and refining how and what one perceives. All of us are biologically equipped at birth with many basic capacities for perception. With experience, the basic elements that we perceive naturally (they are sometimes called natural categories) combine and gel into more complex categories (such as forests and computers and houses and cars). We have added capacities to organize information so that we can represent things symbolically and we can organize things in terms of how they relate to each other. One way to talk about the totality of a person’s perceptual repertoire is in terms of mental models (Johnson-Laird, 1983; Siegel, 1999). We may not even know what our mental models are, but we act in accordance with them.

This second aspect of learning is crucial for survival because in order to survive in a complex world, people have to be able to make sense of experience. This requires a constantly developing perceptual “apparatus.”

As the English chemist and philosopher Michael Polanyi puts it, our language, tools, and actions create faculties: “. . . we interiorize these things and make ourselves dwell in them.” By dwelling in them, new organs of cognition arise. (Zajonc, 1993, p. 184)

Once a person “gets” a pattern, it sticks. We get the concept. We see how an airport works. We grasp the flow of traffic or the way the stock market works or how to network to win friends and influence people. We also pick up the ways in which our society and culture think. Different people are “at home” in the desert, in mountains, on the sea, in a mall. Prejudice works the same way. A prejudice is what psychologist Ellen Langer (1989) calls a “premature cognitive commitment”. A person has learned to perceive some aspect of his or her world - say gender or race or way of speaking - and reacts to that perception automatically and strongly.

However, it is not just a matter of acquiring new categories and of organizing what is perceived. As people learn about the world in meaningful ways, the
learning changes them. They are changed psychologically, and they are changed physiologically (Bransford, 1999). This is in accord with the views of Lakoff and Johnson, who argue that all learning is embodied (1999). As they learn, human beings are literally reshaped and re-formed.

The phenomenon of neurons changing in response to experience is called neural plasticity. Neuroscientists such as Diamond (1988), Greenough (1987) and Goldman-Rakic (1995) show that experience literally changes the ways in which brain cells are connected and interact. Where patterns stick, a myriad of brain cells - neurons - will fire together in neural networks. The notion is that “cells that fire together wire together”. A single stimulus can subsequently set the entire assembly firing together. These networks become the hidden building blocks that house the patterns that constitute our understanding and mental models of the world. They are basic forms and structures for all the stuff that needs to be recognized and understood.

Neural plasticity confirms that new modes of perception are embodied. Cognition is a core aspect of the way in which people interact with their world. It is an aspect of life itself. Thus, Maturana and Varela describe cognition as embodied action (1998).

**DYNAMICAL OR PERCEPTUAL KNOWLEDGE**

What is the link between the acquisition of knowledge and a shift in perception? It is clear that a great deal of what most students learn in courses does not transfer (Haskel, 2000). This can be true even if, according to several different modes of assessment, there appears to be a substantial intellectual understanding of ideas and material. The conclusion to which we have come (see e.g. Caine and Caine, 1994) is that it is appropriate and useful to talk about knowledge in terms of the quality or degree of meaningfulness. It takes a sufficient degree of meaning to lead to a shift in perception, and knowledge that is sufficiently deeply internalized is what we call dynamical or perceptual knowledge.
We have suggested that

\[ \ldots \text{people who “get it” have acquired a new way of looking at the world.} \]

That means that they can see the problems that they could not see before; they can grasp the needs of the situation. Those who have not made this perceptual shift literally cannot read contexts in a fresh way. Their training does not transfer because they were not equipped with the perceptual lenses that are needed to operate in new environments (Caine and Caine, 2001).

The essential point is that perceptual knowledge always involves more than intellectual understanding. It is accompanied by a “felt sense” or “felt meaning.” It is as though we come to know something with our whole body and mind. We relate to it or resonate with it. We get it “in our belly.” Note that the word “feeling” is not the same thing as being emotional. The sense of feel being addressed involves visual, kinesthetic and other modes of sensing and coming to know, though emotion is always included. As the Root-Bernsteins note:

This feeling of knowing without being able to say how one knows is common. . . The great nineteenth-century mathematician Carl Friedrich Gauss admitted that intuition often led him to ideas he could not immediately prove . . . Claude Bernard, the founder of modern physiology, wrote that everything purposeful in scientific thinking began with feeling.

\ldots (p. 2).

They add that the introspective reports of eminent thinkers cannot answer all our questions about thinking, but they . . . tell us that conventional notions of thinking are at best incomplete, for they leave out non logical forms of thinking that can’t be verbalized.” (p. 3)

The term “felt meaning” was coined by psychologist Eugene Gendlin. The same phrase was used by author and noted management consultant Peter Vail in his book “Learning as a Way of Being” (1996). There Vail specifically invites people who wish to understand something in depth to get a felt meaning for it. More recently, neuroscientist Damasio (1999) has attempted to shed light on what occurs in the brain as people get “a feeling for what happens.”
The feeling of knowing is generated when thought, emotion, senses and body gel. The way to systematically and simultaneously engage most or all of a learner’s subsystems is through multiple, complex experiences in which content is embedded in context. The best word we have found for this process is immersion (Caine and Caine, 1994). The learner needs to be engaged in talking, listening, reading, viewing, acting, valuing and processing. In other words, the system as a whole is engaged.

Experience by itself, of course, is never enough. (Caine and Caine, 1994, 2001). If we look at good apprenticeships as evidence of effective immersion, it is clear that apprentices need guidance and mentoring in some form from masters, that some aspects of the larger context supports their endeavor and that they learn how to learn from experience. (See e.g. Schon, 1983; Perfect and Schwarz, 2002).

Two groups of people who are probably master learners - in all cultures and ethnic groups - still do the bulk of their learning in precisely this way. The first group are infants. Every infant acquires its language and develops a feel for its native culture through partially guided immersion. Moreover, it looks as though even infants are born to formulate and test hypotheses (Gopnik, Meltsoff and Kuhl, 1999). The second groups are experts - not people who are just labeled experts but those who demonstrate a very high standard of performance within their chosen field. It is not possible to become an expert without a blend of instruction, experience and processing. Thus two leading researchers in the field wrote a decade ago that:

*Expertise is based on a deep knowledge of the problems that continually arise on a particular job. It is accumulated over years of experience tackling these problems and is organized in the expert’s mind in ways that allow him or her to overcome the limits of reasoning* (Prietula and Simon, 1989, 120).
I suggest, finally, that the three principles of living systems described above all come into play in the context of coming to know so well that a felt meaning is acquired and perception shifts.

• First, the system as a whole is necessarily engaged in acquiring a feel for something because many subsystems need to work together to have and process experience. Felt meaning, then, is a system property.
• Second, a shift in perception such that one comes to see one’s world differently necessarily engages identity because to a large extent identity defines and expresses itself in terms of perception of self in the world.
• Third, the overall process of engaging with experience to change one’s own perception is an example of the self-making or autopoesis about which Maturana and Varela speak.

CONSTRUCTIVISM REVISITED
The core notion of constructivism is that meaning is not something that can be installed nor imposed but that all people construct meaning as they make personal and social sense of their experience. I suggest that the construction of meaning is precisely what living systems do as they come to know so well that there is a shift in perception. My wife and I use the phrase “brain-mind constructivism” to convey the notion that the entire system is engaged in the process of generating meaning, and that meaning itself needs to be seen as embracing the feel for an idea or process as much as an intellectual grasp or remembered practice.

From this perspective, the concerns about constructivism raised above can be resolved.
• It is true that constructivism has multiple and not always mutually supportive roots, but a living systems perspective shows that the roots need to be reconciled. For instance, both the Piagetian and Vygotskian origins need to be honored because the construction of meaning is both an individual and a social process.
• It is true that
learning is an active process in which students create their own knowledge rather than receive it from teachers. (Bennett et. al., 2000).

The reason is that no matter how much another person knows, students must “get” a concept or acquire a feel for things themselves. However, informed teachers can guide students just as informed parents can guide their children. The learners are also exposed to what others have learned and are immersed in a context in which they are constantly breathing into the learning of those (including peers) in their immediate environment.

- There is a difference between drill and practice and the systematic development of some structures, on the one hand, and learning for understanding on the other. Yet even drill and practice is constructivist in at least one ways. Learners perceive, interpret and make sense in their own way of what is being practiced and the context in which it occurs. Even that which is learned by rote has some qualities of personally constructed meaning. That is why smiley stickers, words of praise and detention do not mean the same things to all students.

- There are many reasons why constructivism has not made headway, even when professed. One of them is that there is a difference between espousing a theory and actually having a feel for the process and ideas being espoused. Teaching can begin to become constructivist when teachers genuinely believe that students do, need to, construct their own meanings.

**IMPLICATIONS FOR EDUCATION**

Human beings are living systems. Learning, broadly conceived as making sense of experience, is a psychophysiological aspect of life itself. Education, again broadly conceived, is society’s way of guiding what and how individuals learn and become. The challenge is to come to an understanding of how people learn naturally, and then to translate that understanding so as to inform and guide practitioners and others in their day-to-day practice.
Our approach has been to develop a set of principles that we call Brain-mind Learning Principles (Caine and Caine, 1990, 1994; Caine, R., unpublished)). They are our attempt at discerning the laws of learning that explain in somewhat more detail the processes and the conditions of “natural” learning in a way that can be used by educators. They explain the ways in which the system as a whole engages in the construction of meaning.

By themselves the principles cannot guide nor prescribe practice, but they can set the stage by informing educators of what to look for and how to think about teaching. For instance, if we extrapolate from the points made above, educators need to

• work with the individual AND social nature of learners;
• help students develop a “feel” for anything that needs to be mastered; and
• engage the conscious mind of learners while also discovering how to better prime their unconscious.

With the appropriate set of learning principles in mind, it becomes possible to develop a theory of instruction and so a guide to practice that takes into account the enormous differences between people and their needs and contexts (Caine and Caine, 1994; Caine and Caine, 1997b).

A major challenge, even then, is to find a way to think about the larger education and social system and to engage that larger system so that it supports learning and teaching with life in mind. We have explored this in the context of work with two schools over a five-year period (Caine and Caine, 1997a) and with a charter high school (Caine and Caine, 2001). My goal, now, is to find ways to participate with others engaged in similar ventures in the hope that as we network and connect, the dynamics will become sufficient for the emergence of a new approach to education that better capitalizes on how people learn naturally.

References


