One of the more compelling theoretical models for adult learning centers around the concept of schema theory, a conceptual framework that is defined as "the cognitive structures that are built as learning and experiences accumulate and are packaged in memory" (Knowles, Holton, & Swanson, 1998, p. 140). The schematic approach is clearly constructivist in that it is founded on the model in which information aggregates in such a way that individual experiences become the framework for assimilation of new information. Given the variety in individual experiences, one can infer that the schema possesses sufficient variety and that each learner thus builds on prior knowledge in a unique fashion. Knowles briefly mentions three "different modes of learning in relation to schema: accretion, tuning, and restructuring" (Knowles et al., 1998, p. 140). This brief treatment of a potentially rich topic leads to a multitude of questions: What is the nature of the "cognitive structures" in schema theory? What are the implications in terms of teaching and learning relative to the three modes of schematic learning? What are some other perspectives on schema theory? This brief treatise will attempt to respond to those prompts and expand upon the introduction provided in the Knowles text.

Nobel Prize winner Murray Gell-Mann describes schemata as condensed models that are fundamental to all complex adaptive systems (Gell-Mann, 1994). In his view, there are always "various competing schemata, and the results of the action in the real world feed back to influence the competition among those schemata" (Gell-Mann, 1994, p. 17). To complement the competition among schemata, cooperation or recombination of schema can be "possible and advantageous" (Gell-Mann, 1994, p. 242). The competition and cooperation among schema lead to adaptive behavior which takes place at three different levels: 1) direct adaptation which requires no change in the prevailing schema; 2) change in schema based on "selection pressures in the real world;" and 3) elimination of maladaptive schema (Gell-Mann, 1994, p. 293). For

example, an animist schema may react to a drought with a rain dance (direct adaptation)—if that does not work, there may be a change in the religion (change in schema)—if that does not work the individual who carries the schema may cease to exist "as a consequence of the failure of its schemata to cope with events" (Gell-Mann, 1994, p. 293). Progressing through these levels of adaptation eliminates maladaptive schema and promotes the survival of schema with greater fitness. Furthermore, the three levels of adaptation are generally associated with different time scales. That is, direct adaptation can be implemented quickly, a change in schema typically occurs over a longer time scale, and, paradoxically, the elimination of schema may "come swiftly" (Gell-Mann, 1994, p. 294). Gell-Mann's three levels of adaptation appear to correlate with the schematic modes of accretion, tuning, and restructuring mentioned in the Knowles text.

Interestingly, almost any complex system nests various schemata within itself and these complex systems invariably contain maladaptive schema in some regard. For example, the human body possesses toxins, viruses, and seemingly useless organs such as the appendix. According to Gell-Mann, "One of the most common reasons, and perhaps the simplest, for the existence of maladaptive schemata is that they were once adaptive but under conditions that no longer prevail. The environment of the complex adaptive system has changed at a faster rate than the evolutionary process can accommodate … Rather than change our way of thinking, we tend to cling tenaciously to our schemata and even twist new information to conform to them" (Gell-Mann, 1994, p. 303). The implication for learning appears to require cognizant coupling of the environment and the individual such that periodic review of the schema can allow for comparison with environmental/conditional changes, thus promoting dissonance and self-initiated learning endeavors.

In his dissertation on schematic theory, Stanford Psychologist Ben Martin refers to Plato and his description of schema as inclusive of important but not exhaustive information (Martin, 1994). Additionally, schemata "encode regularities in the world in terms of the internal states of a system" (Martin, 1994, p. 266). That is, schemata facilitate the organization of information in a foundational and systemic fashion. This advantageous feature of schema also creates constraints in that information inconsistent with the schema is often discarded or it is not possible to assimilate the new information into the schema. Referring to a Kantian formulation, Martin suggests that "anything that schemata cannot represent cannot be experienced" (Martin, 1994, p. 268). A more linear explanation for the aforementioned assertion comes from the work of Frederic Bartlett, who argued that we encode experiences by "relating them to similar events with which we are familiar. In other words, we instantiate a schema that represents novel information in terms of existing conceptual orientation" (Martin, 1994, p. 269). Again, these propositions strongly relate to the constructivist philosophy of teaching and learning.

Rumelhart and Ortony go on to identify four "essential" characteristics of schemata: 1) schemata have variables; 2) schemata can embed one within the other; 3) schemata represent generic concepts which, taken all together, vary in their levels of abstraction; and 4) schemata represent knowledge rather than variables. They further propose two ways in which schema can develop and adapt: 1) specialization (subsets of schema) and 2) generalization (combining multiple schema and reducing the schema into subsets of the new schemata) (Martin, 1994). This bi-directional approach to the creation of new schema suggests that teachers and learners may need to be well-versed in at least two differing strategies for information processing.

This short review of schematic theory suggests that compression of information is cooperative and competitive, driven to generalization and specialization, adaptive and

maladaptive, and occurring at multiple levels across differing time frames. Additionally, schema can be nested within other schema and this holarchical system should then conform to the tendencies of other holonic manifestations, exhibiting increasing complexity and less frequency at the higher levels (Wilber, 1996). This implies connections to evolutionary theory, further relationships to complex adaptive systems, chaos theory, and game theory (Gleick, 1987; Mero, 1998; Waldrop, 1992). If we learn through adaptation to schema at various levels and schema exhibit holonic characteristics that are common with other complex adaptive systems and if we can better understand complex adaptive systems such as living organisms, the stock market, traffic patterns, and the brain, then syllogistically it is reasonable to conclude that we may be able to improve our capacity to learn via the application of study of interactions in similarly complex systems. For example, John Holland's study of adaptive systems has identified several common features of complex adaptive systems: aggregation, nonlinearity, flows, diversity, internal models, tags, and building blocks (Holland, 1995). Perhaps those features are similarly applicable to the learning process—Holland explicitly connects schemata to the concept of building blocks—and we can escape the current dogmatic schemata related to learning to generate a truly novel understanding of learning and its role in the process of adaptation, evolution, and survival.

Thus it is that the application of schema theory logically extends from abstraction to practice in that accretion, tuning, and restructuring of schema may result from the implementation of concrete practices such as reflection, use of feedback, and integration of discrete and distinct information. For example, the stated mission of Jefferson Elementary School is to develop a learning community. The idea that learning occurs at multiple scalar intervals in a Mandelbrot-like fractal sense necessitates ongoing professional development for

staff, routine parent education components, and strong community involvement (Gleick, 1987). These elements require utilization of andragogous practices that relate to schema theory (Knowles et al., 1998). It would be ideal if the instructional methodology correlated with the level of schematic focus—"accretion" training would be more traditional and informative, focusing on the declarative aspects in a conventional sense whereas "restructuring" training would incorporate and integrate various instructional approaches in a more rigorous, transformative sense (Clark, 1993). Assessment and evaluative methods would demonstrate a similar alignment with schematic approaches, using more superficial and efficient quantitative, Likert-scale data for accretion and more comprehensive qualitative, narrative documentation for restructuring.

One implication that arises from the application of schema theory is a need for some tool that could be used to assist in the determination of schematic approach. Criteria for accretion, tuning, and restructuring should be made available in explicit, comprehensive terms such that facilitators of adult learning could more easily classify the desired level of schema change and then work from that determination to align instructional strategies, curriculae, and assessment. This apparently facile endeavor belies enormous complexity in the nether regions between the schematic levels that would require intensive effort and resources to clarify overlapping and unclear distinctions. For example, when a parent learns about ways to encourage their child to routinely complete homework, is that considered accretion, tuning, or restructuring? It may be that the same content has variant influence on a diverse constituency and that it is the developmental stage of the learner that determines the impact of the schema change. If so, must the facilitator of the learning experience begin with an assessment of the current schema? This complicating factor merely scratches the surface of a complex web of conundrums, paradoxes,

and algorithmically-complicated (AIC—Algorithmic Information Content) learning patterns (Gell-Mann, 1994). Despite the presence of gray areas, it seems as if certain instructional activities are more easily classified and sorted into the level of schema change; an information meeting for community members about the science fair and the judging process is more likely to be accretion than a one-week retreat for the Site Council to exhaustively review the vision and current reality such that it can create a comprehensive school plan for improvement of student achievement. This suggests that the ideal instrument for classification of desired instructional outcomes manifest itself as some sort of continuum in which the distinctions do not need to be defined by intervals.

One of the barriers to implementation of a schematic classification approach is the shortage of available time to pursue new ideas at the K-12 level of the public education system. Interestingly, there is decreased preparation and collaborative time as one decreases in the grade level of instruction. A college professor may teach only a few hours per week and devote the majority of time to study and preparation, where the opposite is true for a kindergarten teacher. Considering the dramatic changes that are required for success at the K-12 level, it may also be helpful for policy-makers to consider the requisite amount of time for restructuring of schema and examine potential discrepancies between desired outcomes and current structures. In terms of application, it may be advisable for the author to present information on schema theory to hierarchical superiors and discuss the variant levels of investment necessary to achieve incremental or transformative results.

Generating a schematic continuum and organizing instructional strategies, curriculum, and assessment around the desired level of schematic impact would be a profound departure from current practice in terms of adragogical interactions at the K-12 level of public education.

Presenting information about the stages of schema change, from accretion to tuning to restructuring, may be helpful in terms of aligning organizational strategies with desired outcomes as well. These two applications of schema theory have the potential to create a non-linear positive feedback loop with sensitive dependence (SDOIC) and unpredictable but generative outcomes (Gleick, 1987; Waldrop, 1992).

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