The Implications of Evolutionary Patterns on Learning: Issues of Variation, Non-Linearity, and Non-Progressivism

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Ever since the time of Plato, we, at least in the Western world, have viewed learning as a process of attaining some "ideal essence" of knowledge. Throughout our history and at the present time, we have pursued learning primarily as a linear process of acquiring particular truths directed toward the overarching goal of progress. In today's schools, we find curricula that suggest a particular linear sequence of activities geared towards students' learning specific, well-defined, and mandated content. The rationale for such curricula is based one way or another on the notion of progress (e.g., "education for the 21st century", "learning for success in the future", etc.).

This particular paper takes issue with such a view of learning. Based primarily on Stephen Jay Gould's (1996) book, *Full House: The Spread of Excellence from Plato to Darwin*, and the works of Gregory (1971; 1979; 1991) and Mary Catherine Bateson (1994), I will explore the implications of current thinking in evolutionary theory on our understandings of learning. Three key concepts in evolutionary theory (i.e., variation, non-linearity, and non-progressivism) form the basis for the development of the argument that successful learning may need to take place in a way that is radically different from our current status quo. The supposition that serves as the basis for this argument is that since we, as biological organisms, are the result of evolutionary mechanisms, we might expect to find similar patterns operating within individuals.

Variation, Non-Linearity, and Non-Progressivism in Evolutionary Theory

In order to place the discussion of evolution in context, we need to delve briefly into the history of various schools of thought. Mayr's (1970) description of the change in evolutionary theories depicts the synthesis of several single-factor explanations (e.g., environmentally induced, such as adaptive response and random response, and intrinsically controlled, such as orthogenesis, volitional or Lamarckian, mutational, and epigenetic) into several multiple factor explanations. The multiple factor explanations include early and recent Lamarckian based theoretical positions, early Darwinian, and early and recent "modern syntheses" based primarily on Darwin's work. For the sake of simplicity, two general groupings can be delineated as Lamarckian and Darwinian. The major differences between these two groups is described in Table 1. Although the Darwinian group is accepted most widely by a majority of biologists, the Lamarckian group is still active, particularly among a small group of theorists contending with broader issues of learning and culture.

Table 1. Two general categories of evolutionary theories.

Lamarckian	Darwinian
• adaptive response to extrinsic factors	• adaptive response to extrinsic factors
• orthogenesis - a process of continuous, directional change	• random variation
• volitional - individual intent to acquire and pass on changes	• natural selection

For years, Stephen Jay Gould (in the Darwinian group) has been maintaining that our ordinary, common sense understandings of evolution are misconceived. Among these misconceptions, two stand out as particularly important in our discussion of evolution and learning: (a) progressivism -- that evolution is a process directed towards greater complexity and (b) linearity -- that the evolution is a linear process or sequence of stages. At the same time, the notion of variation as "the primary expression of natural reality" (1996, p. 42) has not been seen as the critical factor to the extent of which it is. So, the importance of variation must take a central position for an accurate and meaningful understanding of evolution.

The importance of variation not only rests in the notion of providing for genetic mixing, but also contributes to the overall pattern and possibilities of evolution. Gould (1996) discusses two aspects of the limits of variation: one in terms of the demise of .400 hitting in baseball and the other in terms of the current state and potentialities of evolution. The major concept common to both aspects of variation is the notion of "wall" or limits to variation. In the case of baseball (and other sports), the wall is on the right. Athletic ability, as measured by batting averages, earned run averages, speeds in the 100 meter race, and so forth, may have appeared along more of a bell-shaped curve many decades ago. However, as athletes performances get better, the curve becomes more skewed to the left as the upper limits of what is biomechanically possible are reached. For example, records in the 100 meter dash were broken by seconds decades ago, but are broken by hundredths of a second now, as we reach the right wall limits of variation.

In terms of evolution, the misconception that evolution is progressing towards greater complexity can be demonstrated by the left wall of minimal complexity. Any random variation can only move to the right when the minimal level of complexity for any living system is adjacent to the left wall of what is possible. According to Gould (1996), citing the work of other researchers, the mode (a better measure of central tendency in this case) of complexity has not changed since the beginning of life on Earth (see Figure 1). Bacteria were the only organisms in existence during the first 1.8 billion years or so of the existence of life on this planet. At the present time, bacteria are still the most numerous of all organisms on the planet. The mode has not changed, however, the curve of the complexity of life has become skewed to the right.

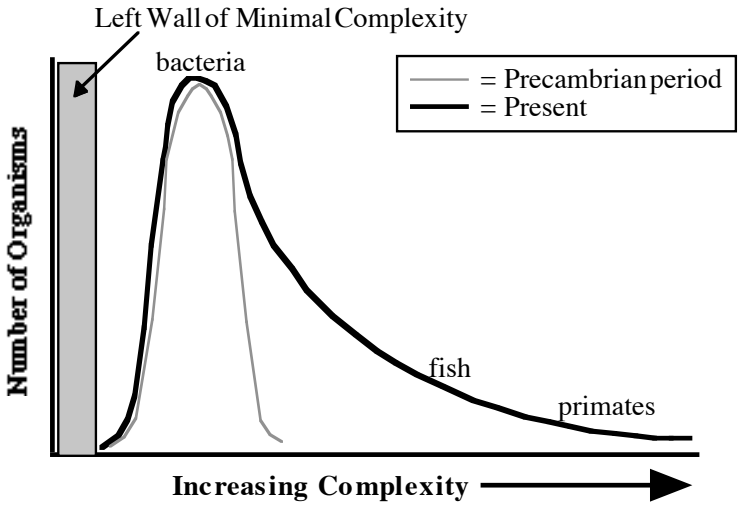

Figure 1. "The frequency distribution for life's complexity becomes increasingly right skewed through time, but the bacterial mode never alters" (quote and figure [adapted from Figure 29] from Gould, 1996, p. 171).

The point is that any notion of progress (in terms of increased complexity) is not warranted. The mode of complexity has remained the same throughout time. However, variation does occur, but cannot vary towards the left. Any possibility of variation occurs to the right, towards greater complexity, since the left wall represents the limit of minimal complexity. Not only does such an understanding undermine any notions of progressivism, but also notions of linearity. Random variation occurs in any available direction. In lineages beginning away from the left wall of minimal complexity, Gould (1996) cites studies that show variation in both directions: both towards less complexity and towards greater complexity.

Variation, Non-Linearity, and Non-Progressivism in Learning

From the previous basis in evolutionary theory, we will explore the implications of the key concepts of variation for our thinking about learning. We begin with a brief description of the territory, then embark in a more thorough exploration of variation, non-linearity, and non-progressivism. Ultimately, a tentative model will be developed that represents the major concepts and processes explored in this section.

Defining the Territory

As we begin to look at the implications of evolutionary mechanisms on how we learn, we need to take care in defining the territory or the context of what we are examining. Although this paper is not concerned with the evolution of culture or consciousness, we do need to place this discussion within an overall context of the significance of learning for human beings. In other words, we need to look at learning in terms of its adaptive significance. In a way, the concern with adaptive significance is the major point to learning, which will be discussed throughout the rest of this paper.

In fact, many theorists, including Gregory Bateson (1979, 1991) and Henry Plotkin (1993), suggest that learning is adaptation, as well as that adaptation is learning. In Plotkin's words, "what we commonly understand by the word 'knowledge' is closely related to what evolutionary biologists call adaptations. All adaptations are forms of knowledge" (p. 181). Knowledge is information embedded in some context. So, according to this contention, the genetic information in most dogs to grow thick coverings of hair during the winter and shed a considerable amount of this hair in the summer is a form of knowledge. In the same way, the knowledge acquired not to follow a car too closely on a highway is adaptive (unfortunately, far too many people do not appear to have made this adaptation). The problem with these two examples appears in how we define "knowledge" and "adaptation." In terms of "knowledge," both examples relate to knowledge as information. In the case of genetics, that knowledge is, as Bateson would have said, "hard programmed." Whereas in the second example of knowledge about driving a car, the information is "soft programmed." Bateson continued to suggest that "soft" information can become "hard" in the process of habit formation. The notion of whether such a process of becoming "hard" programmed involves change at the genetic level is unclear; but, I suspect that Bateson would have taken this position based on his Lamarckian alignment. In terms of "adaptation," biologists discriminate between adaptation as change at the level of species and "acclimatization" at the level of an individual's response to particular environmental characteristics. Such variations in meaning for "knowledge" and "adaptation" make it difficult to

suggest any direct correspondence between learning as an individual and cultural phenomenon and adaptation as a biological and evolutionary phenomenon. However, from the perspective of this paper, we can view the notion of learning as a process of adaptation metaphorically. At the very least, we can view learning as acclimatizing.

We also need to consider Darwin's notion that "natural selection can forge only local adaptation" (Gould, p. 140). From the perspective of this paper, the question arises of what constitutes "local"? Are we referring to the individual, the family, the tribe or clan, the neighborhood, the culture, the society, or the entire species? I do not know that we can clearly delineate the boundaries of "local." From the point of view of social constructivism, learning occurs within various groups or sets of groups. Each individual belongs to different groups. For example, two young children in the same classroom may belong to different social groups in school. When they leave school they belong to two different families and play with different or sometimes overlapping sets of children. Their families may belong to different religious, cultural, or ethnic groups. However, they share the groups of people who live in the local community and society. At the same time and considering the post-modern condition, the two children also are subject to the influences of global mixing of cultures through contacts in their neighborhoods, in local and more distant travels, and through the media. So, the notion of local can mean anything from the individual, with his or her own sets of unique and shared learning experiences, to all human beings, who share some experiences and have a wide variety of uniquely related sets of experiences. From a global perspective, however, the amount of inter-mixing within groups can be highly variable. In Western and other industrialized societies, the inter-mixing of cultural groups is increasing rapidly. On the other hand, within tribal cultures, such as the Xavante in Brazil, the Wodaabe in Niger, or the Gabra in Kenya, very little intermixing of cultures occurs (Maybury-Lewis, 1992). In such cases, most learning takes place within the self-contained cultural (i.e., tribal) group.

Such cultural diversity is one part of the basis of variation upon which we draw. From the perspective of cultural psychology, Schweder (1991) contends that "we are multiple from the start" (p. 5). He contends that,

> ... the conceptions held by others are available to us, in the sense that when we truly understand their conception of things we come to recognize possibilities latent within our own rationality, or existent in the history of our own reason, and those ways of conceiving of things become salient for us for the first time, or once again. (p. 5)

In other words, the variation or diversity is apparent in the cultures with which we have contact connect with the variation of ideas and experiences within each of us. The variation within ourselves is evident in the nature of our own children. In previous research, I have suggested the term "contexts of meaning" as a way of conceptualizing the variation and diversity of perspectives apparent in children's thinking (Bloom, 1990; 1992a; 1992b; 1995). Such diverse perspectives arise naturally in children's conversations about a variety of phenomena. These perspectives include emotional reactions, metaphors, a variety of personal experiences, fantasy, stories, and so forth. Within the context of science activities and discussions, children draw on such widely varied perspectives in their attempts to embed new ideas and experiences in meaningful contexts.

In returning to the notion of "local", for the purposes of this paper, "local" will be considered from the perspective of the individual, primarily of a Western industrialized society, within the context of his or her potential social groupings. Therefore, the adaptive significance is not so much from the evolutionary perspective of the survival of the species, but rather from the

perspective of the individual's ability, in some sense, to acclimatize or acculturate. Such terms, however, tend to minimize the significance. The point is not so much whether an individual acclimatizes or acculturates at the level of mere survival, but whether an individual can successfully participate in societies undergoing increasingly rapid changes. So, the issue of learning is one of how learning contributes to successful participation. Such a statement sounds very familiar in terms of the current party line coming from educational bureaucracies. Successful participation from such a perspective involves acquiring the skills necessary to get a job and handle some of the day-to-day routines of contemporary life. On the other hand, we may want to extend this definition of successful participation to include (a) acquiring the skills necessary to participate actively in a democracy (or other political system); (b) developing intellectual and creative abilities to a greater degree, so that individuals can contend with a variety of problems and issues and can represent their feelings, views, and understandings in a variety of ways; and (c) developing multiple ways of understanding, so that individual's can relate successfully (and more sanely) to the increasing mixing of cultural, racial, ethnic, and religious groups, as well as to the increasing fragmentation of knowledge and society. In contrast to the evolutionary sense of success (as continuity of the species), "successful," from the point of view of this paper, is more a matter of living and participating in society in ways that are more sane and humane and that capitalize on a variety of human potentialities.

Thinking, Learning, and Evolutionary Patterns

As mentioned in the beginning of this paper, the assumption that the biological patterns of evolution are imbedded within the patterns of mind of individuals serves as the basis for this exploration of thinking and learning. However, the Darwinian patterns of evolution as discussed by Gould (1996) serve as only one part of the picture of cognition. Gould admits that Lamarckian patterns of intentionality, linearity, and progress are a major part of cultural change. In this section, we will explore how these two very different processes can come together to provide an integrated perspective of learning and cognition.

The notion of variation serves as the basic ground and material for learning. Within the context of biological evolution, natural selection is driven by variation. However, the notion of natural selection shifts from one of adaptation for survival (prescriptive) to proscriptive selection of what "is not compatible with survival" (Varela, Thompson, & Rosch, 1991, p. 195). In other words, selection in the context of cognition acts to de-select those aspects of variation that are not likely to be useful ("useful" in its broadest sense). This notion is similar to Bateson's (1991) contention that selection acts on those things which will survive both prior to and after change.

However, before looking at the selective processes, we need to examine the nature of variation in the context of cognition. From previous studies in which I have examined the thinking of hundreds of children, a pattern of thinking has been described as "contexts of meaning" (Bloom, 1990; 1992a; 1992b). The notion of contexts of meaning was intended to capture the diversity of ideas and perspectives utilized during the process of sense-making. This diversity of ideas and perspectives includes not only the formal, school-type knowledge typically examined in studies of learning and cognition, but also emotion, values, aesthetics, metaphors, imagery, fantasy, stories, personal experiences, and interpretive frameworks (which include beliefs, models, phenomenological primitives [diSessa, 1993], and other guiding frameworks). A basic contention derived from this context of meaning research has been that people do not think

along disciplinary lines. Rather, we draw on a variety of ideas (which include emotions) in our attempts to make sense of particular events or objects.

The question is from where does such variation and diversity arise? Traditional Western psychology has little to offer in this regard. However, Varela, Thompson, and Rosch (1991) have developed a framework of cognition based on both Western and Buddhist psychological traditions. From the extensive psychological framework of Buddhist psychology (referred to as abhidharma), we can gain some insight into the source of variation from the notion of consciousness (Guenther, 1974; Narada, 1979; Nyanatiloka, 1971; Varela, Thompson, & Rosch, 1991). According to the abhidharma, there are eight levels of consciousness. The first five correspond to the five senses, with each sense as a level of consciousness. The sixth consciousness can be conceived of as a sort of manipulative consciousness, which is what we might typically consider to include our normal awareness and thinking. Skipping the seventh consciousness for a moment, the eighth level is considered to be a vast storehouse of all memories, all ideas, and so forth (this consciousness extends beyond what we ordinarily consider a possession of an individual; in some ways, we may view this level as a kind of storehouse of culture or humanity or as the Jungian "collective unconscious"). The importance of understanding this level is that it randomly generates thoughts which are pushed out into the seventh consciousness. Here, at the seventh level, thoughts are de-selected or selected to transfer to the sixth consciousness. In our typical day-to-day experience such random thoughts develop into little story-lines that go by hardly noticed, like a kind of background chatter. At times when more focused thinking is necessary, the seventh consciousness selects appropriate or related ideas. However, even at these times, random unrelated thoughts arise in what we experience as our mind wandering. From this perspective, random variation in thoughts appears to be a constant force. We access this constant stream of thoughts for specific relations to topics upon which we are focusing.

Once thoughts reach our normal (sixth) consciousness, they go through a sequence of arising, developing, and decaying. This sequence is particularly evident in the moment-to-moment story-lines (background chatter), mentioned in the last paragraph, which arise, develop, and disappear with very little impact on other activities and which are hardly noticed. However, the aspect of this sequence or cycle that is particularly relevant to our discussion, here, is the development of ideas and concepts during periods of more focused thinking.

In contrast to Gould's (1996) contention that evolutionary processes can generate less complex as well as more complex organisms if the starting point is away from the left wall of minimal complexity, human learning appears to generate more complex understandings. We need to keep in mind that learning in this sense is not confined to the classroom, but occurs throughout one's life. In some situations, students may not appear to generate more complex understandings in school. On the other hand, such students develop complex understandings of topics and situations of greater personal relevance in their everyday lives. The point is that the intentionality of the learner is a key factor. Such intentionality may be explicit or implicit. Explicit intentionality is where the individual wants to learn about a particular event or topic. For instance, in writing this paper, I want to develop a greater understanding of learning. A motivated student in a classroom wants to learn and understand the material. A student who does not relate well to school may be very interested in music or cars and will spend his or her time reading and learning about such topics. In contrast, implicit learning does not involve a conscious decision. The individual who is faced with particular situations in his or her life and learns how to deal with such situations. A child who is always being beat up in school may learn

how to avoid such situations without necesarily making explicit decisions. We all learn the rules and ways of particular cultural, ethnic, and social groups without consciously intending to learn. However, at some level, we select what to incorporate into our understandings. Such intentionality forms the basis for taking more of a Lamarckian view of evolution and learning.

A Lamarckian-type view of learning serves as the basis for the burgeoning literature on evolution of mind and culture. Such views are apparent in the work of Merlin Donald (1991), Stuart Kauffman (1995), Varela, Thompson, and Rosch (1991), and Gregory Bateson (1971; 1979; 1991). Bateson's work, in particular, has looked at a number of processes which he contends work in both biological evolution and individual cognition. Although this paper is not concerned with biological evolution, Bateson's examination of evolutionary processes in cognition are of particular importance. Bateson (1979; 1991) contends that human learning is a process of evolution, that evolution is learning and learning is evolution. From this perspective, the major processes are stochastic (of which there are two: genetic change and learning), where "a sequence of events combines a random component with a selective process so that only certain outcomes of the random are allowed to endure" (1991, p. 253).

The basis for a stochastic process is random variation. As Bateson (1979) maintains, without an element of randomness there is no possibility of innovation or of the development of anything new. Divergent processes are creative. Bateson further suggests that such processes involve schismogenesis, which is an escalated, divergent, and directional change that depends on the interactions among organisms (schismogenesis also is related to the notion of co-evolution in which the interaction between species or individuals results in the divergent and directional change; in other words, behavior in species "A" will prompt change in species "B", which in turn prompts change in species "A" and so on). We see such processes in arguments and discussions. In a recent study of a student argument about density (Bloom, submitted), I found that the back-and-forth nature of the exchange produced an ever-increasing development towards greater complexity of the ideas on each side of the argument. Such a schismogenetic process produced two competitive, though intuitively sensible, explanations. The result of this schismogenetic argument was the development of two complex explanations between which the relation was, as Bateson (1979; 1991) described, symmetric. By symmetric, the resulting interactions of a schismogenetic process are competitive. Two concepts or explanations are antagonistic, contradictory, or competitive. In terms of human relationships (e.g., marriages, teacher-students, etc.), such symmetric relations can lead to dysfunctionality. In a similar way, schismogenetic processes can lead to complementary interactions, where one idea or person is dependent upon another (e.g., dominant-submissive relations between individuals or foundation-extension relations between particular concepts). In the realm of conceptual development such relations may be necessary and useful, but may lead to a fixed or inflexible understanding or mind-set. In human relationships, complementary interactions may lead to non-productive rigidity and possible antagonism. A third type of interaction can develop which is characterized as mutually connected or interrelated, which Bateson (1975, July, personal communication) has referred to as reciprocal. Such interactions tend to be more functional than either of the previous two.

Bateson also described such interactions in terms of minimizing, maximizing, and optimizing. Symmetrical interactions tend to maximize difference, divergence, or relations. Complementary interactions can initially minimize, but ultimately maximize divergence or relations. Reciprocal interactions tend to optimize relations. For example, in human physiology, a low body temperature minimizes enzymatic reactions. On the other hand, high body temperatures maximize enzymatic reactions. However, such high temperatures also lead to the

break down of the enzymes. Whereas, temperatures in the 98.6º F (37º C) range tend to optimize, so that a balance is reached between enzymatic effectiveness and maintenance of the chemical structure of enzymes. From such a perspective, it appears that complementary interactions may tend to minimize complexity, whereas symmetrical interactions may tend to maximize complexity.

In classroom discussions where the role of the teacher is that of the knowledge authority and transmitter of information and the students are passive receivers of knowledge, the interaction is complementary. Such interactions tend to minimize the construction of complex understandings. On the other hand, situations, such as the one mentioned in the previous paragraph, where students (with or without teacher participation) are engaged in an intense and impassioned argument are characteristically symmetrical. The resulting understandings constructed by the participants tend to be much more complex. In addition, the diversity of understandings can be competitive with one another. Ideally, we may want to work towards reciprocal interactions, which can lead to reasonably cohesive and complex understandings. In such situations, participants engage in processes more characteristic of negotiation, as it has been described in recent literature (such as Wood, Cobb, & Yackel, 1992). Although disagreements and knowledge claim challenges may occur, the process is not competitive. Rather, participants engage in clarification, justification, elaboration, or further inquiry in response to disagreements and challenges. In reality, reciprocal interactions may not be possible in all circumstances. Certainly, in looking at society, including science and science education communities, all three types of interactions are commonly found. If we want classrooms to reflect the processes characteristic of any learning community, we should expect to find complementary, symmetrical, and reciprocal interactions both within small groups and within the class as a whole. However, the pedagogical emphasis we may want to promote is that of reciprocal interactions. Karen Gallas' (1995) work with creating classroom learning communities, where reciprocal interactions appear to be the goal, involves using a variety strategies to help students learn appropriate and constructive ways to interact. Even with such successful pedagogical strategies, symmetrical and complementary interactions may be unavoidable, especially if students are deeply embedded in very different personal or cultural beliefs. The problem of maximizing or minimizing occurrences within the classroom may not be so problematic if we view the situation of the classroom as whole. Bateson (1975, August 4, personal communication) suggests that in complete systems, the parts may tend to maximize, but the whole tends to optimize. So, from the perspective of the classroom, we may see individual interactions maximizing from time to time, but within the overall context of the social construction of knowledge the process may be optimizing.

The final aspect of this model of learning involves general patterns of knowledge construction, rather than specific component processes, such as deduction, induction, and so forth. The common assumption about the nature of learning, as evidenced in many approaches to curriculum and instruction, appears to be one of linearity. Learning activities and lectures are sequenced in a linear pattern from less complex subordinate concepts to broader and more complex concepts. However, based on the previous discussion, we might expect that learning, as it occurs naturally, may involve much more complex patterns. Both Gregory Bateson (1971; 1979; 1991) and Mary Catherine Bateson (1994) have suggested alternative patterns. Gregory Bateson (1979), in particular, saw these patterns as characteristic of both evolution and learning. One pattern involves the back and forth sequence of form and process from the random to the selected. In learning, we see this alternating process between classifying and class to classifying

and classes of classes to classifying and classes of classes of classes and so forth. Each alternation of this sequence develops a hierarchical sphere of understanding and relevance based on feedback from the previous sequence. Another related pattern is more circular, which Bateson (1975, July, personal communication) referred to as multiple perspectives and loop processes. This patterns extends the notion of an alternating sequence of form and process to circular or more complex patterns of knowledge construction. Basically, such a process is composed of complex sets of recursive circuits, where multiple understandings or perspectives can connect across relational pathways and across contexts.

Mary Catherine Bateson (1994) extends this notion of recursive loops to a spiraling of multiple themes over time. She uses the metaphor of the double helix to describe how in our natural way of learning themes develop and move apart, then cross and reconnect at other times:

> ...we sometimes present learning in linear sequences, which may be part of what makes classroom learning onerous.... Learning outside the classroom is not like that. Lessons too complex to grasp in a single occurrence spiral past again and again, small examples gradually revealing greater and greater implications. (p. 30)

Such non-linear modes of learning present the possibility of constructing much more complex knowledge. She suggests that we weave our traditional habits of thought and belief with new experiences of multiplicity. In such a way, we can begin to incorporate the variation and diversity of our worlds and our own minds with previously entrenched ways of thinking and perceiving. The spiraling patterns allows for the development of diverse understandings - ones that even may be contradictory - where "the goal is to build a complex structure in which both sets of ideas are intelligible, a double helix of tradition and personal growth" (p. 44). The construction of complex understandings does not appear to be a linear process. Rather learning occurs in complicated patterns of recursiveness.

At its most fundamental level, learning involves the construction of simple relations, which Gregory Bateson (1979; 1975, August 14, personal communication) referred to as Learning I. At this level, we may learn that the digestive system is comprised of the mouth, stomach, and small intestines. Learning II involves learning about context. Digestion is not only an important process in providing nutrients to cells, but occurs within the context of complex sets of information exchange (e.g., when our brain receives messages that our blood sugar level drops below a certain level, we eat) and within the broader context of where we or a particular animal is situated in the complex ecological frame. Even more complex understandings of digestion can cross disciplinary boundaries to artistic, poetic, and other contexts. Bateson referred to the final level of learning at level III, deutero-learning, or learning about learning. This level of learning not only includes those activities suggested by contemporary educational researchers, such as Novak and Gowin (1984) who discuss learning how to learn, but also includes an extension of epistemic learning Nersessian, 1989). At this level, learning about learning is learning about contexts of contexts or learning how to recognize and deal with contexts beyond the familiar. Such learning involves being able to set aside our habitual reliance on interpreting familiar contexts in certain ways. Bateson referred to the way of interpreting situations as glosses. Unconscious glosses include depth perception and perspective. Other more conscious level glosses involve the way in which we interpret an interaction in the super market, at home, or in the classroom. Such glosses involve sets of assumptions which formulate the basis for the way we habitually interpret and interact within our familiar contexts. The problem is that these underlying assumptions and resulting glosses may not work or be appropriate in a different context. At the extreme, we might notice how a foreign visitor has difficulty interpreting and

interacting when visiting this country or how we have difficulty when visiting a foreign country. The habitual patterns of interaction do not work effectively. However, learning at this level requires learning not only about the nature of knowledge, but about the nature of contexts.

What we have seen in this discussion of knowledge construction and levels of learning are not only patterns of learning, but also patterns that connect (Bateson [1979] referred to them as "patterns which connect"). Such patterns that connect represent relations between ideas and ways of knowing. These patterns include (a) patterns that connect ideas within a discipline, (b) patterns that connect ideas across disciplines, (c) patterns that connect across ways of knowing or patterns that connect us to our world, and (d) patterns that connect us to each other - across cultures and groups and between individuals. In general, these patterns provide a way of providing cohesiveness to complex, diverse, and otherwise fragmented knowledge.

Up to this point, we have discussed how learning begins from a basis of random variation and moves towards greater complexity along recursive paths, levels of knowing, and patterns that connect. Figure 2 provides a representation of this model of learning. However, the fluidity and complexity of learning is difficult to represent in a two dimensional and static drawing. Given these rather significant draw-backs, the Figure may help to provide a visual Gestalt for the overall pattern and process.

The overall layout of Figure 2 places the eighth level of conscious at the bottom proceeding to the sixth level occuping most of the top half of the diagram. At the top of the diagram, above the circular cycle of arising, developing, and decaying thoughts, the general processes of knowledge construction (i.e., the alternating sequences of form and process, helical and spiral patterns of concept formation, and multiple perspectives--loop processes and circular patterns of concept formation) are represented. The notion of "patterns that connect" appear as (a) arcs crossing between the form--process sequences and helical patterns, (b) the points connecting the spirals of the helixes, and (c) the connecting lines in the multiple perspectives--loop processes. In the multiple perspectives--loop processes, the shaded circular nodes represent specific perspectives, concepts, or understandings. The lines between these nodes and the helical and form--process sequences represent conceptual links or "patterns that connect."

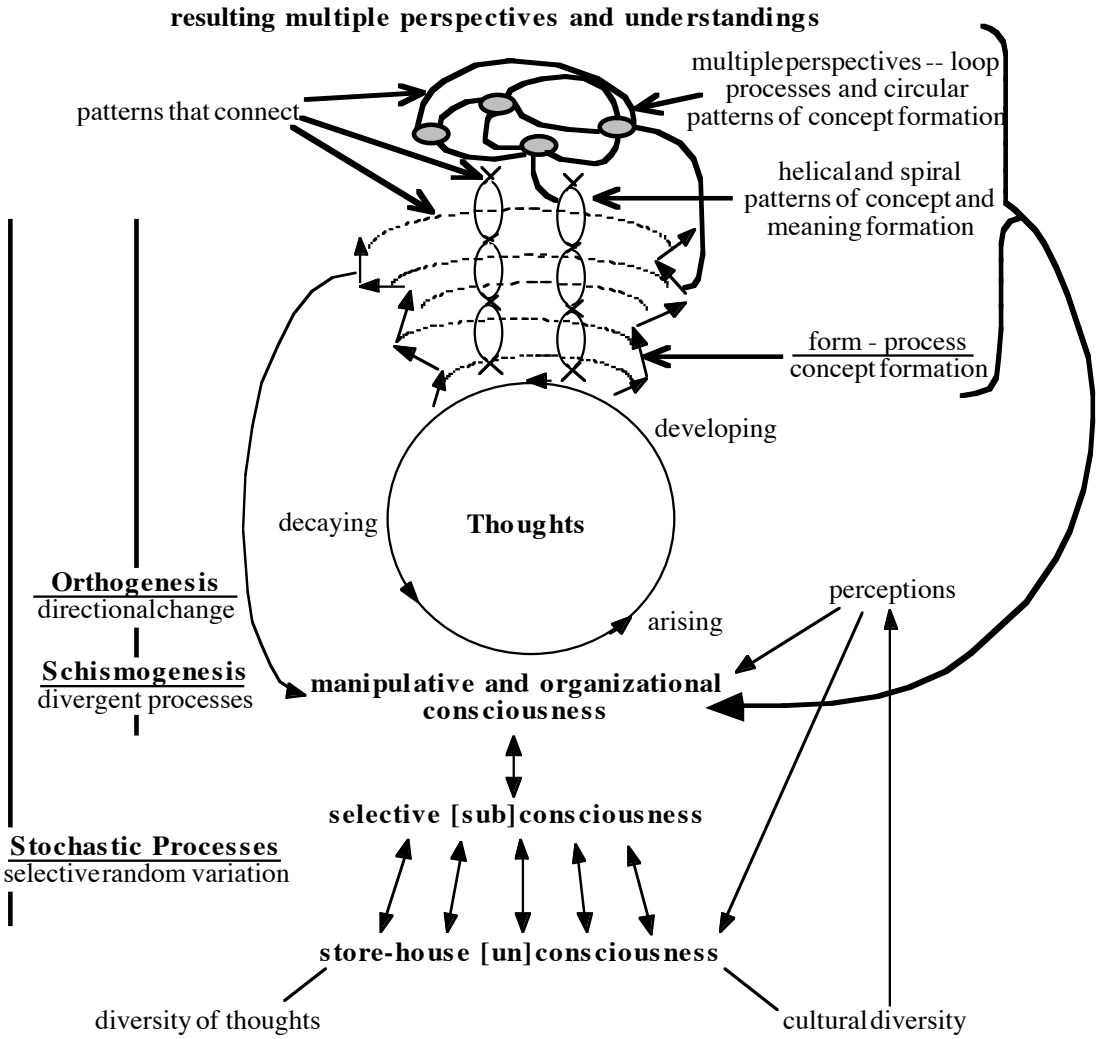

Figure 2. Model of learning based on evolutionary patterns.

Implications

In attempting to understand human learning, we cannot look at just a few aspects of the cognitive context. The notion of variation lies at the core of Gould's (1996) argument about the spread of excellence in the evolution of biological organisms. Few scientists and other scholars will argue with Gould about the importance of variation as the basic necessity for evolution. As we have seen in the previous discussion, the diversity or variation of ideas and other factors can play an important role in the development of conceptual complexity. Consequently, we need to look at the total picture. As Gould (1996) suggests,

> the history of any entity (a group, an institution, an evolutionary lineage) must be tracked by changes in the variation of all components -- the full house of their entirety -- and not falsely epitomized as a single item (either an abstraction like a mean value, or a supposedly typical example) moving on a linear pathway. (pp. 72-73)

The "full house" of all components or all aspects of human learning must be examined. Our emphasis on just the development of formal, school-type knowledge is problematic. In addition, Gould's contention of how representing the history of an entity by a mean value or a typical

example can misrepresent the picture is directly analogous to our tendency to represent learning as a letter or numerical (mean) grade. Both ways of representing are problematic. The problem becomes further exacerbated as we combine the mean values of individuals into a group mean value. The meaninglessness of such values is cogently addressed by Gregory Bateson in his discussion of using statistical analyses in the study of human behavior. He (1991) contends that "the most elementary requirement of statistics -- uniformity of sample -- is not met" (p. 73). He elaborates further that there is,

> no possibility of handling data statistically. The contexts, the individuals, and the behaviors are too various for their combinations and permutations to be handled in this way. The units are too heterogeneous to be legitimately thrown together into a statistical hopper. (p. 39)

If we wish to formulate a more accurate picture of human learning and understanding, we need to find ways of examining the variability and diversity of human approaches to learning and knowing.

Certainly, schooling tends to limit variation by taking a narrowly focused approach to what ideas are incorporated into the curriculum as is evident in the focus on specific content in national and local standards. If we want to work towards learning that is more complex, we need to start by acknowledging the value of variation and how such variation can lead to much more complex understandings. Postman (1995) suggests a principle of diversity in which "... diversity wants one to turn outward, toward the talents and accomplishments of all groups" (p. 144). As a result, turning outward and developing expressions of diversity can reveal "...how difference contributes to increased vitality and excellence, and, ultimately, to a sense of unity" (p. 145). Postman's claim corresponds to Gould's (1996) contention that variation is basis for the spreading of excellence, as well as to Gregory Bateson's (1979; 1991) notion of the random acting as the basis for developing greater complexity. The framework of "contexts of meaning" suggests a way of conceiving of such variation in ideas and ways of making sense that are evident in children's thinking (Bloom, 1990; 1992a; 1992b). The ground of such variation can provide for the development of diverse understandings.

The value we place on variation and the development of complexity also needs to be reflected in the way in which we describe student learning. Numerical scores, especially those that rely on mean performance values, do not provide an adequate picture of student learning. At this point, we have ways available to us for assessing such complexity (such as Bloom, 1995; White & Gunstone, 1992), but much of this work does not reach classrooms, and, more importantly, it appears not to affect practice at the level of state or provincial policy-makers.

The narrow focus and linearity of such a focus of schooling is counter-productive to any notion of providing opportunities for students to construct complex understandings. Mary Catherine Bateson (1994) describes this situation in the following excerpt:

> Systems of education are everywhere in ferment, visions of promise countered with proposals for increasing rigidity... This suggests that many proposals have too narrow a focus, are directed at local problems when the entire concept of education needs to be rethought. (p. 9)

Although Gregory Bateson (1979; 1991) suggests two processes of linear construction of complexity in schismogenesis and orthogenesis, he also suggests much more complex and recursive pathways. I suspect that his intent was to describe the overall drive to complexity as linear. However, the specific processes of alternating between form and process, recursive and circular pathways, the much more complex recursiveness of multiple perspectives and loop

processes, and Mary Catherine Bateson's (1994) spiraling thematic development do not follow linear pathways, but do result in overall increases in complexity. In fact, such processes do not even result in a strictly linear and narrowly focused product. Multiple understandings can result from the general process of schismogenesis and the specific processes of recursive and circular pathways, multiple perspectives and loop processes, and spiraling thematic development. So, the result of starting from a basis of variation can result in variation of more complex understandings.

From the perspective of our increasingly global society, the drive towards variation of complexity has been the focus of much post-modernist writing. Smith and Wexler (1995) describe the postmodern condition as

> ... characterized by the social construction of reality which relativizes claims to knowledge and authority; multiple realities, multiple goals and diverse evaluation criteria so that the concept of rational decision-making is threatened. (p. 2)

Such diversity is not necessarily problematic. However, we have had no model for dealing with and relating to variation throughout our schooling. We have been trained to operate using a single approach. In describing this situation Mary Catherine Bateson (1994) suggests that,

> The quality of improvisation characterizes more and more lives today, lived in uncertainty, full of the inklings of alternatives. In a rapidly changing and interdependent world, single models are less likely to be viable and plans more likely to go awry. The effort to combine multiple models risks the disasters of conflict and runaway misunderstandings, but the effort to adhere blindly to some traditional model for a life risks disaster not only for the person who follows it but for the entire system in which he or she is embedded, indeed for all other living systems with which that life is linked. (p. 8)

Such a linear focus of our models and a focus on singularity rather than multiplicity are not likely to be successful. The alternative approach is to pursue ways of understanding across multiple versions of the world, multiple understandings, and so forth.

> Ambiguity is the warp of life, not something to be eliminated. Learning to savor the vertigo of doing without answers or making shift or making do with fragmentary ones opens up the pleasures of recognizing and playing with pattern, finding coherence within complexity, sharing within multiplicity. (Bateson, M. C., p. 9)

Variation and its concomitant uncertainty should be a source of identifying and working with patterns. Trying to narrowly focus and ignore variation is a matter of trying to control, distance, and dominate (Bateson, M. C., 1994). This notion of distancing ourselves is in stark contrast to Kauffman's (1995) and both Batesons' notion of seeing the sacred, as well as to the Batesons' notion of patterns that connect. Taking a fresh look at our world, and its variation and our position in that variation can provide a way for us to connect with our world. Such a process is summarized by M. C. Bateson in that "seeing anew is a kind of intimacy" (p. 10). Both Batesons have suggested that we need to focus on "patterns that connect." However, Mary Catherine Bateson's notion of such connecting patterns, which she refers to as "peripheral visions," is much more directly applicable to the pressures of social and cultural multiplicity. Her father's work, on the other hand, is useful in finding ways of connecting diverse conceptual understandings, ones that cross disciplinary boundaries (Bateson, 1979; 1991).

Following a linear approach to learning and teaching - one that does not draw on variation or the multiplicity of ways of knowing - can lead to, as Gregory Bateson (1975, July 28, personal communication) suggests, incomplete understandings. Borrowing a phrase from Whitehead's reaction to a talk on quantum physics talk by Bertram Russell, Bateson suggests that schools are

oriented “to obscure the vast darkness of the subject.” The tendency is to use the current explanatory devices and associated rules to cover areas which are not that well understood, to “obscure the vast darkness of the subject” (Bateson, 1991, p. 49). For example, statements, such as (a) the mean complexity of living organisms has increased since the beginning of time, (b) the mean family incomes have increased over the past so many years, or (c) gravity is a force of attraction between two bodies, obscure the reality of the situation. In each of these statements, the vast darkness (i.e., the extent of potential understandings) is obscured. Bateson’s contention is that one way of not obscuring the vast darkness is to apply multiple ways of knowing, such as an aesthetic entry into the study of a particular topic or phenomenon. He suggests further that the intellectual study alone of phenomena tends to avoid the context by trying to objectify. Jane Goodall (1990), in her work with chimpanzees, tried to avoid such obstructions. Her entry point to her studies was aesthetic and empathic. However, she met with much resistance in the scientific community as is evident in the following:

> The editorial comments on the first paper I wrote for publication demanded that every *he* or *she* be replaced with *it*, and every *who* be replaced with *which*. Incensed, I, in my turn, crossed out the *its* and *whichs* and scrawled back the original pronouns. As I had no desire to carve a niche for myself in the world of science, but simply wanted to go on living among and learning about chimpanzees, the possible reaction of the editor of the learned journal did not trouble me. In fact I won that round: the paper when finally published did confer upon the chimpanzees the dignity of their appropriate genders and properly upgraded them from the status of mere 'things' to essential Being-ness. (p. 15)

Goodall’s aesthetic and empathic approach to the study of chimpanzees allowed her to understand something of the context. As Bateson (1991) suggests, the intentional use of introspection and empathy can be used to understand other people as well as other species:

> ...it is silly not to compare what we personally know about being human with what we can see of how other people live, and silly not to use what we human know of living as a background for thinking about the being of other species. (pp. 76-77)

Goodall’s approach attempts to uncover the vast darkness by elucidating the patterns that connect.

By uncovering the vast darkness and making explicit the patterns that connect, we see the sacred. Perpetuating the vast darkness “deadens” our view of the world. It tries to objectify and thus, as Varela, Thompson, and Rosch (1991) contend, drive us towards nihilism. On the other hand, acknowledging the subjective and providing a way of connecting with our world and with one another, we enliven and enrich.

In revisiting the notion of progress, we may want to modify what has been discussed previously. As Gould (1996) suggests, progress in cultural change is possible. However, the question of what progress looks like is an important, although difficult, task. Progress may not be a linear or a non-linear sequence towards greater complexity alone. “Progress,” as we tend to conceive of it, has led to increased fragmentation of knowledge and increased pressure on the survival of the human species. Instead, we may want to look for a notion of progress that encompasses the greater context of human (and all) life. Such a view may involve moving towards the recognition of and learning about patterns that connect and from there to a notion of the sacred. “Sacred” does not have to necessarily involve the trappings of religion, but should involve a notion of connectedness and appreciation of the inherent variation and complexity of our world.

For all intents and purposes, there is no right wall. Although Gould (1996) suggests that we may have reached the right wall in certain areas, such as art and music, the realm of our understanding of science is far from the right wall. However, his view of art and music are based on a mechanistic view of these disciplines. Such a view obscures the vast darkness. Art and music are not about technique, but about patterns that connect. The possibilities of new understandings, new connections, and new ways of representing our insights are essentially limitless.

References

Bateson, G. (1971). *Steps to an ecology of mind.* New York: Bantam.

Bateson, G. (1979). *Mind and nature: A necessary unity*. New York: Bantam.

Bateson, G. (1991). *Sacred unity: Further steps to an ecology of mind.* New York: Harper Collins.

Bateson, M. G. (1994). *Peripheral visions: Learning along the way*. New York: Harper Collins.

Bloom, J. W. (submitted). Classroom discourse and cognition: An extended argument about density.

Bloom, J. W. (1990). Contexts of meaning: Young children's understanding of biological phenomena. *International Journal of Science Education, 12*(5), 549-561.

Bloom, J. W. (1992a). Contexts of meaning and conceptual integration: How children understand and learn. In R. A. Duschl and R. Hamilton (Eds.), *Philosophy of science, cognitive science in educational theory and practice* (pp. 177-194). Albany, NY: State University of New York Press.

Bloom, J. W. (1992b). The development of scientific knowledge in elementary school children: A context of meaning perspective. *Science Education, 76*(4), 399-413.

Bloom, J. W. (1995). Assessing and extending the scope of children's contexts of meaning: Context maps as a methodological perspective. *International Journal of Science Education, 17*(2), 167-187.

diSessa, A. A. (1993). Toward an epistemology of physics. *Cognition and Instruction, 10*(2 & 3), 105-225.

Donald, M. (1991). *Origins of the modern mind: Three stages in the evolution of culture and cognition*. Cambridge, MA: Harvard University Press.

Gallas, K. (1995). *Talking their way into science: Hearing children's questions and theories, responding with curricula*. New York: Teachers College Press.

Goodall, J. (1990). *Through a window: My thirty years with the chimpanzees of Gombe* . Boston: Houghton Mifflin.

Gould, S. J. (1996). *Full house: The spread of excellence from Plato to Darwin*. New York: Harmony Books.

Guenter, H. V. (1974). *Philosophy and psychology in the abhidharma*. Berkeley, CA: Shambhala.

Johnson, M. (1987). *The body in the mind: The bodily basis of meaning, imagination, and reason*. Chicago: University of Chicago Press.

Kauffman, S. (1995). *At home in the universe: The search for the laws of self-organization and complexity*. New York: Oxford University Pres.

Maybury-Lewis, D. (1992). *Millennium: Tribal wisdom in the modern world*. New York: Viking.

Mayr, E. (1970). *Populations, species, and evolution*. Cambridge, MA: Belknap Press (Harvard University Press).

Narada, M. T. (1979). *A manual of abhidhamma*. Kuala Lumpur, Malaysia: Buddhist Missionary Society.

Nersessian, N. J. (1989). Conceptual change in science and in science education. *Synthese, 80*, 163-183.

Novak, J., & Gowin, D. B. (1984). *Learning how to learn*. New York: Oxford University Press.

Nyanatiloka, M. (1971). *Guide through the abhidhamma-pitaka*. Kandy, Ceylon: Buddhist Publication Society.

Plotkin, H. (1993). *Darwin machines and the nature of knowledge*. Cambridge, MA: Harvard University Press.

Postman, N. (1995). *The end of education: Redefining the value of school*. New York: Vintage Books.

Schweder, R. A. (1991). *Thinking through cultures: Expeditions in cultural psychology*. Cambridge, MA: Harvard University Press.

Smith, R., & Wexler, P. (1995). *After post-modernism: Education, politics, and identity*. Washington, DC: Falmer Press.

Varela, F. J., Thompson, E., & Rosch, E. (1992). *The embodied mind: Cognitive science and human experience*. Cambridge, MA: MIT Press.

White, R., & Gunstone, R. (1992). *Probing understanding*. London: Falmer Press.

Wood, T., Cobb, P., & Yackel, E. (1992). Change in learning mathematics: Change in teaching mathematics. In H. H. Marshall (Ed.), *Redefining student learning: Roots of educational change* (pp. 177-205). Norwood, NJ: Ablex.