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ABSTRACT

This paper addresses contemporary (i.e., postmodern) concerns with the disintegration of meaning and fragmentation of knowledge. As society continues to move towards increased specialization and separation of disciplines, people are becoming increasingly disconnected from the broad connecting conceptions within the disciplines, i.e., the patterns that bridge the disciplines, to the natural world, and to each other. A potential remedy, based on the work of Gregory Bateson and Mary Catherine Bateson, for providing a way to develop such connections is explored. Such as remedy is founded on the framework of "patterns that connect" (G. Bateson, 1979). In this paper, the discussion of such patterns is situated in the context of a view of learning that is based on nonlinearity of thought processes and on variation both as a source and outcome of thinking (J. Bloom, 1998; F. Capra, 1996). This view of learning leads to: (1) more cohesive and elaborate understandings; (2) an emphasis on meaning rather than decontextualized content; (3) emphasis on creativity; (4) a greater sense of connection to the learner's world; and (5) the development of a sense of ownership over what is learned. (Contains 5 figures and 19 references.) (SLD)

Patterns that Connect: Rethinking our Approach to Learning and Teaching

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Science and science education, and for that matter schooling in general, are situated in the midst of the problems of living in a post-modern world. Broadly speaking, post-modernism involves "...the social construction of reality which relativizes claims to knowledge and authority; multiple realities, multiple goals, and diverse evaluation criteria..." (Smith & Wexler, 1995, p. 2). Furthermore, such a perspective of our current cultural context sees an increasing fragmentation of knowledge and of the way we approach problems. Such fragmentation is evident in the modernist perspective of past decades, upon which our scientific communities have been built. Modernist perspectives are based on positivist, reductionist, and mechanistic approaches, as well as "...the premise that dealing with reality as a set of technical fragments will inevitably produce moral, aesthetic, and scientific progress for the human race" (Oliver, 1989, p. 9). However, as Oliver suggests in reflecting on Walker Percy's work, the modernist approach has resulted in numerous pathologies, including environmental destruction, and a host of other "bizarre human behavior" (pp. 8-9). Gregory Bateson (1979) pointed to this situation of increasing pathology in terms of adaptation of both the biological world and of human societies -- adaptation leads to increasing specialization resulting in pathology. As our own specialized worlds focus increasingly upon a narrower view, we lose a sense of panoramic awareness, of how our view fits into the whole. Pathology arises as we feel separated and disconnected from our worlds. We fall into patterns of relationships which are (a) antagonistic or (b) controlling and submissive. Bateson (1979) refers to these patterns of pathologic relationships as symmetrical (e.g., individuals in competition for being in control or being "right") and complementary (e.g., one individual in control and the other submissive). Both of these patterns of relationship tend to promote cascading effects of separation.

This paper addresses contemporary (i.e., postmodern) concerns with the disintegration of meaning and fragmentation of knowledge. As we continue to move towards increased specialization and separation of disciplines, people are becoming increasingly disconnected (a) to the broad connecting conceptions within disciplines, (b) to the patterns that bridge disciplines, (c) to the natural world, and (d) to each other. A potential remedy -- based on the work of Gregory Bateson and Mary Catherine Bateson -- for providing a way to develop such connections will be explored. Such a remedy is founded on the framework of "patterns that connect" (Bateson, 1979). In the present paper, the discussion of such patterns is situated within the context of a view of learning that is based on non-linearity of thought processes and on variation as both a source and out-come of our thinking (Bloom, 1998; Capra, 1996). This view of learning (including "patterns that connect") leads to (a) more cohesive and elaborate understandings, (b) an emphasis on meaning rather than decontextualized content, (c) an emphasis on creativity, (d) a greater sense of connection to the learner's world, and (e) the development of a sense of ownership over what is learned.

Context of Post-Modern Life

Science education, even with its "reforms," still maintains a strong base in modernist paradigms. Goals and objectives focus on the acquisition of conceptual content within narrow areas of specialization. The approach is a linear one, with hopes of progress and technical solutions to the problems facing our world. However, the whole notion of progress is questionable. Even Gould (1996) finds our notions of human progress to be curious. Although biological evolution is not progressive, human societies have the potential to change in ways that are progressive, but the evidence of our "progress" is marked by a rather dubious record of

achievement. In addition, science education has always and continues to isolate and distance itself from other disciplines and other ways of knowing. Such isolationism continues to fragment our understandings of the world, to disconnect children from their own ways of knowing, and to disconnect them from their worlds.

In general, children face many conflicting messages from society, including those of fractionated knowledge and views of the world. In the west, especially in the United States where individual rights are paramount, children are socialized towards the cultural values of separateness (i.e., individuality) and autonomy. However, when they enter school they find that these values are no longer valid. As Mary Catherine Bateson (1994) observes, "... what an extraordinary thing it is that in a society where we regard the self as central, we are so often engaged in silencing its expression or putting confidence at risk" (p. 67). The learning that children do outside of class in their families and neighborhoods (e.g., self-sufficiency, beliefs, cultural and societal mores, conceptual understandings, processes and procedures, etc.) are required to be left outside the door to their schools. By demanding conformity and obedience, schools contradict children's learning from the society in general. Democratic ideals are exchanged for the corporate agenda of efficiency, conformity, and obedience (Wood, 1990).

Furthermore, this whole notion of separateness of individuals and isolation of disciplines contributes to the propagation of a blindness to the whole - to the complexities and interconnectedness of the contexts in which we live and work. As autonomous individuals, we may find it difficult to see patterns that connect us to our worlds, because of a focus on our own needs, on our own agendas. In the same way, disciplinary isolation fails to recognize patterns that connect across disciplines and across ways of knowing. Gregory Bateson (personal communication, June 7, 1975) suggested that schools "obscure the vast darkness of the subject"

by attempting to be objective, while ignoring the context in which a phenomenon occurs or an object is situated. For example, children studying fish in an aquarium may be required to record observations in a rather "objective" way, while not paying attention to the entire context or contexts. In addition, both Stephen Jay Gould (1996) and Gregory Bateson point to our difficulties in seeing the complexities of phenomena by concentrating on abstractions, such as those used in statistical analyses of human or animal behavior (Bateson [1979] refers to such analyses as obscuring the vast darkness of the subject). In other words, our learning tends to be decontextualized and, therefore, lacks meaning.

Patterns That Connect

The notion of "Patterns That Connect" originally appeared in the work of Gregory Bateson (1979) as the "pattern which connects." In this work, Bateson pursued a unifying link between mind and nature. This ultimate unity was based in the idea that all change, all phenomena occurred through processes that were cognitive. In other words, all change, all adaptation could be viewed as a process of learning. Bateson's work was an effort to remove the entrenched distinction in Western thinking between mind and nature (i.e., a problem of Cartesian dualism in which mind and body are irrevocably separate). Such a dualistic distinction has had the effect of preventing people from seeing the patterns that connect and unify all phenomena.

At the same time, Bateson was developing his ideas, Humberto Maturana was developing a similar theoretical perspective of combining "the process of knowing with the process of life" (Capra, 1996, p. 273). Drawing on Dell's analysis, Capra sees the primary distinction between the two approaches as one of the difference between the nature of knowledge (i.e., Bateson's emphasis on epistemology) and the nature of existence (i.e., Maturana's emphasis on the nature of existence). Both Bateson and Maturana viewed cognition (i.e., mind and nature) from a

cybernetic perspective. Although Bateson saw both natural processes and cognitive processes as mental processes, he emphasized the development of hierarchical orders of mental representations. On the other hand, Maturana saw mental processes or cognition as a way of manifesting or creating a world.

More recently, the ideas of Bateson and Maturana have led to the development of a more complex theoretical framework involving three criteria of life: (a) *patterns* of life, also known as autopoiesis (i.e., self-generating and self-maintaining systems); (b) *structures*, known as dissipative structures (i.e., structures that are far from equilibrium and hold the possibility of continually increasing in complexity); and (c) *process*, which connects pattern and structure (can be thought of as a process of knowing or cognition). In other words, a structure can be made up of any number of parts. However, putting all of the parts together do not make a structure unless they exist in ordered relationships. These ordered relationships in turn appear as a network of patterns, which demonstrate the characteristics of self-regulatory or self-generating feedback loops and production processes. Within this context, the notion of pattern is the major defining feature of autopoesis as a network of patterns that feedback upon each other in processes which generate and maintain themselves (Capra, 1996; Maturana & Varela, 1998; Prigogine, 1984).

In the previous description, the notion of pattern relates to the relationships evident in biological systems. However, Maturana (as cited in Capra, 1996) maintains that such a model of autopoeitic systems does not apply to social systems. On the other hand, Varela (as cited in Capra, 1996) suggests that the idea of *organizational closure*, which is similar to autopoiesis, may be a viable model for social systems. In this model, production processes are not specified as in autopoeitic systems. In social systems, communication becomes the primary mode of self-reproducing and self-maintaining patterns: "the closure of the network results in a shared system

of beliefs, explanations, and values--a context of meaning that is continually sustained by further conversations" (Capra, 1996, pp. 212-213).

In essence, these two models of living systems and social systems describe self-sustaining, complex networks, in which the relationships among components of systems emerge as interdependent patterns -- as *patterns that connect.* Based on the previous discussion, examples of such patterns appear to fall into three categories: (a) patterns that connect in living systems, (b) patterns that connect in physical systems, and (c) patterns that connect in social systems. At the same time, the contrasting positions between Maturana and Bateson set up a division between (a) patterns that connect as ontological descriptions of emergent phenomena (i.e., descriptions of the nature of the physical, biological, and social world) and (b) patterns that connect as epistemological descriptions of phenomena (i.e., the nature of knowledge about, or even contained in[i], the physical, biological, and social world).

From the perspectives of Bateson and Maturana, we can distinguish two basic ways of "viewing" patterns that connect: (a) as emergent, ontological patterns and (b) as descriptive, epistemological patterns. Emergent patterns are active processes that are taking place in real time, at the moment. We can be active participants in such processes. On the other hand, descriptive patterns are viewed as features or characteristic patterns of a particular context. Within the context of education, the point seems to be of a difference in "view." An emergent pattern can be viewed as epistemological -- as a way of understanding relationships. On the other hand, working within an emergent pattern can provide ways of knowing and acting. For instance, we can examine the patterns that connect specific concepts in biology (which may be emergent within the context of the biological system) as a way of developing more complex and interconnected understandings. Within the context of classroom dynamics, we may see emergent

patterns of relationships occurring. In such a case, we can act in ways that facilitate such relationships or that change those patterns in ways which are more productive.

The discussion thus far essentially describes the notion of patterns that connect as networks or webs of relationships. How is such a notion different from what we have been doing already in classrooms? For instance, we teach children about the "food web" as a network of relationships among various organisms (e.g., producers, consumers, predators, decomposers). Such a web has the appearance of connecting patterns of relationships, but the relationships describe only a small part of the context and do not point to processes of self-organization or hierarchies of knowledge. Furthermore, as Bateson (1979) contends, patterns that connect are meta-patterns or patterns of patterns of relationships. In the case of food webs, the relationships are only a small piece of larger patterns of energy flow, population growth and stability, and various symbiotic relationships. All of these larger patterns are interrelated as self-organizing and self-maintaining processes (see Figure 1).

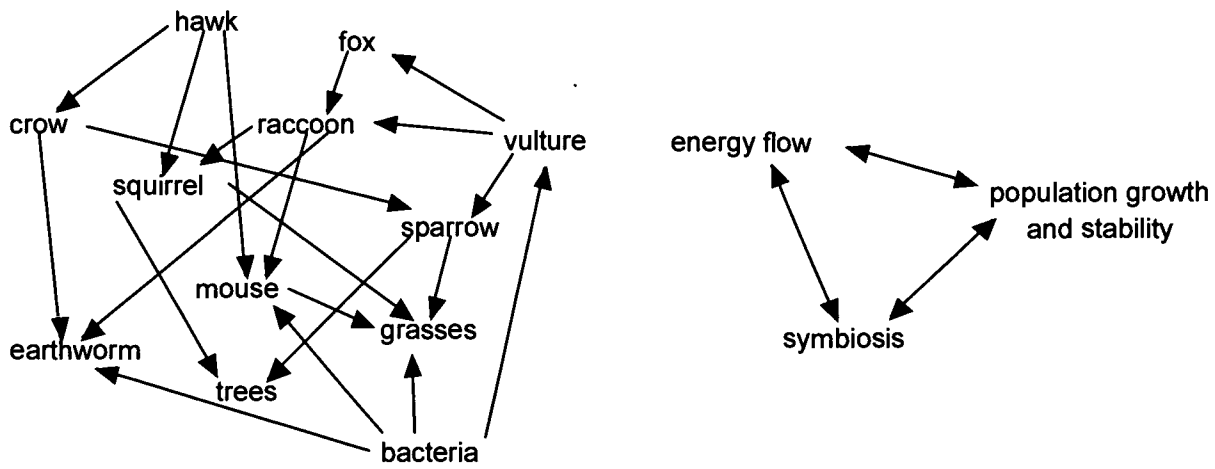

Figure 1. Food webs as a network of relationships vs. food webs as one aspect of meta-patterns of self-organization.

The defining features of patterns that connect can be described as (a) meta-patterns or patterns of patterns of relationships (or patterns of patterns of connections); (b) contexts of relationships that provide greater depths of meaning; (c) pointers to processes of self-organization or hierarchies of knowledge; and (d) creative processes that generate new knowledge (e.g., new forms of biological structures or new forms of knowledge and understanding). Such features appear to be characteristic of both emerging and epistemic patterns that connect in biological and social contexts, and to some extent in physical contexts. However, within the realm of education, it may be helpful to categorize patterns that connect in terms of contexts of applicability:

1. Patterns that connect within a particular discipline, such as biology, physics, history, economics, etc.;
2. Patterns that connect across disciplines, such as between (a) biology and physics; (b) biology and art; and (c) biology, geology, economics, history, etc.;
3. Patterns that connect people with their biological and physical worlds;
4. Patterns that connect people to one another across individual, social, and cultural differences.

In each of these categories, patterns that connect can be viewed as either emerging or descriptive. However, in either case, such patterns go beyond the networks of simple relationships to over-arching patterns of connections evident in such relationships. In addition, categories can overlap resulting in even more complex patterns.

Patterns That Connect Within a Discipline

Typically, schooling emphasizes the acquisition of specific facts and concepts, which are generally presented in ways that are devoid of or are weakly embedded in context. As a result, any learning that occurs tends to be fragmented. Such knowledge lacks the depth of meaning that is possible when concepts are learned within richly interconnected contexts. As in figure 1, students who learn about the food web may leave with an understanding that different organisms are food for other organisms. What is important about that concept? Not much. However, if students were to explore what happens (a) when certain populations lose their natural predators, (b) how the energy flows through the physical and biological environment, and (c) what relationships exist among various organisms and between those organisms and their environment, then what begins to happen is the development of an increasingly complex understanding of the patterns of connectedness. Where there is a paucity of meaning in studying the food web, a rich context of meaning arises in studying the network of relationships and overarching patterns of an expanded view. The entire situation of the food web is embedded in a context of multiple interrelationships.

In this previous example of how food webs can be situated in numerous sets of interrelationships, we also get the sense of a dynamic system of growth of understandings. As each connection spins off into another set of connections, there is an increase in complexity. Such a "spinning of webs of complexity" is the cognitive version of a *dissipative structure*. Once children are given "permission" to diverge and to start making connections, the whole process can take on a life of its own. The creation of meaningful understandings of ever increasing complexity becomes a socially situated *autopoeitic* (i.e., self-generating, self-making, self-sustaining) process.

The same sort of process of patterns that connect ideas within a discipline can occur with any particular topic. In history, students may be studying about Martin Luther King. Obviously connections to the history of slavery in the United States is a major part of the historical patterns leading up civil disobedience in the 1960s. However, there are connections to slavery throughout the history of humankind, to the social mentality of the European immigrants to the "New World" (i.e., what was it about the mentality of the culture to even consider the notion of "slavery" and from where did this idea come?), to civil disobedience in other cultures (e.g., Gandhi in India), to contemporary versions of the mentality of "slavery" (e.g., compliance, servitude, power, control, genocide, and other human rights abuses in various institutions and societies; attitudes towards the environment as a resource for human beings rather than human beings as one part of the environment). What may start out as a narrow study of a particular event, situations, or person mushrooms into complex understandings with multiple contexts of meaning.

Patterns That Connect Across Disciplines

Patterns that connect across disciplines extend this notion of spinning webs of complexity to interrelationships that span disciplinary boundaries. In biology, students may be studying about the notion of bilateral symmetry in organisms. This notion alone is rather limited and lacking of substantial meaning. However, the notion of symmetry spans many aspects of biology, as well as physics, chemistry, geology, astronomy, mathematics, art, and social studies. Gregory Bateson's (1979) favorite example he used in talks involved the notion of how we can define evidence of living organisms. He had various audiences pretend they were from another planet with no knowledge of Earth. They received a crab shell and were asked how they could tell whether this

object was evidence of life. The primary characteristic (identified more easily by artists) was symmetry. But the symmetry was not always exact. One side of the crab was not identical to the mirror of the other side -- the claw on one side was bigger than the one on the other side. So, the notion of symmetry was not limited to exact mirror images. Such symmetry of "similarity" is evident in many types relationships. The relationship between a couple can be symmetrical, if both individuals tend to vie for control over the relationship. Two countries or groups who vie for control over a land area or an economic entity are in a symmetrical relationship.

At the same time, the notion of symmetry can extend to galaxies and other astronomical phenomena, to tornadoes, to mathematical equations, to poetry, to patterns represented artistically, to a dance performance, and so forth. Hindu and Buddhist understandings of psychological and social aspects of life involve symmetrical representations in the form of mandalas. Many native cultures view the world as a symmetrical balance of various factors and forces. What might start as a discussion of bilateral symmetry (i.e., structure) can extend to symmetry of function, action, behavior, power, and so on.

Developing such cross disciplinary patterns of connectedness provides opportunities to develop much more complex understandings and contexts of meaning. Such understandings lead to the development of abilities to critically discriminate. For instance, we can take a terms, such as "power," and look at how it is used in different contexts. Power, as a scientific term, has a specific meaning which is quite different from uses of the term in other contexts: "that was a powerful movie," "who has power in the classroom," or "the power of the written world." Examining how such terms vary in meaning across contexts is not typically done in classrooms. As a result, students are often confused and have difficulty doing well in courses, especially in science where the meanings of commonly used words (e.g., force, resistance, energy, etc.) often

have very different and sometimes counter-intuitive meanings. However, when such differences in meaning are addressed, students are given the tools to start discriminating between contextually appropriate meanings. Students not only can discriminate between differences in meaning across contexts, but also can examine how such terms are similar. Although "power" has a specific meaning in science and one that is different from "power" in human relationships, there is a sense of similarity in both usages. In such cases, where a particular word appears in many different contexts, but with different meanings, the notion of patterns that connect can involve such transitions in meaning while maintaining an almost poetic similarity.

Patterns That Connect People with Their Worlds

Both of the previous categories of patterns that connect have the potential for allowing us (including students) to connect with our world. However, more explicit ways of developing such connections are possible. For instance, a grade five girl describes her experience of walking in the forest: "...I think squirrels are really really nice. I have a bunch of squirrel friends down in the woods.... whenever I'm down in the woods the squirrels always come around and chatter to me" (Bloom, 1994, data set). In this example, the girl feels a connection with the squirrels, who come and chatter to her. Of course, from what we know of squirrel behavior, their chatter is probably a reaction to a perceived threat. The important point is that she feels a connection to and understanding of her world. Her understandings are enlivened by the connection she sees between the squirrels and herself. On the other hand, the same sense of connectedness could hold true if she saw the squirrels as screaming at her for invading their territory. In either case, the anthropomorphism serves as a basis of the pattern that connects the girl to her world.

In a similar way, the grade 3 girl who says, "it's wagging its tail," as she observes an earthworm in a tray, is making a connection to the earthworm (even though earthworms do not have tails) (Bloom, 1990, 1992). "Wagging" a tail has implicit meanings. Although the following "meanings" are often discouraged in biology, a cat wagging its tail is generally an indication of "irritation"; and a dog wagging its tail generally means that it is "happy". Both of these meanings of wagging tails deal with emotions with which we have experience. So, when we talk about a dog being happy when it's wagging its tail, we can identify with the dog's experience to some extent. The point here, however, is that in school we either ignore or criticize such statements. On the other hand, we should be encouraging such connections and explorations of meanings. We could ask, what do you think it means when the worm is wagging its tail? What does it mean when a dog wags its tails? when a cat wags its tail? Such questions can lead to further explorations, such as, how do we and other animals express different emotions and so forth? What other meanings for wagging tails are there, such as with cows, horses, and monkeys? Then, do we, as humans, do similar things with similar meanings? Again, as with the previous two categories of patterns that connect we can see how such questions can lead to the spinning of complex webs of interconnections and understandings. However, in this case, we also are creating connections between us and our world.

Patterns That Connect People to One Another

The fourth category of patterns that connect people to one another, extends beyond the typical scope of science or any other discipline, although it becomes vitally important within the context of the classroom, as well as in our society, in general. The notion of "difference," as described by Maxine Greene (1988) and Lisa Delpit (1995), is at issue in all classrooms. Not

only is each individual different, but racial, ethnic, religious, and cultural groups each bring sometimes radically differing contexts of beliefs, world views, and ways of conducting oneself. In extreme cases, some children may feel culture shock as they enter as immigrants into a strange new society. Mary Catherine Bateson (1994) suggests that "true culture shock occurs when differences run deep and immersion is complete, so much so that ordinary assumptions are overthrown, when panic overcomes irritation" (pp. 57-58). Children in our classrooms may be in the midst of such panic. However, as Mary Catherine Bateson suggests, looking for the patterns that connect us across cultural and individual barriers may be a solution. Revealing such patterns requires empathy and openness. What common sense of humanity do we share? What things do we care about and share in common? These and many more questions are a start to the development of patterns that connect people to people.

In a way that is similar to patterns that connect us to our world, we can begin to explore our similarities across expressions of difference. Explorations of our experiences of love, security, fear, friendship, insecurity, and so forth can open avenues for people to begin to understand one another. As these avenues are opened, we can begin exploring difference. However, as we explore difference we need cycle back to how such instances of difference affect commonalties of shared emotions and feelings. For instance, many cultures view the act of a child looking at an elder in the eyes is an insult. Many white teachers expect children to look at them when they are talking. This difference in relating to adults can lead to a lot of misunderstandings and negative feelings. On the other hand, what is the commonality between the two different ways of relating to adults? Both are expressions of how a particular group shows respect for adults.

Such investigations and discussions of difference and similarity can lead a diverse group of students to come to an understanding and appreciation of each other. As all individuals continue

to explore their relationships, they can continue to develop complex webs of understandings of differences and similarities in their ways of communicating meaning. At the same time, we are providing students with the tools to communicate effectively with others (Bateson, 1994).

Implications for Learning and Schooling

Meaning is not self-existing in the world. We create meaning through patterns of connections with our world. Such patterns of connections comprise the context or contexts that provide the possibility of generating meaning (Bateson, 1979). From the perspective of semiotics, a sort of cybernetic cycling occurs between the sign, object, and the individual or individuals involved in interpreting. As we encounter and relate to phenomena, we assign labels, which can, in turn, be related to specific contexts of meaning. Our connections to specific contexts can then lead to interactions with the particular phenomena, which can lead to further labeling and connections to contexts and so on. This cycling occurs as non-linear patterns of knowledge construction and meaning-making. Student to student discourse frequently follows such cyclical processes. In argumentative discourse, students react to other students' claims, which are countered by the original proponents of a claim. As such arguments continue, the complexity of meanings and understandings increase (Bloom, in press). Bateson (1975, personal communication) referred to such processes as "multiple perspectives and loop processes." Such processes result in increasingly complex patterns of connections.

However, schooling rarely encourages processes that lead to the development of complex patterns of connections. Instead, teachers tend to follow narrow and linear approaches to instruction. When children deviate from the planned agenda, they are generally ignored or reprimanded. When connections are made to other conceptual areas, they tend to receive

superficial treatment. As mentioned in the beginning of this paper, the typical approaches of schooling result in fragmented knowledge with little or no relevance or meaning to the students.

A Patterns That Connect Approach to Curriculum and Instruction

Traditionally, K-12 curricula are designed so that each discipline proceeds along separate and divergent paths (see figure 2). The learning that results from such an approach is marked by fragmented and minimally connected understandings both within and across disciplines. In some elementary schools, teachers pursue an integrated approach, where they attempt to provide connections across the disciplines. However, such approaches tend to be controlled by the teacher and to make superficial connections between the disciplines (see figure 2). Although some progress is made in helping students to construct more meaningful understandings and connections across the curriculum, the resulting learning is still highly fragmented and weakly connected.

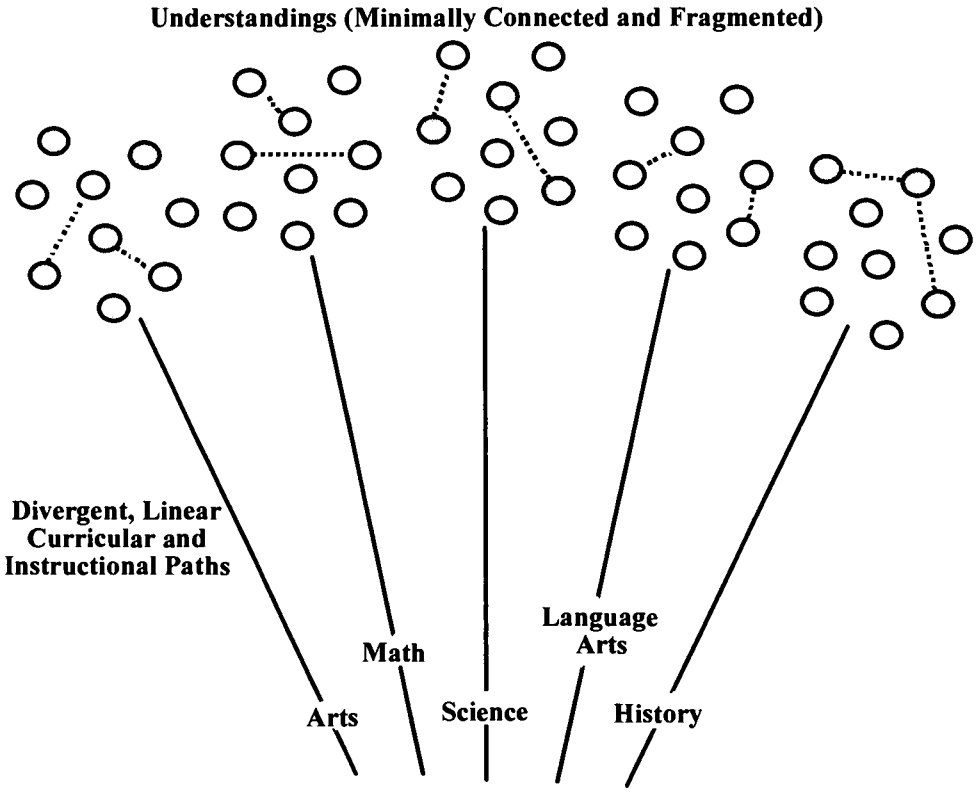

Figure 2. A representation of a traditional approach to curriculum and instruction.

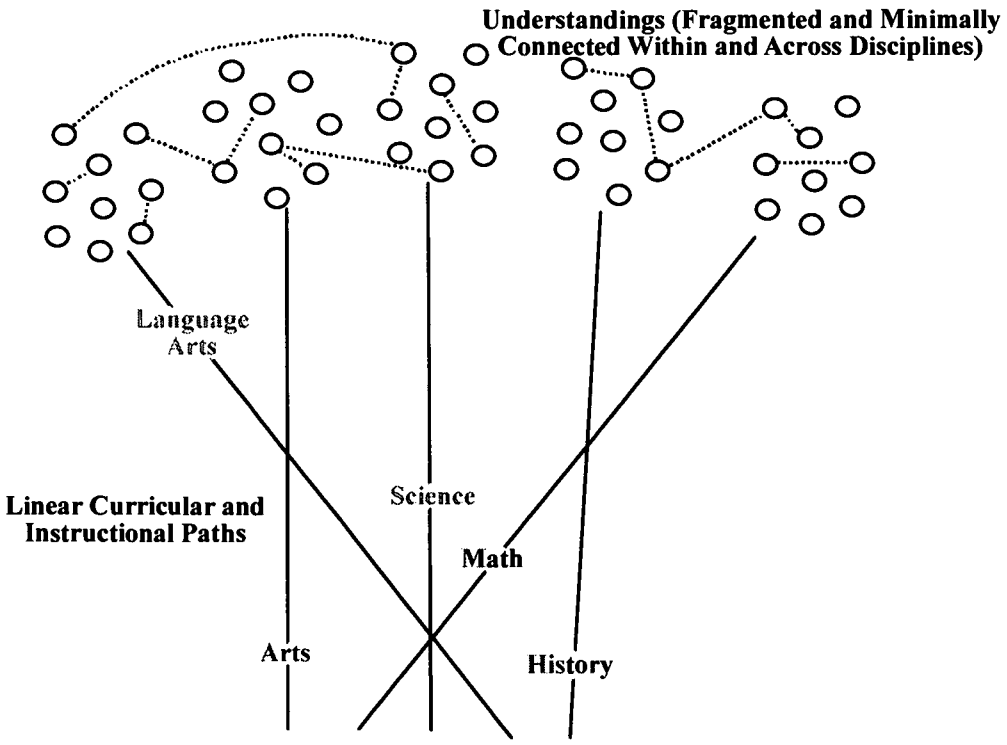

Figure 3. A representation of a typical integrated curriculum.

In contrast, Mary Catherine Bateson (1994) suggests that learning occurs when various experiences and ideas interconnect as they spiral together over time. Such an approach can be established by providing students with opportunities to engage in learning experiences and lines of inquiry arising from common over-arching topics or questions. However, these experiences need to have a common grounding in critical reflection, where students can ponder and discuss their insights and understandings (see figure 4). Such an approach provides for the development of "patterns that connect", which result in understandings connected within and across disciplines. In this approach, teachers cannot necessarily predict the outcomes of instruction in terms of what is typically referred to as specific "learning outcomes." On the other hand, learning goals which describe general characteristics of student learning can be described. Such general characteristics can include (a) complex and richly interconnected conceptual understandings; (b) meaningful understandings embedded in one or more contexts; and (c) descriptions that discriminate between contextually appropriate knowledge claims and understandings.

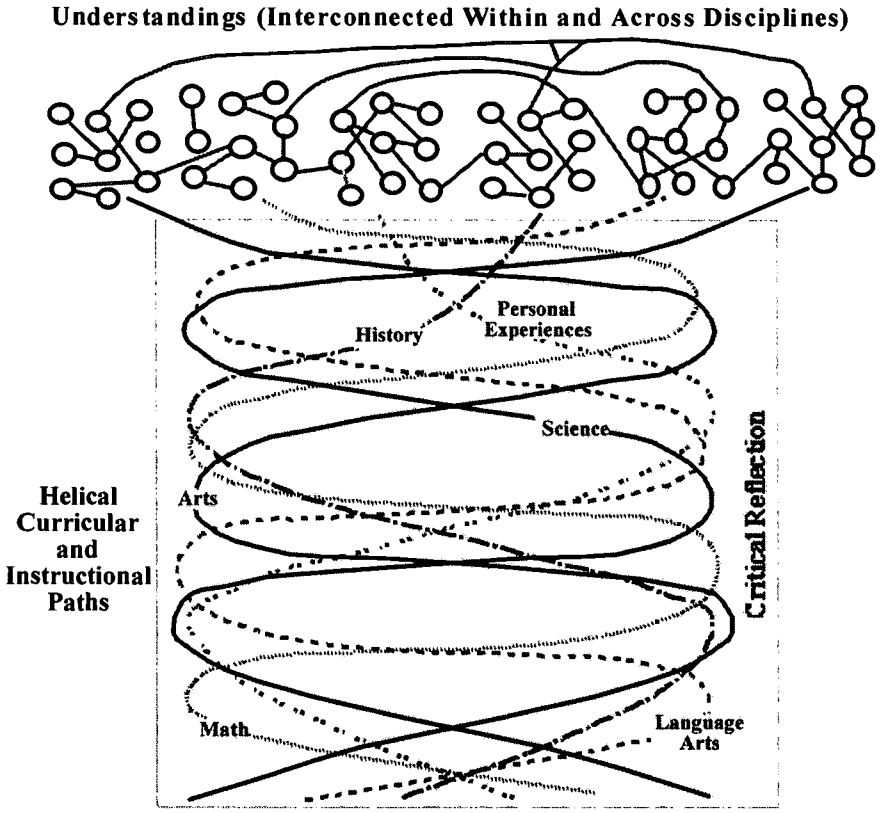

Figure 4. A representation of a curricular approach based on the notion of "patterns that connect."

In teacher education programs, the same sort of curricular patterns occur as represented in figures 2 and 3. Such approaches provide little opportunity to create connections between programmatic experiences in courses that explore children's learning, in various subject matter teaching methods courses (especially for elementary majors), in teaching practica, and so forth. These kinds of programmatic experiences tend to result in fragmented knowledge lacking in meaning and relevance. However, structuring teacher education programs on a "patterns that connect" approach can result in much more meaningful, relevant, and complex understandings of teaching and learning. Figure 5 provides a representation of such an approach to elementary science teacher education. In this case, students would engage in a science content course presented through an inquiry approach. This course would explore a conceptual area that integrates all the sciences. The same conceptual area would serve as the major theme in other courses, such as those that emphasize (a) science teaching methods; (b) ways of representing understandings (e.g., written and spoken language, mathematics, visual arts, dramatic arts, etc.); (c) reflection on experiences working with children; and (d) children's learning, thinking, and discourse.

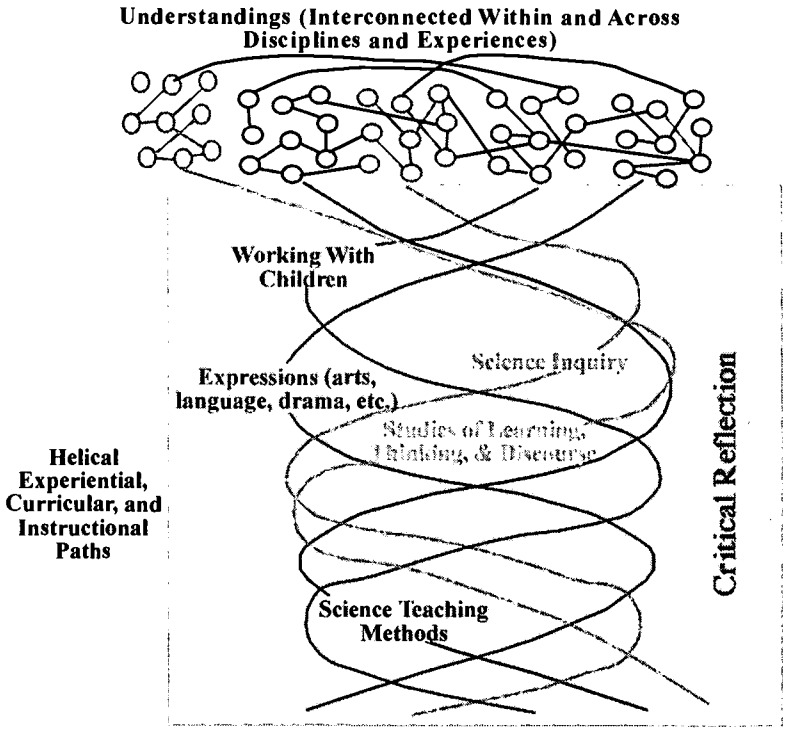

Figure 5. A representation of a "patterns that connect" approach to elementary science teacher education.

Such patterns that connect approaches to curricular design provide students with opportunities to see and develop connections between various learning experiences. In some cases, what develops are emergent patterns that affect their actions, whether in their inquiry within and between subject matter disciplines, in the teaching of children, or in their working with others (e.g., fellow students in group work). In other cases, descriptive patterns that connect result from their inquiry within conceptual areas.

Taking a "patterns that connect" approach to instruction requires students to be inquisitive and to see the relevance in exploring the complexity of relations. Such student characteristics are not generally encouraged in schools where (a) teachers act as knowledge authorities, (b) the curriculum is narrowly focused and follows a linear progression, and (c) students are expected to recall specific information for tests. For a "patterns that connect" approach to work, the

classroom needs to be viewed as community of learners and inquirers. Drawing on the Lave and Wenger's (1991) notion of situated learning, students need to formulate identities of independent learners and move toward full participation in communities of learners and inquirers. Developing such communities in the classroom requires that teachers act as models, coaches, and facilitators (Gallas, 1995). By taking on such roles, teachers can help move students from the periphery as they enter the classroom in the fall to full participation (Lave & Wenger, 1991).

In order to deal with the fragmentation of knowledge, approaching learning and teaching as a way of revealing and constructing "patterns that connect" may provide a way of developing a coherence and cohesiveness that has been missing in our society. Focusing on "patterns that connect" can lead to greater understandings of the complexities of the world, while serving as a fundamental organizing principle. As such, "patterns that connect" can allow children to develop skills in dealing effectively with complexity and diversity and to develop broader and more relevant conceptual understandings. As suggested by Lave and Wenger (1991) and Mary Catherine Bateson (1994), the development of such skills and complex understandings are essential in helping children move towards full participation in learning communities and beyond.

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[i] By "or even contained in", I am referring to Gregory Bateson's (1979, 1991) notion that knowledge is contained within any particular cybernetic system.

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