The Application of Chaos, Complexity, and Emergent (Meta)Patterns to Research in Teacher Education

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"But he never told us what we were supposed to do!"
"The best course I've ever had!"
"A complete waste of time and money!"
"Awesome course and professor!"

These quotes came from student course evaluations and other comments heard by graduate research assistants during and after an undergraduate elementary science teaching methods course. How do we make sense of such extreme comments? What are the assumptions and expectations about learning and teaching that underlie such comments? What classroom dynamics contribute to such reactions and valuations (and evaluations)?

The challenges presented by classroom research in teacher education (or, for that matter, throughout the K-doctoral spectrum of education) are defined by the complexity of such dynamic systems. These dynamic systems are comprised of highly diverse participants in a complex web of learning. The participants (students and instructor) vary widely in background, experience, knowledge, personalities, goals, expectations, etc. At the same time, the context of learning is comprised of formal knowledge interwoven across numerous fields (e.g., diverse aspects of cognitive psychology, developmental psychology, sociology, pedagogy, science or whatever subject matter provides the focus, and how to think critically and reflectively) and informal knowledge that is characteristic of participation in a community of teachers (e.g., the meanings associated with the formal knowledge in the context of actual participation and practice, the discourse of teachers, and the activities of participation). In addition, such learning can involve the development of intangible attributes, such as, integrity, passion, curiosity, caring, responsibility, initiative, humor, intentionality, creativity, and identity as a professional community participant. Although research into teacher education and other aspects of education has led to insightful understandings of teaching and learning, we still face many challenges in understanding such complex dynamics and contexts in teacher education.

The questions below refer to the some of the major areas of concern that can be addressed by research that draws on the theoretical frameworks of chaos and complexity (Capra, 1996; Gleick, 1987, Prigogine & Stengers, 1984; Volk, 1998; Waldrop, 1992), as well as the related framework of metapatterns (Bateson, 1979; Volk, 1995).

1. What underlying assumptions and presuppositions affect the thinking and actions of students, teachers, and teacher educators? What situations have led to their development? How do they affect the dynamics and contexts of teacher education?
2. As students enter the community of educators, what factors (both positive and negative) affect their induction into and participation in the professional community?
3. What social and political factors affect the belief structures, practice, and thinking of pre-service and in-service teachers?
4. What personal, social, physical, and pedagogical factors in universities and classrooms affect the dynamics and contexts of teacher education?
5. How can teacher educators design and implement contexts of and instruction in teacher education that positively affect the development of teachers?
6. How can we design and implement instructional contexts that result in more complex learning among children and pre- and in-service teachers?

This paper examines approaches to research that can lead to understandings of the complex dynamics as referred to by the previous questions. These approaches are based on key concepts from chaos and complexity theories and a metapatterns framework, which was initially

developed by Gregory Bateson (1979) and elaborated upon by Mary Catherine Bateson (1994) and Tyler Volk (1995).

Chaos and complexity theories provide a perspective on social dynamics based upon the connections between pattern, process, and structure in dynamic, complex, and self-generating and self-maintaining systems. Patterns of organization refer to those patterns that contribute to the autopoietic nature of complex system, which tend to involve circular patterns of organization, such as cybernetic feedback loops. Processes of production continually generate structures that manifest as patterns of organization. These processes are the "fuel" that energize the autopoietic patterns of organization, which in social systems generally involve passion and other social and psychological factors (e.g., anger, frustration, and other emotions). The structures of complex systems include dissipative structures (i.e., those involved autopoiesis), attractors, and bifurcation points, all of which contribute to complex system dynamics (Capra, 1996; Gleick, 1987, Prigogine & Stengers, 1984; Waldrop, 1992).

Although chaos and complexity theories, which originated in the biological and physical sciences, have been providing exciting new ways for understanding social systems, the depth and extent of the tools provided by such theoretical frameworks are in some ways limited when applied to the social sciences. Part of this problem involves the transfer of a mathematically-based system as originally applied in the physical and biological sciences to the social sciences, where the mathematics are not necessarily applicable or helpful (Volk, July, 2002, personal communication). Although mathematical modeling has moved beyond the standard experimental research that utilizes the *mean* as a basis for description (which fails to describe complexity), the descriptive (i.e., analogical and metaphorical) nature of these theories is quite powerful in developing understandings of social systems. However, in the transference from the natural sciences to the social sciences, these theories lose some of their descriptive power. For example, the terms autopoiesis and attractor are key concepts in understanding complex, self-sustaining systems. Any such system contains one or more attractors that help to initiate the system and to provide for continued maintenance and organization of the system. However, what patterns comprise the attractors in social and psychological systems? What patterns develop from the patterns in the attractors that lead to self-maintenance and self-regulation? How can we describe the specific patterns of relationships, the organizing patterns, the contextual patterns in which such social and psychological systems take place, and the complex patterns inherent in the variation of human beings as they manifest in social contexts?

Such questions point to the limitations of chaos and complexity theories, in terms of the lack of adequate terminology to describe social systems. However, the use of metapatterns (Bateson, G., 1979; Bateson, M. C., 1994; and Volk, 1995), which describe the embedded and emergent patterns of chaotic and complex systems, offers powerful tools for extending our understandings of social and psychological systems. Specifically, metapatterns are "organizing patterns that possess general (universal) functional properties in evolving systems, including natural (biological and physical), technological, social, and cognitive systems" (Volk, July, 2002, personal communication). The core meaning or meanings associated with each metapattern are common across occurrences in all disciplines or facets of experience. Because of their appearance across disciplines and across all facets of human experience (from everyday events to cultural beliefs), they also act as powerful analogical and metaphoric tools that extend the development of complex understandings. These tools allow for the identification of more specific patterns inherent in social and psychological contexts and dynamics, as well as for the

description of the interactions among a variety of different patterns. Table 1 provides a brief overview of metapatterns identified by several researchers.

Table 1. (Meta)patterns by Volk, G. Bateson, M. C. Bateson, Alexander, Stevens, and Kappraff.

Spheres [1]	Unity [3] Bubbles [4]
Tubes [1]	Networks, Lattices [5] Conduits, Relations [3]
Sheets [1]	Films [4]
Borders and Pores [1]	Boundaries [2] Containers, Containment [3] Partitions [4]
Layers [1] Hierarchies [1.] Holons [1] Holarchies [1.] Clonons [1]	Levels of Scale [2] Parts and Wholes [3] Packing [4 5] Proportions, Tilings [5]
Centers [1 2]	Prototypes, Purpose, Causation [3]
Binaries plus [1]	Contrast [2] Duality, Reflections [5] Relationships [3] Complementary, Symmetrical, Reciprocal Relationships [6]
Arrows [1]	Stages, Sequence, Orientation[3] Stress, Growth, Meanders[4]
Breaks, Transformation, Change [1]	Branching, Explosion, Cracking[4] Translations [5] Transformation [3]
Time and Calendars [1 3]	
Cycles [1]	Alternating Repetition[2] Vortex, Spiral, Turbulence[4] Helices[7] Rotations[5]
Clusters, Clustering	
Gradients [2]	
Void [2]	
Positive Space [2]	
Good Shape [2]	
Local Symmetries [2 5]	
Deep Interlock, Ambiguity [2]	
Simplicity [2]	
Truncation [5]	
Solidity [5] Substance [3]	
Similarity [5]	
Golden Mean [5]	
Maps [3 5]	
Rigidity [5]	
Space Filling [5]	
Emergence	Creation (Birth) [3]

[1] Volk (1995) [2] Alexander (2000) [3] Lakoff & Johnson (1980) [4] Stevens (1974) [5] Kappraff (1991) [6] G. Bateson (1979) [7] M. C. Bateson (1994)

Drawing on the framework of metapatterns as descriptors of chaotic and complex systems, this paper will utilize data from a number of studies to develop a scheme for research, analysis, and design in teacher education. The research studies used in this paper include those involved in examining pre-service and in-service teacher education (Bloom, 2004, 2000, 2001a, 2001b, 2001c, 2002), as well as theoretical papers and papers that have been directed at the overall use of metapatterns in design of communities, curriculum development, and educational research (Bloom, 2003, 2004).

Metapatterns Overview and As Descriptors of Complex Systems

This section provides an overview of metapatterns and how they can be used as more detailed descriptors of dynamic social and psychological systems. Each metapattern will be described in a general sense, then discussed in terms of its applicability to research in teacher education. It is important to keep in mind that, although each metapattern is discussed separately, their manifestations in real world settings are rarely separate. The general tendency is that they manifest in complex "knots" of interrelatedness. This interrelatedness will become more apparent in the next section of this paper. In addition, metapatterns can be used as descriptors and as pointers to the type of data to collect and to how to organize data analysis and interpretation. (The photos with each subheading show examples of metapatterns. They are not discussed, but can be pondered by readers as to how they depict each metapattern or multiple metapatterns.)

Spheres

Background

Spheres and the tendency towards puerility are common forms in the sciences, as well as in other disciplines. As physical forms they maximize strength and durability, have a reduced surface area to volume ratio, and minimize environmental contact. In more general terms, the fundamental meanings underlying this form involve equanimity, omni-directionality, simplification, and containment. Spheres and sphericity can be actual physical forms as well as invisible and metaphoric senses of form. In contending with the sense of sphericity, the forms can range from near perfect spheres to partial spheres to squared-off and box-like forms. When nested together, spheres can form holarchic layers.

Examples

In science: cells, many fruits (e.g., apples, spheres, cherries, tomatoes), planets, stars, eyes, droplets, heart, skulls, eggs & spores, bubbles, biosphere, ecosystem, inflated puffer, jellyfish, sea urchin, etc.
In architecture and design: domes, geodesic domes and spheres, atria, light bulbs and fixtures, etc.
In art: halos in Renaissance paintings, spherical forms in paintings and sculpture, etc.
In social sciences: spheres as communities, spheres as context, spheres as schemata (as in schema theory), etc.
In other senses: sphere of influence, sphere of friends, sphere of consciousness, sphere as neighborhood, etc.

In teaching and teacher education research, spheres as "containment" can be used to describe individual, social, physical, and political contexts. Such contexts may includes cliques, social contexts both in and outside of the classroom, the physical and social contexts of classrooms, the physical and social contexts of schools and universities, and the social and political contexts of the institution of schooling, in general. They also can be used to describe professional communities and the contexts of knowledge, meaning, identity, practice, and other factors affecting teaching and learning. From this perspective, spheres also can imply "equanimity and balance." As such, spheres can be used to demarcate and describe a particular autopoietic system. What is the extent of the particular context or system? What are the characteristic sub-contexts or what other contexts overlap with the particular system?

As "strength" and "durability," spheres are useful in describing not only contexts, but also key ideas, frameworks, beliefs, and other orientations that influence the actions of individuals and groups. In this way, *spheres* act as *centers* or attractors that affect the durability, organization, and continued maintenance of particular patterns of thought and action. *Spheres* also can describe the "minimization of contact" by insulating what is contained from outside influence, which in essence acts as a *border* or barrier. What provides the durability of the particular context?

Tubes

Background

As physical forms, tubes seem to have three fundamental aspects, which, in some cases, appear as one aspect and, in other cases, are combined in one form. One aspect involves the notion of strength and support along a linear dimension. The second aspect is that of bidirectional or unidirectional transport of energy, materials, or information. The third aspect involves the ability to penetrate, extend, or grow along a linear dimension. In biological forms, they increase the surface area to volume ratio, compared to spheres. In a more general sense, tubes involve the concepts of linear strength, linearity, extension or bridging, transfer or flow of information, and connection or relationship.

Examples

In science: nerve cells and fibers, blood vessels, appendage and some other bones, phloem--xylem, stems--branches, hair, cilia, flagella, digestive tract, streams and rivers, lava tubes, pine needles, eels, snakes, worms, spider webs (tubes making sheet), bodies of airplanes, rockets, etc.
In architecture and design: hallways, internal support structures, elevator shafts and stairwells, highways, trails, tunnels, bridges, electrical wires, pipes, networking cables, utility poles, suspension bridge (traffic flow, support structures, support cables), etc.
In art: shape, brushes, pottery forms, sculpting forms, etc.
In social sciences: relationships between people, connecting lines in concept maps, patterns of interaction, lines of communication, patterns of movement, support mechanisms, etc.
In other senses: tobacco pipes, cigars, syringes and needles, etc.

Probably the most useful aspect of the notion of "tubes" in describing social and psychological systems involves the notion of relationship. *Tubes* are the connections between people in conversation, where discourse follows a back-and-forth exchange of ideas. The relationships within a classroom or community can be represented by a web of *tubes*. In a cognitive psychological sense, relationships within and between (*spheres* of) ideas are often represented by *tubes*. The common use of *tubes* in cognitive psychology research and pedagogy involves the use of concept maps and semantic webbing. The lines drawn represent tubular relations between ideas.

In other senses, *tubes* can be used to describe traffic patterns in the physical context of classrooms and schools. From such a perspective, mapping flow within the physical setting can provide information on how movement is facilitated, inhibited, controlled, and so forth. Such information can contribute to an understanding of how the physical context affects the psychological, social, and learning contexts. How does the flow affect participation in a learning community? How does the flow affect student communication and interaction? What messages about fundamental assumptions of schooling, power, identity, etc. are communicated by the physical patterns of movement within a classroom or school?

Sheets

Background

As physical forms, sheets maximize transfer across surface areas, maximize surface area to volume ratio, and extend or grow two-dimensionally. In general terms, sheets represent capture, contact, and movement across a plane. In addition, when put together, they can form layers and can act as borders. Spheres and tubes can be made of sheets.

Examples

In science: leaves, surface tension, membranes, individual layers of the Earth and atmosphere, fins, airplane wings, skates and rays, films, snow coverage, etc.
In architecture and design: walls, open areas as in large convention centers, fans and windmills, sails, turbines, etc.
In art: canvas, shapes, etc.
In social sciences: movement within a space, separation, etc.
In other senses: clothing, rain coming down in sheets, bed coverings, parking lots, etc.

Where *tubes* can describe flow in two directions, *sheets* can point to physical settings where flow can move in multiple directions. Sheets also can be used to describe the layout of specific physical settings, such as a classroom. How does the layout of a particular physical setting contribute to the function (or dysfunction) of a dynamic system? In other senses, *sheets* can be used to describe *borders* or barriers, such as physical, psychological, social, cultural, or political barriers or obstacles. As a barrier, what does a particular sheet contain that contributes to its function as a barrier or obstacle? A *sheet* also can represent one *layer* in a *hierarchy* or *holarchy*. As a *layer*, the description of the components, activities, and other factors can be compared to a

sheet in another layer. To what degree is movement or transfer (of people, information, etc.) regulated across sheets?

Layers

Background

Layers point to increasing complexity as sheets, spheres, tubes, and other fundamental patterns combine in linear or nested layers. The process of layering is a building up of order, structure, and stabilization.

Layers in social systems create order and stability. However, in social systems, do all *layers* create self-sustaining stability? Can certain types of layering lead to a collapse of the system? What assumptions underlie different types of layered systems? What relationships arise from different types of layering systems? In addition to social systems, layers can be used to describe layers of knowledge, meaning, values, emotions, types of activity, types of thinking, resistance, openness, and so forth. So, we ultimately can have systems of layered knowledge and meaning residing within and affecting a layered social system. How does one system of layers affect systems of layers within it? How does one system of layers affect the system of layers within which it resides?

The following four subsections (hierarchies, holarchies, clonons, and holons) are specific types of layering systems.

Hierachies

Background

Hierarchies tend to be depicted as pyramidal arrangements of sheets. Hierarchies are identified as the relationships between layers become evident. In most cases, hierarchies are exemplified by power or control moving downward. In other cases, the top layers may indicate greater importance or significance. Information, materials, or energy move upward. They tend to create stratified stability. However, this stability may depend upon the types of binary relationships and other patterns that are created within the overall structure.

Examples

In science: trophic layers, phylogenetic trees, animal societies (bees, ants, chimpanzees, wolves), etc.
In architecture and design: pyramids, building design and layout, etc.
In art: as form, etc.
In social sciences: governmental and organizational structures; classrooms, schools, and schooling; some learning theories; etc.
In other senses: information trees, branching decision trees, etc.

Hierarchies are useful in defining the types of layering within a classroom, school, and the larger contexts within which schooling occurs. In order to "see" a hierarchy, the relationships between layers need to be described and defined. Is "power" centralized? Who has the power and control and how do these manifest in terms of the relationships between layers? In what ways do these relationships stabilize or destabilize the system? What assumptions underlie the hierarchical system? Who benefits and how do they benefit? What are the ultimate goals of creating and maintaining a hierarchy? What patterns of thinking, action, reaction, valuation, emotions, and personal relationships "spin off" from the hierarchical system?

Holarchies

Background

A holarchy is a nested system of layers in which the units (wholes) within one layer are parts for the wholes in the next larger, encompassing layer. Holarchic layers can be used to describe certain types of social, political, and institutional organizations, as well as structures in science and other disciplines. In holarchies the wholes at each level have particular kinds of relationships with the other wholes on that same level, and these relationships change as we move up the nested layers from physics to organisms to social systems. The relationships between layers in holarchies tend to be ambiguous and more difficult to describe.

Examples

In science: rose flowers, the Earth and atmosphere, atoms, bodies of organisms, holarchic layers of complexity in organisms (from DNA/RNA components to the whole), solar system, galaxies, etc.
In architecture and design: some building and community designs, etc.
In art: forms as depicted, etc.
In social sciences: communities (as described by Jean Lave and Etienne Wenger), many tribal societies, democracy in its purest form, etc.
In other senses: mandalas, apprenticeships, etc.

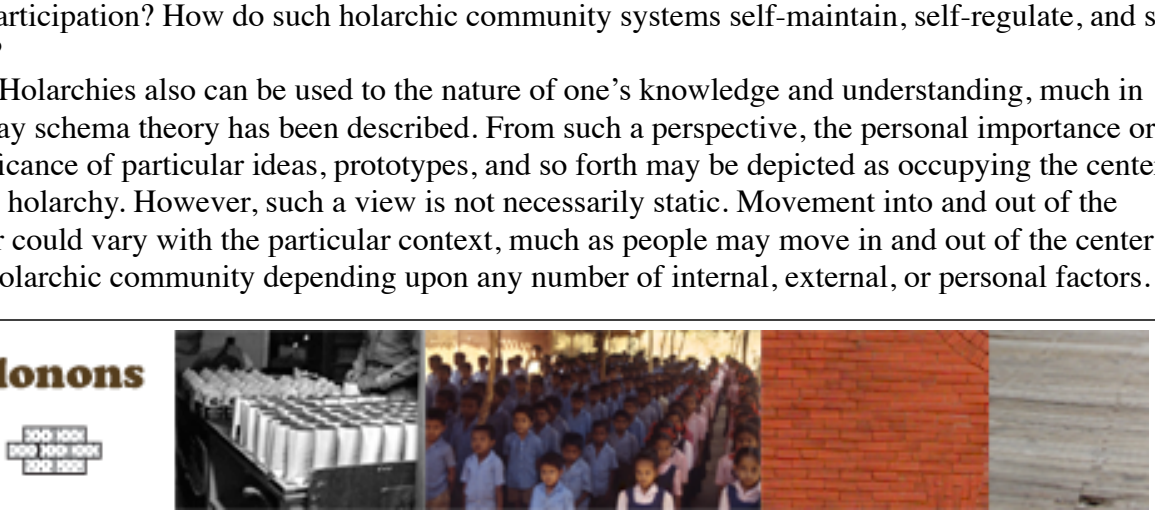
Holarchies can be easy to find, but the relationships between layers are often difficult to determine. Where power and control move downward through the layers of a hierarchy, power and control in holarchies can be distributed or shared between layers. How is a holarchic classroom different from a hierarchic classroom? Who has power and control? What kinds of relationships develop within a holarchy? What is the nature of these relationships and how do they differ from those in a hierarchy? How does a holarchy stabilize or destabilize the system? What are the underlying assumptions of social holarchies? Who benefits and how do they benefit? What are the ultimate goals of creating and maintaining a holarchy? What patterns of thinking, action, reaction, valuation, emotions, and personal relationships "spin off" from the holarchic system?

Holarchies can used to describe and analyze the nature of communities, such as professional, classroom, learning, inquiry, and school communities that attempt to function as apprenticeship communities (Lave & Wenger, 1991; Wenger, 1998). The nature of such

communities is one of inducting participants and facilitating their movement towards full participation in the community. So, what factors contribute to participation in such holarchic communities? How do participants' actions, talk, identity, knowledge, meaning, and senses of what the community is change over time? What obstacles occur that hinder movement toward full participation? How do such holarchic community systems self-maintain, self-regulate, and so forth?

Holarchies also can be used to the nature of one's knowledge and understanding, much in the way schema theory has been described. From such a perspective, the personal importance or significance of particular ideas, prototypes, and so forth may be depicted as occupying the center of the holarchy. However, such a view is not necessarily static. Movement into and out of the center could vary with the particular context, much as people may move in and out of the center of a holarchic community depending upon any number of internal, external, or personal factors.

Clonons



Background

The notion of clonons falls within the scope of holarchies, in that specific objects or ideas are repeated to create layers of embeddedness. As with the process of cloning, a specific object can be replicated. Clonons can build wholes and each whole can be a clonon of larger set.

Examples

In science: identical cells in different layers of tissue, protons, neutrons, electrons, worker ants, each fish in a school, identical atoms in a molecule (e.g., two clonons of hydrogen joining a holon of oxygen to form a holon of a water molecule, which in turn become a clonon of water molecules in a cup of water), etc.
In architecture and design: bricks in a wall, tiles on a floor or ceiling, each light fixture in ceiling, each office or room on a floor, each floor in a building, windows in skyscraper, each house in a subdivision, etc.
In art: each brush stroke in a painting, each decorative design unit in a pottery bowl, each point in a pointillism painting, etc.
In social sciences: each individual in a community or society, each client in a business, each factory worker at a specific point in an assembly line, etc.
In other senses: each tomato on a tomato plant, each tomato plant in a tomato garden,

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The notion of clonons (and holons) describes a sense of layering that does not appear as sheets or embedded spheres or tubes. Rather, clonons depict layers as component parts. In classrooms and other social settings, clonons can be individuals making up the group or class. Although each individual is a holon (comprised of smaller clonons and holons), the set of individual holons can be considered a set of clonons making up the whole. In terms of cognitive psychology, clonons can be individual ideas (building blocks) that comprise a whole concept. In what ways are individuals "identical" building blocks of the whole? In other words, what characteristics of each individual provide for the pattern of the whole? Such questions can be

useful in defining functions, actions, and characteristics of the component parts as layers within a particular system. They also can be helpful in identifying underlying assumptions about the way in which students are viewed and treated within the context of the classroom or school. Are students just another "brick in the wall," as suggested by Pink Floyd? Are students treated like identical component parts? Previous (and current?) views of teaching and learning assumed all students entered as blank slates and were supposed to "learn" the exact same content.

Holons

Background

Holon, as mentioned previously, refers to a whole, which is often comprised of clonon parts or sets of clonon parts. Holons themselves can become clonons of even greater wholes. The idea of holons (in contrast to indistinguishable clonons) is that holons are functionally and structurally distinct parts on the level of a holarchy. Holons are like organs, on different scales of wholes. Thus the body's holons are heart, lungs, brain, and so forth, which themselves are composed of many clonons, the relatively indistinguishable heart cells, liver cells, and so forth.

Examples

In science: a planet, a solar system (made of holons-planets that become clonons of the solar system), an atom is a holon of three fundamental types of clonon particles, atoms become clonons of larger holon molecules, etc.
In architecture and design: buildings, a community, etc.
In art: subjects, figures formed from points or strokes, a sculpture, etc.
In social sciences: a concept, a community or society, an action holon of component clonon actions, a family, a class of students, etc.
In other senses: a wall or fence, an archway made of stone clonons, a gang or clique, etc.

Where clonons describe a sense of "identical" component parts, holons are distinct parts or wholes, which can make up a greater whole. In classrooms, students are viewed as distinctive individuals with their own unique knowledge, personalities, approaches to thinking, and so forth. As opposed to clonons, which are building blocks of a whole, holons have unique functions within the greater whole. How does "James" contribute to the function of the classroom community? This question values the unique qualities that one member of the community offers to the function of the whole system. What assumptions about teaching and learning are exposed by the notion of holons vs. clonons?

Borders and Pores

Background

Borders involve the concepts of protection, separation of inside from outside, containment, and barrier or obstacle. With pores, borders regulate the flow and exchange of materials, energy, or information. Small pores heighten regulation and reduce flow, while larger pores decrease regulation and increase flow. Borders can be visible entities, fuzzy, or invisible. Physical borders tend to be built of sheets of repeating parts (clonons).

Examples

In science: cell membranes and osmosis, skin and pores, eyes, ears, nose, mouth, stomata, the Earth's crust and volcanoes, clouds with fuzzy borders, atmosphere, ecotones, edge of a pond, etc.
In architecture and design: walls with doors and windows, roof and skylight, etc.
In art: depicted forms, frame with canvas as opening pore to another world, pottery bowl or vase with circular pore, etc.
In social sciences: personal space, psychological and social obstacles, problem as border with paths to solutions as pores, physical space divisions and openings, social barriers, borders between social strata, racism and other biases as barriers, propaganda as a barrier to truth, borders between countries with border crossings and immigration pores, etc.
In other senses: borders and openings in feng shui, borders between properties, airline security, etc.

Borders can be both visible and invisible. In physical settings, the teacher's desk, a podium, or other object that separates the teacher from the students are not only physical barriers, but also psychological barriers. A difficult concept can be an obstacle to further learning. A school district policy to utilize a specific curriculum can be a border to a teacher's desire to teach in a more active and relevant way. A teacher may design a classroom with an area that allows children to sit or lie down on a carpeted area partially surrounded by shelves or curtains. In such an area, the border offers a different kind of private, secluded space. Students may decide that certain kinds of actions are not appropriate for the class. In this case, the self-generated rule is a border that affects the dynamics of the classroom. Certain assignments and classroom activities can have embedded challenges involve emotional obstacles (i.e., built-in potential frustrations and other emotional issues), physical challenges (i.e., embedded problems that require some kind of physical manipulation that may be difficult), and cognitive challenges (i.e., problems whose solutions are not readily apparent). In general, borders can have effects on any particular system's dynamics. They may foster or hinder certain kinds of patterns. They may set up unintended patterns that lead to a system's breakdown or that lead to the emergence of a new system. What borders are evident in a particular classroom setting? Are they intentional or unintentional? How do they affect the system's function? What patterns emerge from the presence of such borders?

Pores in borders serve to regulate flow of information, materials, and people. An instructor's demeanor, personality, and socio-culture norms (as with all people) set up borders. Edward Hall (1966) described such borders as intimate, personal, social, and public spaces. But

each space or border has invisible pores. As my son, when he was 11 years old, suggested, "the more you get to know somebody, the smaller the space gets [referring to the spherical intimate space]." You allow certain people and not others into various spaces. In problem-solving, the more difficult the problem, the smaller the pore. Certain actions by a teacher, such as controlling the flow of discourse, can create borders with small pores that do not allow for the free flow of ideas or for the emergence of creative ideas and solutions. To what degree does a particular border regulate the flow of students, ideas, or creativity? Does a particular policy or rule create a small, highly regulated "pore" or does it maximize the flow of ideas? How do specific actions regulate student autonomy, student choice, etc? To what degree do a teacher's actions set up borders that minimize or maximize (i.e., establish pores) student learning? How do borders and pores affect a particular system's (e.g., classroom community) functioning, self-regulation, and continuity?

Centers

Background

Centers act to stabilize the whole, provide resistance to change, and provide for organization of the whole. They can act as attractors for autopoietic (self-generating, self-sustaining) systems. In a more general sense, they can imply importance or significance and a sense of centricity. As such, centers can radiate relations to other centers, information, and so forth.

Examples

In science: nucleus, strange attractor, queen ant or bee, fulcrum, dominant male in primate societies, center of gravity, heart within circulatory system, brain within nervous system, etc.
In architecture and design: main office, central meeting places, central structural supports (such as elevator shafts in skyscrapers), etc.
In art: the central figure or object as subject; the organizing principle or emotional focus of a piece of art, etc.
In social sciences: president, governor, major, dictator, leader, teacher, principal, central physical site of specific types of activity, heart as center of individual in many indigenous cultures, organizing principles of societies and other groups, brain as center of individual in most technologically developed cultures, focus of life or activity (e.g., individuals may consider self, family, work, sport, hobby, or spiritual efforts as center), ego or self centric, anthropocentrism, conceptual prototype, conceptual defining characteristics, etc.
In other senses: altar in a church, shrine in a temple, a deity or deities, sacred sites (Mecca, Bodhgaya, Jerusalem), shopping center, etc.

As suggested in the discussion of borders, a particular action or instructional design attribute can produce intentional or unintentional patterns. In some cases, a particular problem can set up a problem that acts as a center or attractor. From such a center, student activity can emerge that begins to "spin-off" in new directions. Such a center involves a combination of a challenge (i.e., probably a binary-based border) and some sort of emotional "energy" in the form

of intrigue, curiosity, or conflict (such as conflicting student claims). In establishing classroom communities, one or more centers need to be established that allow a sense of ownership to emerge and set up additional patterns of behavior and thought that help to maintain the community. Centers can be goals toward which students *want to* work. In the negative sense, centers can be established unintentionally or intentionally that set up destructive patterns. What centers are evident in a particular setting and what patterns do they maintain? Do certain assumptions about teaching and learning establish particular centers in a classroom? How can curriculum and instruction be designed around specific centers in order to establish certain kinds of activity? What is the nature and composition of any given center? Is such a center comprised of one or more other patterns, such as a border, a layered situation, a binary, or a break?

Binaries... plus

Background

Binaries are the simplest form of complex relations. More complex relations involve increasing numbers of components (e.g., trinaries, quaternaries, and so forth). Such binary relations are the most economical (in a variety of senses) way to generate complex wholes with significant new properties. Binaries involve senses of separation and/or unity, duality, and tension. They also provide for a synergy between parts and wholes.

Examples

In science: bilateral symmetry (including two eyes, nostrils, ears, appendages, etc.); positive and negative particles, ions, electrodes, etc.; male and female; opposing forces; diurnal and nocturnal; dorsal and ventral; space and time; acid and base; DNA with component pairs and paired helices; inhale and exhale; respiration and photosynthesis; mass and volume; high pressure & low pressure; perception as the recognition of difference; form and function; acceleration and deceleration; etc.
In architecture and design: inside and outside and the associated dynamics between them in buildings; entrance and exit; up and down passages;
In art: light and dark; monotone and multicolored; tensions between parts; attraction and repulsion (emotionally); etc.
In social sciences: report talk and rapport talk; leader and follower; positive and negative attitudes; consumer & producer; passive & aggressive; trust and distrust; unity and disunity or separation; etc.
In other senses: distal and proximal; all or nothing; night and day; open and closed; on and off; asleep and awake; old and young; love and hate; etc.

In the relationships between people, the notion of binaries can lead to unification or separation. The following table delineates three fundamental types of relationships and their ultimate result in terms of relationship continuity. In general, various types of relationships either tend toward unification or tend toward separation and breakdown. In other words, the function or nature of binary-based relationships will affect the continuity of the relationship. On the other hand, it seems that many *centers* or the initiating factors of arguments or extended discourse are

based on divergent binaries. Divergent binaries also the continuity and cohesiveness of novels and movies. Curiosity and the drive to continue on a line of inquiry are often based on conflicting binaries. However, in terms of personal relationships convergent binaries appear to maintain the relationships.

Table 3. Types of binary relationships.

Gregory Bateson:	Complementary	Symmetrical	Reciprocal
Metapattern specific:	Disparate Binary	Competitive Binary Commiserate Binary	Collaborative Binary
Metapattern general:	Divergent Binary Separating Binary	Divergent Binary Separating Binary	Convergent Binary Unifying Binary
Other Descriptors:	Dominant-Submissive Controlling-Subservient Directive-Passive	Dominant-Dominant Submissive-Submissive Vying for control Oppositional	Cooperative Mutuality Supportive

Binaries are intriguing in that they can help define the appearance, nature, and dynamics of relationships, conflicts, and tensions. Binaries can unify or separate, as well as act as centers for the emergence and continued maintenance of particular systems (e.g., initiate cyclical patterns of thematic development over time or initiate systems of interrelationships). As the building blocks of complex systems, the web of relationships can increase to trinaries, quaternaries, and so forth. We can look at a simple binary of a teacher-student relationship. However, in classrooms the complex set of relationships increases to the number of people involved (i.e., 25 to 30). The dynamics that emerge from such a set of relationships can set in motion numerous *cycles*, which can self-maintain or self-destruct the system of the classroom community. Binaries can result from *hierarchies* and *holarchies*, from *cycles* of discourse, from *borders*, and so forth. What is the nature of the relationships in the classroom? Are such relationships destined to unify or separate? What factors have contributed to the development of such relationships? What patterns are set in motion by the complex web of relationships?

Background

Arrows indicate flow, progression, directional links and relationships, and directionality in general. Arrows are often linked to time (as an arrow) and sequences. Arrows of time are equivalent to tubular relations in space. Arrows also depict specific directional relations between binaries.

Examples

In science: chemical reactions, acceleration, nerve transmission, vectors, velocity, osmosis, rivers, currents, wind, volcanic flow, bird flight, etc.
In architecture and design: traffic flow, sequences in construction, escalators, directionality in lighting and décor; structural strength in supporting weight; etc.
In art: as objects, as eye movement in looking at piece of art, choreography, drama, etc.
In social sciences: directional relations, movement, flow, stages and sequences, etc.
In other senses: journeys and pilgrimages; travel plans; agenda; etc.

Arrows can represent the directionality of relationships between people or between institutions and people. They can show direction of development, cause and effect, thematic development over time, action and flow within dynamic systems, and so forth. What effect does a particular action have on specific individuals or on community development? How have the notions of inquiry, student ownership, or other thematic goals developed over the course of the semester? How has the classroom community progressed (or regressed) over time? How did the students move from this point to the goal?

Time and Calendars

Background

Time can be considered a binary of movement and memory and can be observed by connecting several spaces. Time can be seen as an arrow or cycle. Time also is evident as counting, progression, and sequences.

Examples

In science: biological clocks, animal behavior, velocity, acceleration, time-space phenomena, etc.
In architecture and design: how time is defined and related to in particular contexts; at Arcosanti (an environmentally situated desert city in Arizona) all buildings are multiuse in order to minimize building use down-time;
In art: in drama, music, dance, and other performance arts time is the fundamental organizing pattern, as well as fundamental to the perceptual experience; etc.
In social sciences: calendars, clocks, history, sequences and stages in development, etc.
In other senses: time to kill; wasting time; time management; timeliness; etc.

Time and calendars may seem obvious as framework for living. However, the notion of time can be quite helpful in understanding the functions, nature, and dynamics of social systems. Time limitations can act as borders or obstacles to instruction and the development of classroom communities. Time is frequently marked by a variety of objects and actions, such as bells, flicking of lights by a teacher, a printed schedule on the chalkboard, or a teacher's increased tension in her voice. Student boredom or restlessness can be a function of too much time on a particular topic or activity. Time can fragment a school day or class period. The linearity of time as an arrow typifies much of schooling, while much of life manifests as cycles of time. We return

to tasks and activities as daily routines. Thinking and learning occurs as cycles through time, as we return to particular themes and ideas. Such cycles manifest as helices of thematic development, where the arrows of time have pushed the cycles into helices. How do teachers control time? How do the time limitations of the school day affect teachers and students? What objects and activities signal various demarcations and limitations of time? Does the teacher succumb to time or does the teacher creatively manipulate time?

Breaks

Background

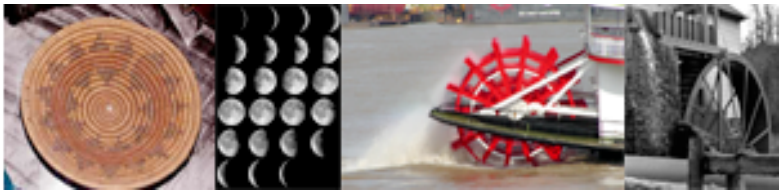
Transformations; change; leaps; shifts; sequences of stages; dilemmas and decisions.

Examples

In science: chemical reactions, metamorphosis, evolutionary change (punctuated equilibrium), energy transformations, phenotypic plasticity, point of change from action to reaction, waterfalls, branching, etc.
In architecture and design: divisions of space and activity, vehicle brakes, etc.
In art: perceptual shifts, design changes, etc.
In social sciences: insights, stages in development, events that change psychosocial states, etc.
In other senses: divorce, death, birth, marriage, crashing waves, breakthroughs, etc.

The term "break" can be somewhat misleading in that we may think of some major and abrupt change. In addition, "break" carries connotations of negativity. However, the concept also refers to transformations, steps in a sequence, and shifts in directionality. Such breaks can be positive or neutral in their ultimate value. In research, we can look at points where relationships (binaries) change, where thematic development diverges, where the systems in communities change, where new insights emerge, where teacher or students face dilemmas (binaries of choice), and so forth. What event acted as the stimulus for change? What activity or comment affected new insights or ability to get through a particular obstacle? What dilemma arose in the classroom and how did the teacher or students deal with it? How did a particular shift in emphasis affect the dynamics of the classroom community? What issue transformed the nature of the community?

Cycles



Background

Cycles are repetitions in space or time, such as, circulations, waves, repetitive routines, etc. Interactions of cycles and arrows create spirals or helices.

Examples

In science: Kreb's cycle, Earth's rotation and revolution, lunar phases, animal movement, biological rhythms, breathing, water cycle, carbon cycle, nitrogen cycle, seasons, tides, bird songs, light, sound, cybernetic feedback loops, etc.
In architecture and design: heating & cooling systems, movement patterns in buildings, etc.
In art: perceptual "movement," musical compositions, choreography, etc.
In social sciences: repetitive actions, routines, rituals, helical patterns of themes running through discourse and other psychosocial situations, etc.
In other senses: laps in a race, wheel of karma, etc.

Cycles serve to maintain systems. They can act as feedback loops or as patterns that maintain or perpetuate particular systems. Affected by arrows, cycles can be viewed as spirals or helices. A particularly negative cycle of behavior and thinking can lead to the destruction of a particular system. A teacher who constantly reprimands students can lead to a self-destructive downward spiral of a classroom community, where divergent or separating binaries of conflict arise and escalate. What cycles of conceptual formation are apparent in the classroom? Are these cycles effective in perpetuating meaningful learning? What cycles of behavior, action, and talk contribute to the development of a classroom community? How do the cycles of interactions within a school affect teacher and student morale? What cycles of discourse and thematic development served to perpetuate a particular argument? How do the classroom routines serve to positively or negatively affect the classroom community? What relationships, barriers, and other patterns develop from particular cycles?

Background

Clusters refer to the accumulation or movement of objects or ideas to positions of proximity to one another. Such clustering may involve one or more center attractors. Clustering seems to involve some sort of attraction that brings objects or ideas together.

Examples

In science: plant growth in particular location, clusters of stars, lichen growth on a particular part of a rock, mold and bacterial growth, bird flocks, colonial organisms, etc.
In social sciences: town and city development; tribal, community, and nation development; clustering of ideas within a conceptual space; formations of cities and town; family structures; cliques; gangs; etc.
In the arts: movement apart and together in drama and dance; pictorial representations of alternating space and clusters; etc.
In architecture and design: building plans that provide space for people to gather; office spaces or rooms in a home that come together around a common space; automobile controls and feedback dials on dashboards; placement of plants and objects in landscape design; etc.
In other senses: cultural and religious events and gatherings; parties; groupings of people in a variety of settings and contexts; etc.

Clusters and the action of clustering can be useful in identifying patterns of learning, of social relationships, and of other types of activities and actions. In classroom communities, students may form cliques or may sit with particular people on a consistent basis. Learning often involves the clustering of particular ideas around a central theme. Teachers may assign seating

around particular insights about the students. Teachers and students may subconsciously perform certain actions around particular events, times of day, etc. The classroom itself may be organized around thematic or functional clusters. Why do particular groups form in a classroom? How do such groups affect the systemic patterns of the classroom? What activities lend themselves to clusters as opposed to sequences? What important and significant ideas and meanings do students hold around a particular concept or theme?

Background

Rigidity and flexibility can be binaries of space, time, and relationship. Rigidity implies strength and impenetrability, while flexibility implies adaptability and change. In a spatial sense, a tube, sphere, sheet, border, or layer can be rigid or flexible. Boundaries of time can be rigid sequences of steps or stages or can delimit actions and activities. Binary relationships can be rigidly established or provide for flexibility. Both flexibility and rigidity can serve to protect.

Examples

In science: Adaptation, acclimatization, organism tolerance to environmental change and variation, cell walls vs. cell membranes, *** class of atoms that are inert ***, etc.
In social sciences: rules, mores, cultural borders, national borders, social layering, personality typologies, institutional and organization, etc.
In the arts: rigid and flexible representations in dance and theater, malleable vs. static sculpture, etc.
In architecture and design: flexibility in skyscrapers, rigid vs. flexible interior designs, car crumple zones and uni-body construction, springs, etc.
In other senses: athletic protective wear, yoga, martial arts, “letter of the law” vs. “spirit of the law”, rigid vs. flexible writing styles, flexible scheduling, open-mindedness vs. close-mindedness and dogma, etc.

Flexibility and rigidity have to do with the nature of previous metapatterns. In educational research, flexibility and rigidity can be useful in describing the manifestation of a variety of other patterns. Are rules established and enforced rigidly or flexibly? Does the teacher manage time rigidly or flexibly? Has the teacher designed a curriculum unit with flexibility built in or as a rigid sequence? Are teachers’ metaphors of teaching and learning based on rigidity or flexibility? Does the teacher treat all students the same (rigid) or with individual differences in mind (flexible)? Is the physical layout of a classroom rigid or flexible? How does the flexible or rigid nature of rules, layout, routines, curriculum, etc. affect the operation of the classroom community system?

Background

Gradients refer to continuums and shades of gray rather than rigid binaries of black and white. Both hierarchies and holarchies can be described as clearly defined and fuzzy demarcations along a continuum. Size, color, light, temperature, speed, quantity, amounts, elevations, distances, etc. refer to continuums. Most choices for humans and other animals do manifest as a clear binary, but as a multiplicity along a continuum with no clear "right" or "wrong."

Examples

In science: speed; acceleration; temperature gradients; slopes; density; solubility; salinity; statistical degrees of freedom; levels of hurricanes, tornado, earthquakes; etc.
In social sciences: population densities, public opinion, intelligence (whatever it is), economic trends, from traditional to modern allegiances in tribal and cultural groups, intensity of emotions, etc.
In the arts: use of color, light, and shading; pace of action in dance and drama; curvatures in sculpture; tempo in music; etc.
In architecture and design: walkway design; handicap ramps; elevators; lighting of spaces; plumbing design; landscape drainage; golf course design; etc.
In other senses: "mixed emotions," degrees of friendship, "closeness" of families, types of lies, etc.

In educational research, gradients are useful in describing levels of engagement, levels of intensity of interactions, pace of action, types of transitions, degrees of understanding, levels of meaningfulness and relevance, degrees of community cohesiveness, and so forth. How do the levels of engagement contribute to the levels of learning? How do levels of engagement and pace of action affect the dynamics of the system? Are transitions abrupt or continuous and how do such transitions affect the system dynamics? How "close" are the relationships between students and between students and the teacher? How do such relationships affect the degree of community cohesiveness?

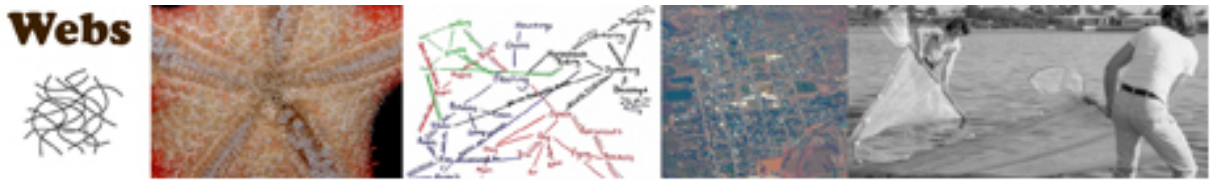
Background

Emergence refers to beginnings and to the arising of new themes and other patterns. Patterns can emerge out of seeming chaos, from cyclical patterns of self-generation, or from breaks or branching. The notion is a sense of some property or pattern arising at a new level of complexity.

Examples

In science: birth, mutation, Big Bang theory, weather pattern formation, new evolutionary lineages, plant growth on bare rock, speciation, star formation, etc.
In social sciences: new trends, city formation, new organizational patterns in social groups, argument formation, etc.
In the arts: novelty, new techniques & materials, representations of emergence, etc.
In architecture and design: new design property, new design leading to unanticipated effect, spatial arrangements to allow for creative gatherings, etc.
In other senses: insight, invention, etc.

In educational research, the notion of emergence can be useful to describe how self-generating arguments and discussions arise and how particular organizational patterns forms in the social setting of the classroom. It also can describe new insights and discoveries. In addition, the emergence of questions is key to authentic inquiry, where meaningful or relevant questions arise and lead to further inquiry. How did a particular argument begin? How did this clique form? How did the classroom community self-organize? How did a particular question lead to a new line of inquiry? What activities provided for a particular insight or understanding?



Background

Webs are physical, biological, social, psychological, and virtual networks of relationships. Where spheres can represent a context, webs describe complex sets of interrelationships of a particular context. A complex lattice of tubes, like a sheet, can involve capture, support, or multi-directional movement. In sheets, such movement is within a plane, whereas movement in webs can become 3-dimensional. Webs also involve a sense of complex organization.

Examples

In science: spider webs, food webs, lattice-like structures in biological and physical forms, retae (network of blood vessels), endoplasmic reticulum, lattice structures of crystals, etc.
In social sciences: semantic webs, concept and context maps, hegemony, street layout in cities, social and political contexts, relationships in social and institutional organizations, matrices, etc.
In the arts: patterns, sculpture design, etc.
In architecture and design: beam structures in buildings, safety nets, etc.
In other senses: web of deceit, fishing nets, electric grids, the internet or world wide web, "The Matrix," etc.

Webs or networks are significant in analyzing the complex sets of relationships in a classroom or school community or in describing the political, cultural, and social contexts of schooling. They also are useful in analyzing the understandings and meanings of students. What is the social and cultural context of a particular school? What is the nature of the relationships within the classroom? How do the classroom relationships change from the start of the school

year to the development of a classroom inquiry community? What is the context of a particular unit of study? How does the political context affect the context of the school's professional community? What meanings and understandings bring into a particular unit of study and how do these meanings and understandings change during the unit? How does the fabric of the classroom community affect the continuity and maintenance of the community? How do the patterns of relationships in a professional school community affect teachers' actions and their ability to establish and maintain a classroom learning community?

Summary of Metapatterns in Research

From the discussion of metapatterns thus far, a description of how such patterns can be used to examine various aspects of complex systems has been delineated. In fact, these patterns provide tools for delineating specific patterns of organization, processes of system production and maintenance, and embedded and emerging structures. In general, the task of unraveling and developing understandings of complex system requires the identification of patterns of relationships. In fact, according to Gregory Bateson (1979), all meaningful understandings are based on relationship. From the specific relationships of simple pairings (i.e., binaries) to the accumulated relationships that form the fabric of context (i.e., webs and spheres), from binary (conflicts and tensions) comprising center attractors to the binaries driving cycles of production, the tasks of understanding complex systems is one of delineating the complex interweaving of patterns of relationship.

From the theoretical framework of complexity theories, metapatterns provide the tools necessary to answer a number of key questions:

1. How do complex social and psychological systems begin? What patterns initiate such systems?
2. What factors or patterns maintain the continuity and sustaining of such systems?
3. What factors or patterns affect the continuity or discontinuity of such systems?
4. What patterns can be used to initiate and sustain complex social or psychological systems?
5. What results from or what patterns emerge from complex social and psychological systems?

These questions are fundamental not only to developing understandings of complex systems, but also to unraveling the complex web of human cognitive factors that affect social and psychological systems. In the human realm, a variety of assumptions, beliefs, emotions, values, and other factors that form frameworks of interpretation and guide thinking and action comprise many of the patterns that contribute to the initiation, maintenance, and dissolution of complex systems (Bloom, 1992). Metapatterns and other broad and over-arching patterns can be used to identify such factors and analyze their affect on systems. With the above questions and the scope of factors that affect systems in mind, table 3 provides an overview of metapatterns, their relationship to complexity theories, and their potential research foci.

Table 3. A summary of metapatterns and their research foci.

Metapatterns	Relations to Complexity Theories	Research Foci
Spheres	• Emergent Structures • Sense of Self-Maintaining Structures	Contexts, groups, beliefs.
Tubes	• Emergent Structures • Patterns of Organization (relationships)	Relationships, connections, movement patterns, communication patterns.
Sheets	• Emergent Structures	Physical layout, a particular layer.
Layers-Hierarchies	• Emergent Structures	Power and control layering in classroom, schools, etc.; nature of knowledge organization, assumptions based in hierarchies.
Layers-Holarchies	• Emergent Structures	Community organization, distribution of power and control, nature and degrees of participation, organization of knowledge.
Layers-Clonons	• Emergent Structures	Components of particular structures, groups, etc.; assumptions based on clonons; component parts of knowledge.
Layers-Holons	• Emergent Structures	Distinctive functional parts;
Borders & Pores	• May lie at source of Bifurcation Points • Process Regulation	Physical, social, and cognitive obstacles and barriers; regulation of flow (physical, social, cognitive, etc.); political barriers; affects of obstacles on various systems; obstacles to relationships.
Centers	• Attractors • Involved in Process of Production • Establishes Patterns of Organization	Central organizing factors, events that set up and maintain various systems (communities, arguments, etc.), emotional "energy" to maintain individual or social systems.
Binaries, etc.	• May lie at source of Bifurcation Point • May be related to Equilibrium	Conflicts, tensions, relationships, dilemmas. Nature of relationships and their tendency to unify or separate.

Table continued on next page

Table 3 continued

Metapatterns	Relations to Complexity Theories	Research Foci
Arrows	• Non-linearity • Patterns of Organization	Directional relationships, flow.
Time and Calendars		Demarcations, limitations, time management.
Breaks	• Bifurcations Points	Transformations, changes, thematic branching, choices in dilemmas, steps in sequences or stages.

(Table 3 continued on next page)

Table 3 continued.

Metapatterns	Relations to Complexity Theories	Research Foci
Cycles	• Feedback Loops • Non-linearity • Patterns of Organization	Self-maintaining patterns, feedback loops, helical thematic patterns, constructive and destructive patterns, patterns in arguments and discussions.
Clusters & clustering	• Emergent Structures	Patterns of learning and concept formation, social relationships and group formation.
Rigidity & Flexibility	• Nature of Patterns of Organization and Structure	Rules enforcement, curricular and instructional implementation, individual treatment, physical arrangements.
Gradients	• Nature of Patterns of Organization & Structure • Degrees of Processes of Production	Levels of engagement, of intensity of interactions; pace of action, types of transitions, degree of understanding, movement toward full participation in communities, degrees of community cohesiveness.
Emergence	• Emergent Patterns	Emergence of arguments and discussions, self-organization patterns in classroom communities, insights, discoveries, new lines of inquiry.
Webs	• Processes of Production • Patterns of Organization & Structure	Networks of interrelationships, interrelationships that form various contexts, knowledge structures, nature of relationships.

Examples of the Use of Metapatterns in Research and Development

This section will provide some examples of how metapatterns can be used in the analysis of social and psychological systems. Although a complete treatment is beyond the scope of this paper, a discussion of some of the more critical aspects of complex systems analysis in teaching and teacher education will be provided. In particular, this discussion will center on the nature of and the development of professional communities of teachers.

Returning to the quotes at the beginning of this paper, they represent rather simple examples of patterns that are embedded in and that affect the patterns of pre-service teacher education courses. These quotes were extracted from course evaluations and from comments made to graduate research assistants. The first quote, "But he never told us what we were supposed to do!", is particularly interesting in pointing to patterns that adversely affected the classroom community. One of the fundamental intentions of the course was to attempt to draw students into a professional community based on a holarchic model of participation, as described by Etienne Wenger (1998). The immediately noticeable pattern is a binary of "us against them," which in itself is separating binary, a conflict based on the assumptions and expectations of hierarchies. In hierarchies, those at upper layers exert control and power over those below. The assumptions involve notions of powerlessness and subservience. The expectations involve the need to be told what to do, how to do it, and how to please those in power. When the pattern of organization of a class is based on the holarchic notions of shared power and control, of self-determination, of initiative, and of self-responsibility the risk of conflict occurs. Such patterns of organization undermine a certain level of comfort for students who have become accustomed to the patterns of subservience. Even though the intentions to change from a hierarchical system to a holarchic system are made explicit, along with discussions of what such a change involves, the patterns can be so deeply embedded that a four month period and 36 hours of contact may not be sufficient to effect change. For some, it is easier to lay blame on those in perceived positions of power. In the specific case of this quote, which was repeated frequently, the graduate students began to believe the student (which, by the way, is the effect of repeated patterns of dialogue utilized in brainwashing and which is apparent in the political and media rhetoric of the current political context in the United States). However, when the graduate students went back to their ethnographic observation notes, they found that not only had the students been told how to go about certain tasks (which involved a great deal of their own decision-making and initiative, as would be expected of practicing teachers), but had been told repeatedly. On a larger scale, only a handful of students fell into these patterns of negativity and conflict with an equal number of students at the other end of the spectrum, where initiative and self-determination were characteristic of their actions and thinking. However, the intensity of the social interactions of those at the conflict end were much more influential than those at the other end of the continuum (*gradient*). As a result, the conflict binary (i.e., the conflict between hierarchic and holarchic expectations and assumptions) created a *center* that perpetuated a *cyclical* downward spiral of dysfunction.

The other quotes from the beginning of the paper ("The best course I've ever had!", "A complete waste of time and money!", "Awesome course and professor!") depict the extreme binaries of student course perception within the very same course section. Such perceptions are embedded in the assumptions and expectations of *hierarchies* and *holarchies* and in their *rigidity* or *flexibility* to change. The assumptions and expectations of hierarchies and holarchies are delineated in tables 4 and 5.

Table 4. Assumptions and expectations in hierarchies.

Layered Organization	Assumptions	Expectations
		LEVEL
Hierarchy		**Top**
	• Static top down organization • Control centered at top and moves down • Ownership centered at top • Control acquired competitively • Competition valued • Deferring of power to higher layers • Identity based on layer (controlling or controlled) • Meaning situated in complex relations among position in layer, rewards, control, power, etc. • Induction is imposed upon inductees from higher levels • Degree of participation is imposed	• Those at lower levels not to be trusted • Obedience to authority • Use of strategies for control and power • Formulate rules • Set expectations of behavior, etc.
		Bottom
		• Those at higher levels not to be trusted (or blindly trusted) • Obedience to authorities • Defer control and power to those at higher levels • Follow rules • Conform to expectations of behavior, etc.

Table 5. Assumptions and expectations in holarchies.

Layered Organization	Assumptions	Expectations
		LEVEL
Holarchy		**Full (Center Layer)**
	• Fluid, distributed organization among participants • Control distributed among participants • Ownership distributed among participants • Control acquired with increased participation • Cooperation and collaboration valued • Shared power • Identity based on participation • Meaning situated in complex relations among participation, identity as participant, etc. • Induction is socially-mediated • Degree of participation is self-determined within social sphere	• New, peripheral participants move toward full participation • Question authority of self and others • Collaborate on and negotiate the formulation of rules, expectations, etc. • Assume responsibility and expect others to assume responsibility
		Peripheral (Outer Layers)
		• New participants determine degrees and approaches to participation • Question authority of self and others • Collaborate on and negotiate the formulation of rules, expectations, etc. • Work towards assuming responsibility and expect others to assume responsibility

In analyzing and/or designing social groupings of various sorts, knowledge of such differences in assumptions, expectations, and characteristics are essential in creating cohesive environments where self-sustaining professional communities can occur. The assumptions and expectations in hierarchies and holarchies are significant in that they can establish binaries that separate or unify. These binaries, in turn, can become the center attractors for the processes of production involved in systems of classroom communities. Over the past several years in a variety of different courses at different levels (i.e., from undergraduate through graduate), I have experienced the emergence of systems across a continuum from total dissolution into dysfunction to total transformation into self-sustaining holarchic communities. What accounts for the variability, even though the basic structures and processes in course establishment vary very little?

In general, we, as human being in western societies, have very little experience with holarchies. From family to religious organizations to schools and classrooms to jobs to political structures, the typical organizational structure is hierarchical. Power and control at the top and submission and obedience at the bottom. In emergent social structures, we seem to fall into the same organizing patterns. In gang formation and structure, the leader emerges, not as one to share power, but to exert power. In social cliques in schools and classrooms, particular students assume power and exert influence on those within the clique to follow and to look down upon students not in the clique. In playing sports in informal situations both in and outside of school, the "pick-up" approach is for specific individuals to self-appoint as leaders then proceed to pick their teams, with those at the lower levels of the hierarchy picked last. In the west, the standard approach to self-organization is hierarchical. On the other hand, many tribal cultures have followed holarchic patterns of self-organization. David Maybury-Lewis' (1992) book and documentary series, *Millennium: Tribal Wisdom in the Modern World*, depicts a variety of tribal cultures, where the leadership is situated in the notion of example or of wisdom as a way of drawing others into participation in the tribe. The same is true of other cultures, as in Tibet, where the Dali Lama was or is (in exile) not the ultimate controller, but rather an example of how "to be." From mutual indebtedness to cooperation, the social organization is based on groupings (from binary to "N^{th}-nary") that unify. Wealth lies in relationship. In hierarchical organizations, competition leads to a vying for power and control over others as the modus operandi. Such organizational structures lead to continual struggles to maintain the systems through increasingly intensified spirals of control, since the fundamental relationships are divisive binaries. In such organizational structures, wealth lies in power and objects (including money).

The contextual sphere of schooling is based on hierarchy, while the implied contextual sphere of community (by definition to commune or come together) is based on holarchy. When one attempts to create school or classroom communities, the juxtaposition of these contexts creates a conflicting binary (see figure 1). This figure was generated from analyses of education students' participation (and lack of participation) in an elementary science methods course along with an overall analysis of the underlying assumptions of schooling, in general. The context of schooling, which is characteristically hierarchic, establishes sets of assumptions that are not conducive to participation in professional communities as suggested by Etienne Wenger (1998). Such a disparate binary of between these two contexts creates significant challenges for teacher educators who attempt to prepare students to take on the roles of self-sufficient and collaborative professionals.

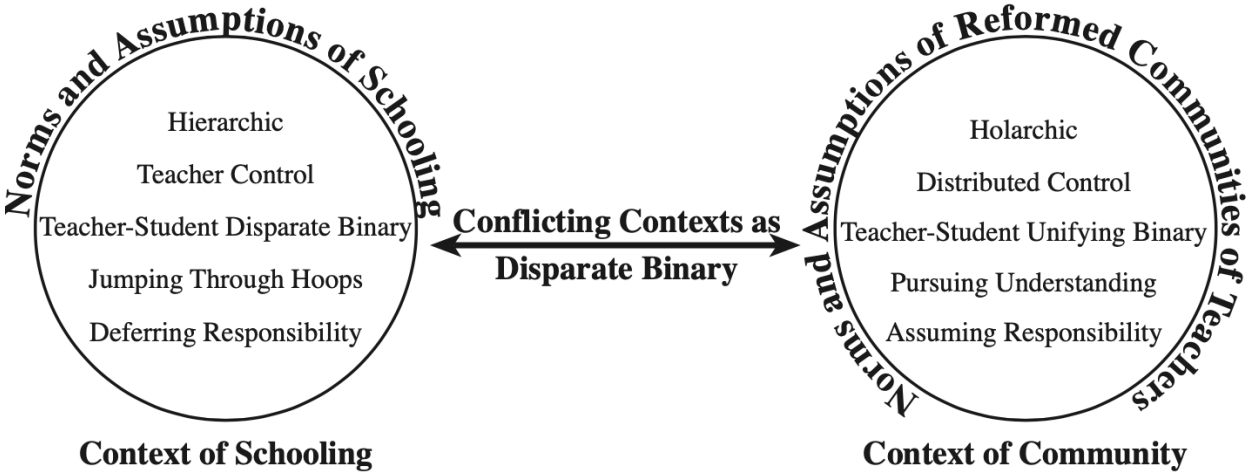


Figure 1. The contexts of schooling and professional communities as a conflicting binary.

In figure 2, the conflicting binaries between hierarchies and holarchies are further delineated. The scope of these binaries extends from the emotional (notions of trust, fear, powerlessness) to patterns of action and process. In establishing classroom communities, any or all of these binaries can become center attractors for individual and group behavior and activity. The challenges are complex in that the instructor, as an example of a full participant and not a controller, must in some way work with the potential conflicting assumptions of each individual in the classroom.

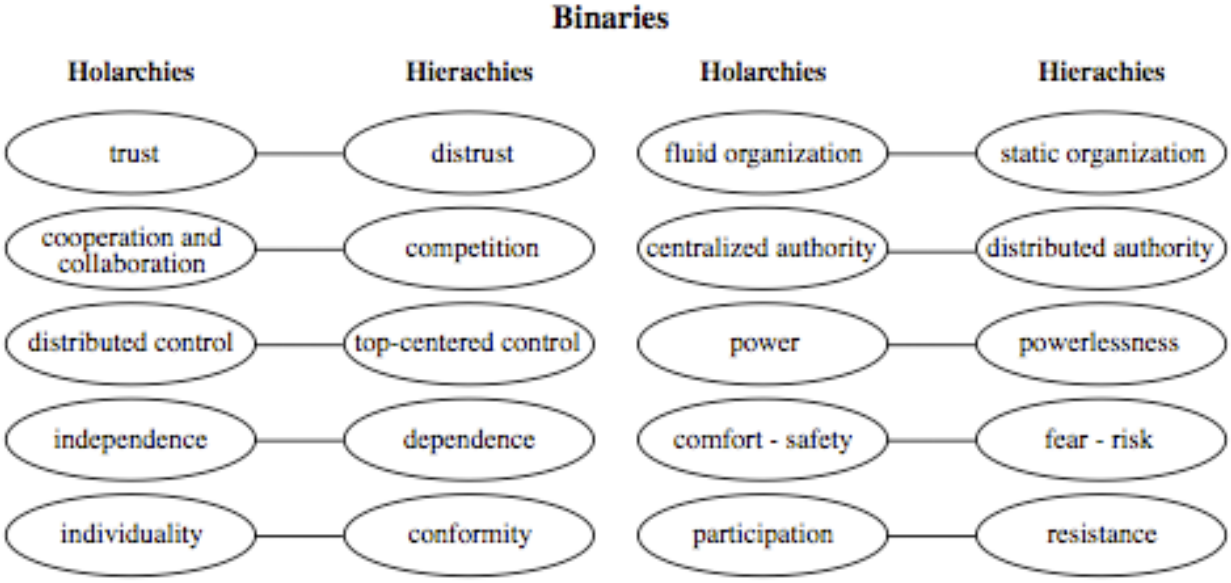


Figure 2. Common binaries evident when comparing holarchic and hierarchic situations.

In attempting to answer the previous question (i.e., what accounts for the variability, even though the basic structures and processes in course establishment vary very little?), the variability of how each of these binaries affects the individual and group is of great importance. The *rigidity-flexibility* of how these binary assumptions are held and to what degree (i.e., *gradient*) of intensity these binaries hold for the individual are a major factor. In a graduate curriculum course, the class transformed into a self-sustaining community of intense inquiry. Part

way through the course, one student commented, "it took a while for us to believe that you meant what you said." The binary of trust-distrust (see figure 2) needed to be addressed on a very personal level. At the transition to the self-sustaining community, the specificity of syllabus assignments dropped away. New goals and tasks were negotiated. The extent of readings and thinking went beyond those initially assigned. Co-participants (no longer "students") led discussions and took the lead on introducing activities and topics for discussion.

In addition to the trust-distrust binary, each participant must have confronted other binaries. A sense of comfort and safety had to be established. A feeling of assuming power, of cooperation, of value as an individual, and of independence must have affected each individual's sense of his or her ability to participate more fully and to take on and share more control and power within the group. In order to achieve self-sustaining communities in classrooms, the implicit and explicit messages by the full participant (e.g., instructor) have to be consistent in that they must not vary from the assumptions of holarchies to those of hierarchies. Providing such consistency is a difficult, because of the automaticity of so many deeply embedded hierarchical patterns of behavior. At the same time, the onus of responsibility or of the effect on establishing such a system does not lie entirely upon the instructor. The nature, rigidity, and extent of binary-based assumptions of each individual, as well as his or her willingness to examine such assumptions, are critical factors in the establishment of community systems.

In classrooms, where there is a critical mass of students with rigidly held assumptions and expectations, deeply held distrust, and dominant personalities (which can be amount to three or four individuals), the likelihood of establishing successful classroom communities can be rather small. On the other hand, if most students (a very large majority) are willing to examine their assumptions, the potential for successful transformation to a community is much larger.

Such a view of group transformation fits with McClure's (1998) model of group development. In his model, each stage in group development consists of confronting a specific binary. Each successful confrontation with a binary conflict is a break or transformation that allows for continued cyclical patterns of production of the group dynamic (see figure 3).

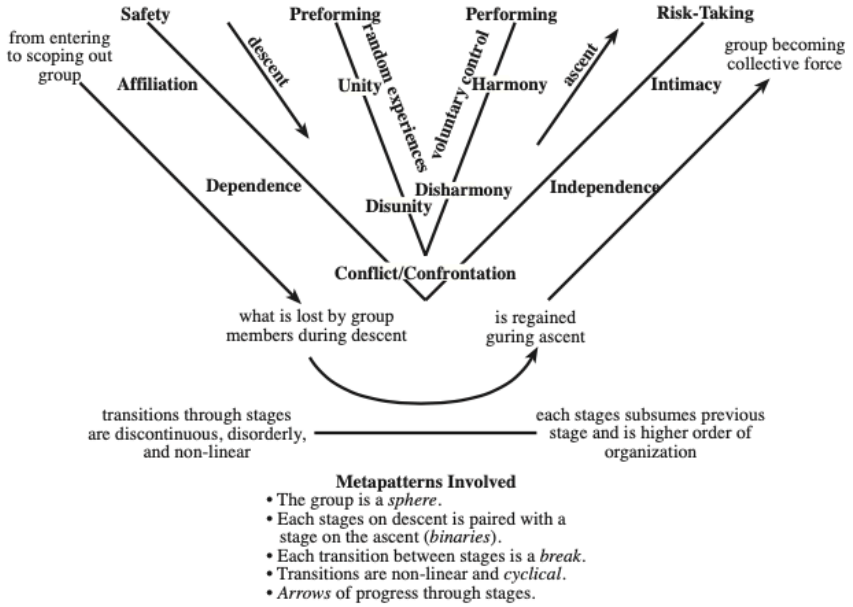


Figure 3. Adaptation of McClure's (1998, p. 50) model (arc) of stages of group development with associated issues, as well as associated metapatterns.

Throughout group development in the establishment of professional communities in classrooms and schools, binaries appear to comprise the center attractors as well as specific bifurcation points or breaks-transformative points in the cyclical patterns of production and organization. As we have seen, many of these binaries lie in the conflicting assumptions and expectations between hierarchies and holarchies. At the same time, the cyclical patterns of interactions between students and between students and instructor, over time (as an arrow) can spiral towards self-sustaining structures or spiral towards self-destructive groups. The spherical contexts that affect the potentiality of community development and the contexts within the classroom group are comprised of webs of interactions containing a wide variety of nodal, binary-based centers. The binaries, webs of interactions, and various centers can create barriers or obstacles to the ability to establish self-sustaining systems within the community. As researchers and teacher educators, we need to continue to examine in depth the nature and extent of the complex knot of relationships between the patterns within classroom and schools and to design approaches that allow for the examination of binary-based assumptions and expectations and other obstacles and to move toward the establishment of productive patterns of production and organization.

Discussion and Implications

In the previous examination of metapatterns as tools for examining teacher education classrooms, I referred to developing a holarchic community. This model is depicted in figure 4 as a holarchically layered set of spheres. As with any holarchy, the relationships between layers are not well defined. However, in this model, the notion is that as individuals move toward full participation, they pass through layers of increasing identity as a participant, of increasing knowledge and meaning associated with participation, of increasing participation and activity representative of the practices of the community, and of increasing notions of about what the community is. In the model, arrows represent the movement towards increases in these areas. The terms scattered around the peripheral layers are some of the characteristics associated with meaning, identity, practice, and community in a professional community of teachers.

In essence, this model and any model of self-sustaining social systems are based on the notion of *connection*. This notion is fundamentally related to the creation of unifying binaries and of seeing the interconnectedness within systems and of seeing the interconnectedness between systems and among systems within systems. In other words, we need to expose how patterns and events within systems affect one another, how the patterns and events in one system can affect another, and how the patterns and events in layers of embedded or hierarchically layered systems affect one another. The system of a classroom community affects and is affected by the systems within the school, and these affect and are affected by the political systems of schooling, as well as by the systems within the local community.

However, in terms of our efforts in research, we need to look beyond just understanding situations and look at ways to implement change based on our research. From this perspective of taking action, we need to contemplate the fact that we are in the midst of increasing *disconnectedness*. In many ways, individuals are becoming increasingly disconnected with themselves. Do we know who we are? Are we happy with ourselves (or do we love ourselves, but not egocentrically)? Increases in suicides, psychotherapy, psychotropic drug prescriptions, and self-mutilation all point to self-disconnects. We also are becoming increasingly disconnected with one another. Family violence, aggressive driving, failing marriages, and workplace and

school violence are escalating. In many ways, technology of various sorts has been a strong contributor to disconnects. We are numbers to corporations, with little care for their clients and customers. Email discussions tend to get aggressive, especially when individuals do not know one another on personal levels. We can hide behind our technologies. Families have been breaking down as members move great distances. Care for elderly family members, once a responsibility for the younger members of the family, are left to strangers in strange and disconnected surroundings. The hierarchical nature of our world creates disconnects between school children, between children and adults, between employees and employers, and between politicians and citizens. We are becoming increasingly disconnected with our environment. From the simple disconnect I see with students unwilling to touch an earthworm or lie on the ground on a field study to the major disconnects with our biosphere, we are losing contact. We do not see ourselves as just another part of an interconnected system. In the past, the environmental disconnect within Euro-Western societies was partly due to ignorance. However, with well-established and continually increasing knowledge, we continue to disconnect.

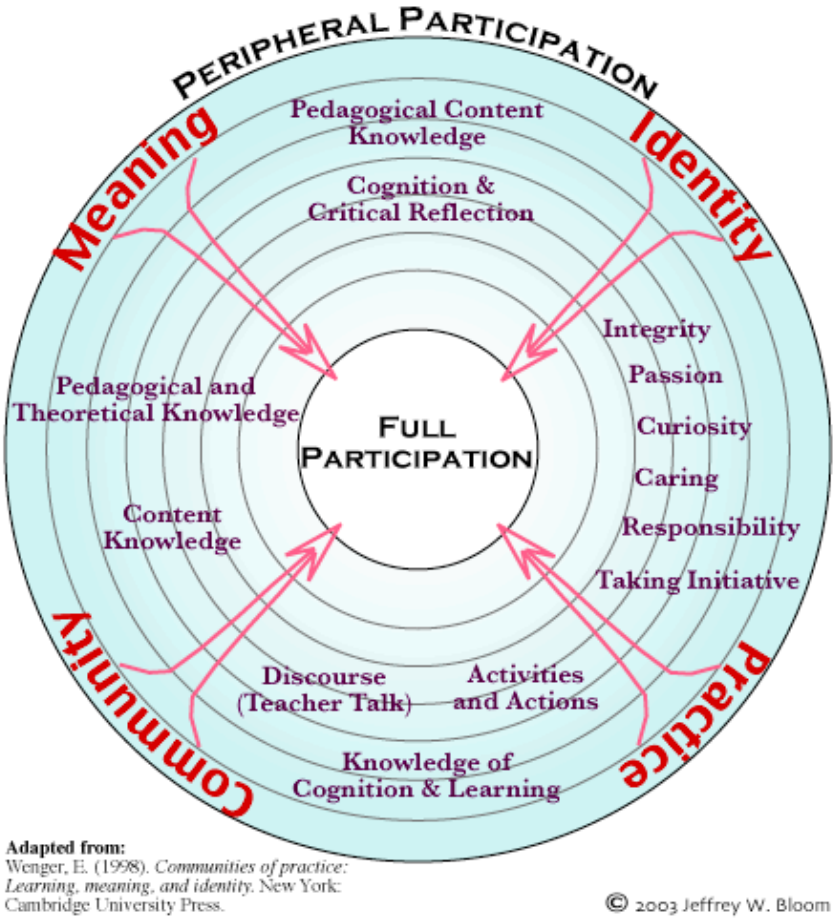


Figure 4. Holarchic model of the professional community of teachers.

Such disconnects are leading us in dangerous downward spirals on all fronts. As researchers and educators, we must begin a process of helping others to connect with themselves and with one another. We must help to support others in their attempts to provide connections for the children in their classrooms. Influencing one can influence many others, if there is time.

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