The Use of Metapatterns for Research into Complex Systems of Teaching, Learning, and Schooling

Part II: Applications

JEFFREY W. BLOOM
Northern Arizona University (USA)

TYLER VOLK
New York University (USA)

Abstract

In part I of this paper set, Volk and Bloom discuss the reasons why metapatterns are important in biological and cultural contexts. Here, in part II, we show how metapatterns can be applied to an important problem in qualitative educational research: the difficulties in elucidating fundamental patterns of interaction. In meeting this challenge we provide a metapatterns-based framework for analyzing and interpreting qualitative data. We begin by acknowledging the importance of context, the setting within which any system under investigation can be expected to exhibit metapatterns as functional components that are vital for the maintenance of that specific system within a particular context. We follow this discussion by defining three dimensions of our proposed analytical framework. The first dimension, which we call depth, examines the various metapatterns involved in the particular system under investigation. Extent is the second dimension, which involves extending to other contexts the interacting sets of metapatterns found in the investigation of depth. The third component is abstraction, which involves generating overarching principles or models from the analytical results of the first and second dimensions (i.e., depth and extent). We recommend that these three dimensions should be used recursively to meet the challenge named above. We demonstrate the framework through an example of a classroom discussion involving children arguing about the concept of density. We conclude with a discussion of the implications of this analytical framework, along with a list of fundamental principles of this framework and a list of questions that can guide qualitative research.

Complicity: An International Journal of Complexity and Education
Volume 4 (2007), Number 1 • pp. 45–68 • www.complexityandeducation.ca

Introduction

Investigations of students, teachers, classrooms, and schools present challenges to researchers. Such investigations involve complex systems of thinking and emotions, interactions between individuals and groups, processes that change over time, and sets of assumptions and expectations about learning and teaching. The challenges we face as researchers involve how we gather and analyze data that elucidate the complex patterns of interactions within such systems. The current status of qualitative research in education includes numerous paradigms, along with a wide variety of well-established approaches to data collection and analysis. Although these paradigms and approaches provide powerful tools for researchers, we are offering another set of tools that can provide for greater depth of analysis, for the extension of analytical claims across diverse contexts, and for the generation of more abstract and overarching explanatory principles and models. The tools we are providing are discussed in terms of a recursive analytical framework based on metapatterns.

As discussed in Part I, we expect metapatterns to be an integral part of any system subject to either biological or cultural evolution. Therefore, metapatterns will be found operating in the social and cognitive systems at play within school and classroom contexts. As such, we can expect to develop conceptual constructs arising from our data analyses, which are based on interacting sets of metapatterns embedded in the particular systems under study. At the same time, since metapatterns appear throughout cultural and social contexts, we can expect to find transferability of these conceptual constructs across contexts.

The Analytical Framework

As discussed in the first paper of this set (Volk & Bloom), metapatterns are broad, overarching patterns that span multiple contexts (e.g., academic disciplines, cultures, personal experiences, etc.), and are transphenomenal and transdisciplinary (transphenomenal and transdisciplinary come from Davis & Phelps, 2005). Although context-specific meanings of each metapattern may differ, the essential core meanings or functions are shared across such contexts.

The use of metapatterns in data analysis, we suggest, will be recursive within and between three dimensions: (a) going into greater depth with context-specific meanings, (b) extending across contexts with more fundamental meanings, and (c) developing generalized principles (i.e., abstractions) based on both fundamental and context-specific meanings (see Figure 1). In other words, as we begin analyzing a data set, we can begin by recursively examining specific patterns and interactions among patterns

with each recursion going into greater depth. At the same time, we can extend our analyses across contexts, from those that are closely similar to those that are highly dissimilar. Such an approach establishes a continuity of meaning as we extend into greater depth and across contexts, as well as levels of scale as suggested by Fleener (2002). As we work with our data in this way, we also can begin to recursively simplify our understandings of the interactions among patterns while developing more abstract guiding principles and models that not only explain the depth of our context-specific understandings of these patterns, but also explain our understandings of these patterns across divergent contexts.

Such recursivity is similar to Davis' (2005) argument for fractals as the basic pattern of learning. The constraints of particular rules or ideas, such as the developing abstractions, generalizations, or models in figure 1, act to develop similar (but not the same) and increasingly complex patterns across layers or levels of whatever system is being investigated. Davis refers to this application across layers as scale independence, where learning follows unpredictable, non-linear pathways that share certain similarities across layers. This particular sense of layers applies to the layers of contexts as "extent" and to the layers of "depth" of analysis in figure 1. The reiterative nature of analysis and learning in the model depicted in figure 1 produces increasingly complex and interconnected understandings of based on the "rules" or functional meanings of metapatterns and other broadly applicable concepts.

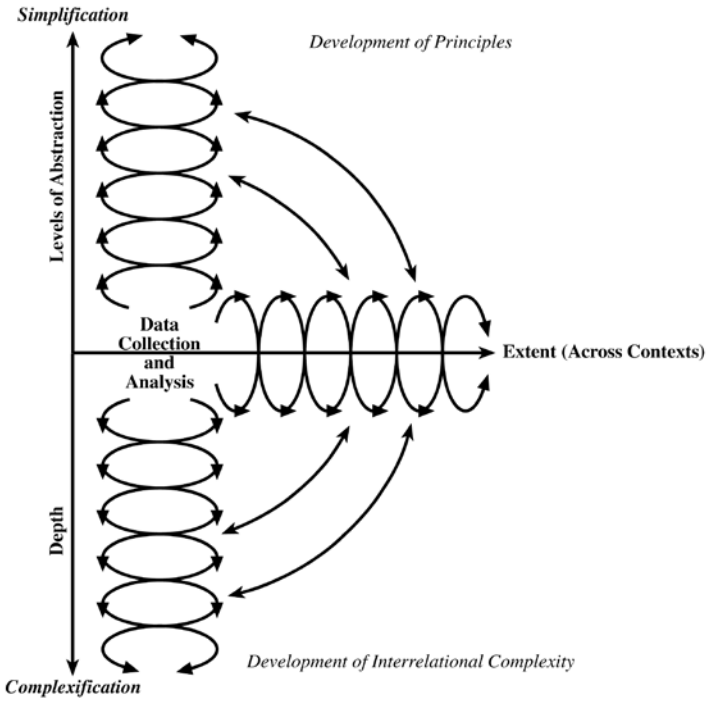

Figure 1. Recursive approach to data collection and analysis.

As we move toward discussing the three dimensions of this framework (i.e., depth, extent, and abstraction), it is important to discuss the notion of context as a critical feature to understanding anything. Bateson (1979) was adamant in making the point that "without context, words and actions have no meaning at all" (p. 16). Words and actions need to be situated in one or more relevant and meaningful contexts, in order to develop any degree of complex understandings. In conducting research in education, the contexts that may (or need to) be addressed include those that are concerned with the historical, social, political, psychological, cultural, and disciplinary (i.e., subject matter) spheres of influence, among others. Context, in this sense, can be thought of as a sphere or spheres in which particular discourse, actions, and thinking occur.

The 3 Dimensions

Depth

Depth of analysis involves the recursive examination of specific patterns and relationships that are parts of the system under investigation. As we encounter particular phenomena in research, we start with general descriptions followed by questions that lead us to examine these phenomena in greater depth. Patterns found in our initial analysis can be applied in the process of revisiting our data in search of more subtle and specific sets of patterns. What we may find are patterns within patterns within patterns or layers of patterns that build upon one another. This entire process of examining depth involves a recursive approach that continues to generate questions that look for increasingly specific patterns and interactions among patterns.

Extent

Extent involves the breadth of the application of metapatterns across contexts. In other words, the same sets of patterns may appear in business, social, and cultural contexts. In a sense, this particular aspect of the application of metapatterns has to do with transference. Since metapatterns appear across multiple disciplines and contexts, transferability is built into the entire process of recursively applying specific interactions of patterns in multiple contexts.

Abstraction

Abstraction refers to the construction of generalized principles. As we begin to develop representations of the interactions of various metapatterns and apply them across contexts, we can begin to develop principles, models, or generalizations. The process of abstraction is one of developing simplified representations of the complex systems of metapatterns elucidated through

the previous processes of going into depth and extending across contexts. In the classroom, such principles can help guide instructional planning for engaged discourse, inquiry, and so forth. At the same time, such principles are tested across contexts (i.e., once again revisiting "extent").

Summary

This entire process of using metapatterns as an analytical framework involves two applications of recursion. The first process of recursion occurs within each of the three dimensions of depth, extent, and abstraction. The second process occurs as we cycle through the three dimensions. Such dual recursivity allows for continual checks and balances against data and observations from the particular context of study through a variety of other contexts.

We argue that metapatterns provide a framework for exposing interactions among patterns of cognition, discourse, culture, organization, physical and social environments, and other contexts. While, at this point, there is a rather short list of metapatterns (see Part 1), any number of other concepts and patterns can be applied in the same way. For instance, we may find that "power" arises in a discussion among teachers when referring to administrators. Power, of course, has a number of context specific meanings, including the scientific meaning, where power is the amount of work done in a particular period of time. However, a basic meaning shared across contexts revolves around the notion of the ability to influence, impact, or control some object, person, event, or situation. As we recursively examine the notion of power, as expressed by teachers, we can probe into the depth of how power from administrators affects other patterns of teachers' actions and thinking, extend the patterns of power interactions to other professional and social organizations, and develop overarching hypotheses about the effects of power relations in social contexts. We suggest that metapatterns are particularly "powerful" tools for this kind of analysis. While we typically assume that such analytical processes deal only with the specific data in hand, the three-dimensional recursive process described here provides for the emergence of creative insight and new connections. Such a process is not unlike Doll's (2003) notion of modes of thought as a triad of science (logic and reason), story (culture and person), and spirit (life, breath, and vital integrity). In a sense, science delves into depth, story involves connecting across contexts, and spirit is related to "breathing" life into the abstractions and generalizations that arise from recursively moving through depth and extent.

The utility and power of this approach lies in the ubiquity and elemental or constitutive nature of metapatterns. The shared functions and meanings across contexts, as well as the context-specific variations of functions and meanings, provide a means for deeper analysis and for more extensive

cross-contextual comparisons. While many useful and powerful analytical and interpretive frameworks already exist for use in education and the social sciences, the approach we are suggesting here can be used both as a stand-alone analytical approach and in conjunction with other analytical frameworks. For instance, Activity Theory (Engström, 1996, 1999, 2000, 2001) provides a powerful model for analyzing the dynamics of human activity. This model overlays two triads of dimensions (i.e., subject-object-community and rules-instruments-division of labor) along with resulting outcomes of activities. By also utilizing a framework of metapatterns and the recursive approach to complex analysis, we can elucidate further details of each dimension, as well as the relations between these dimensions. For instance, communities can be further analyzed in terms of the particular type of layering, the binary-based nature of relationships in and the center(s) of the communities, the directionality of movement or activity within community (arrows and cycles), and how these three aspects of the community interact to produce other patterns of relationship, structure, function, and meaning. In addition, "rules" as a combination of arrows (directionality), tubes (directionality and relationships), borders and pores (limits and regulation), etc. can interact with other dimensions (i.e., community, subject, object, instruments, and division of labor) and their constituent functional patterns. So, while Activity Theory can be used as a stand alone analytical framework, the addition of our recursive metapatterns-based approach not only can bring more specific, underlying patterns to the surface, but also can allow the resulting combined analyses to be applied to different contexts and to the generation of abstracted models, explanations, and generalizations within and across contexts.

The next section of this paper will provide an example of using metapatterns as an analytical framework. This example involves student learning, thinking, and discourse, with specific emphasis on a student generated and maintained argument about density.

An Example from Learning, Thinking, and Discourse

The example we will discuss involves data collected during an argument about density (Bloom, 2001). The original analysis of this data utilized chaos and complexity theories as a framework. However, as shown here, a metapatterns framework provides for a more detailed and in-depth analysis. In providing this analysis, we will focus specifically on the metapatterns of spheres, holarchies, borders, binaries, centers, arrows, breaks, and cycles. The following discussion not only will elucidate how these metapatterns can be used in the description of context, depth, extent, and abstraction, but also will point out how the language of metapatterns can extend the

analysis beyond that of the language of complexity sciences as was used in the original analysis.

Context

We will first provide a brief overview of the original study. The argument about density occurred in a small grade 5, 6, and 7 science classroom with 11 students. The school was private and located in an urban setting on the east coast of Canada. The particular unit of study was based on a portfolio culture approach (Gitomer & Duschl, 1995) to the concepts involved in floating. Three groups of students were "competing" as simulated consulting firms for boat designs to be submitted as proposals to a fictional government committee. On the second day of the unit, the students were engaged in predicting which objects from an assortment would float or sink. Among these objects were 11 blocks of different types of wood with varying densities, including ebony. After the students found that much to their surprise ebony sinks, the argument began with one student stating that "if you scaled up the big piece of wood, then you have to scale up the water, too.... So, then it would float." The argument took place over a period of five successive days of class meetings, which met twice a week.

In the original paper (Bloom, 2001), the description of the context provided additional details within the scope provided in the previous paragraph, but did not provide an analysis of the context. This new analysis focuses upon the context of the classroom as a holarchically layered community (see Figure 2). Holarchies, in this sense, are conceived of as social layering, where students were invited to move through layers of participation and engagement in doing science as knowledge producers. Such a context valued their passion, ownership and control, and meaning-making. In this description of context, we characterize the classroom as a community of participants, where students share in the control of classroom activities, discourse, and conceptual content. This description of the classroom context is in contrast to the more traditional hierarchically-layered classroom, where the teacher is in control and where students are characterized as more passive recipients

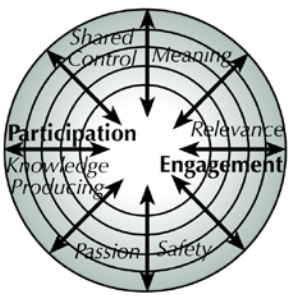

Figure 2. Context of the classroom as holarchic community.

of information, followers of teacher instructions, and responders to teacher questions. Such a description of context provides a more distinctive description of the social atmosphere, relationships, and structure of the classroom than that described in the original study (Bloom, 2001).

It is interesting to note that a holarchic community provides a context for autopoiesis not only in terms of community maintenance and continuity, but also in terms of the growth in complexity of learning. Such an autopoietic view of the social milieu is similar to that of Maturana and Varela's (1998) third-order structural couplings of organisms in autopoietic unity within a particular environment. From this perspective, the roles, rules, and social dynamics must go through a period of change as participants move from the typical hierarchical structures in schools and society at large. In a sense, such a process is consistent with Maturana and Varela's view of human social phenomena, where:

> Coherence and harmony in relations and interactions between the members of a human social system are due to the coherence and harmony of their growth in it, in an ongoing social learning which their own social (linguistic) operation defines and which is possible thanks to the genetic and ontogenetic processes that permit structural plasticity of the members. (p. 199)

As a result, the community becomes an autopoietic, unified social system of individuals, where mutual development and complex learning are key processes.

In addition, the subject matter context included not only the specific conceptual content involved in the exploration of floating, but also the nature of science as an inquiry process of knowledge production. The conceptual content itself included numerous concepts. Two concepts are represented as an opposing binary (i.e., gravity and buoyancy). The third concept is represented as a sphere of inwardly directed arrows (i.e., pressure) (see Figure 3). The fourth concept of density is comprised of a binary of two additional concepts of mass and volume (see Figure 4). The fifth major concept concerned molecular structure. This concept arose from the students, but was not included in the initial planning for the unit. This concept is represented in Figure 5 as a binary of the students' conception vs. a simplified scientific conception. The student conception is depicted as homogeneous spheres, while the scientific version is depicted as heterogeneous sets of spheres connected by tubes. Four of these concepts were a part of the planned conceptual territory to be covered in the unit on floating, while the fifth concept arose from the students during the course of the argument. The fifth conception of molecules, however, was based on the assumption that all molecules were the same size, had the same mass, and occupied the same amount of space. In this analysis, the metapatterns of spheres, tubes, binaries, and arrows have been used to provide simplified representations of student and scientist concepts.

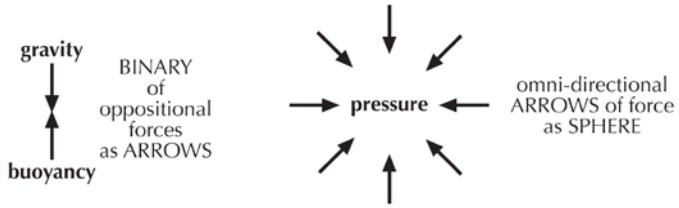

Figure 3. Context of conceptual content as binaries and spheres of arrows.

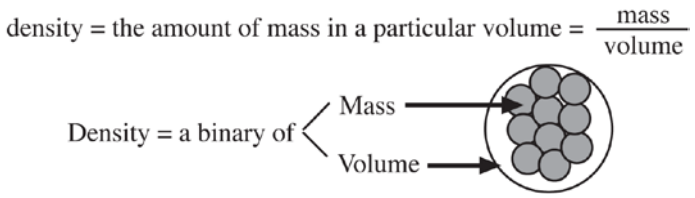

Figure 4. Context of conceptual content of density as binary of mass and volume.

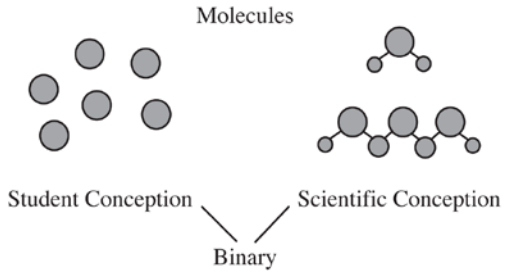

Figure 5. Context of conceptual content as binary of student vs. the scientific conception of molecules.

The graphic representation of these concepts as an opposing binary of gravity and buoyancy, a sphere of pressure, a binary of mass and volume (i.e., density), and a binary of spherical conceptions of molecular structure provide a foundation for understanding the conceptual territory. Additional representations of student conceptions can be juxtaposed to each of these representations, as in Figure 5, to show differences between the students' and the scientific understandings. For instance, the students' understanding of pressure would be depicted as downward, unidirectional arrows (compare to Figure 3). Such metapatterns-based representations not only provide a depiction of the conceptual territory, but also provide for opportunities to show contrasting (binaries) of student vs. scientific conceptions.

The context of the nature of science includes, among a variety aspects, a cycle of inquiry and a cycle of argumentation (see Figure 6). The inquiry cycle is driven by a center of questioning, while the cycle of argumentation is driven by a conflicting binary-based center. Such centers provide a basis

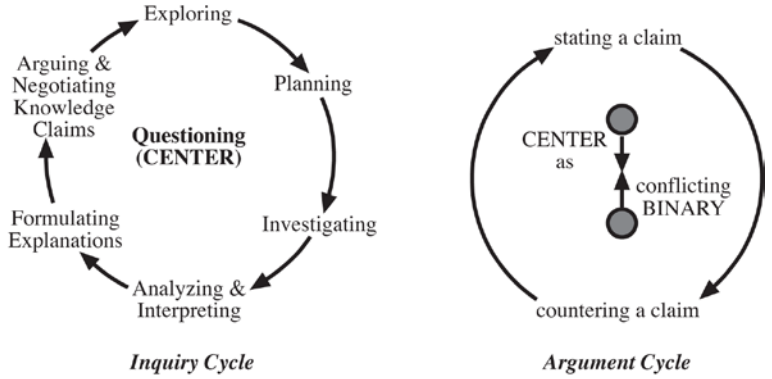

Figure 6. Context of the nature of science as cycles of inquiry and argument with questioning as the initiating, maintaining, and organizing center of inquiry and center as binary in the argument cycle

for organizing and implementing classroom instruction, as well as a basis for analyzing classroom processes, interactions, and activities.

In general, we can depict the context of this particular research or almost any classroom teaching and learning project as the interaction between and overlap of multiple contexts (see Figure 7). Although Figure 7 depicts six overlapping contexts, others could be added as necessary in order to thoroughly describe the overall context of a particular research project. If the particular classroom had one or more distinctive cultural groups (e.g., Native American, Korean, African-American, et al.), additional spherical representations of cultural contexts would need to be added.

The original analysis of the previous aspects of the classroom context (Bloom, 2001) described some aspects of the classroom community, the con-

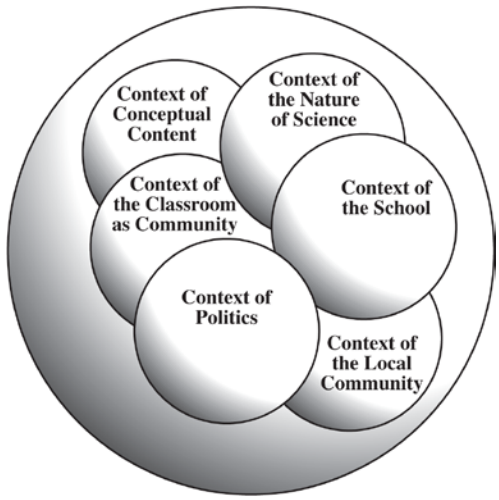

Figure 7. Multiple contexts within the context of science classroom research.

ceptual understandings, and the nature of science. However, the metapatterns-based analysis provided here covers some aspects of the context more succinctly and in more detail (see Figures 3 through 6). In addition, this analysis covers other contextual aspects that were not addressed thoroughly in the original study (see Figures 2 and 7).

The 3 Dimensions

This section will demonstrate how the three dimensions of depth, extent, and abstraction can be applied to this example of a classroom argument. We will point out where the metapatterns approach has added to the analysis.

Depth

As depicted in figure 8, this argument arose from a central (i.e., center) conflict (i.e., binary) as to whether ebony would float in a larger body of water. In the original analysis, the notion of ebony sinking was categorized as the attractor. However, in the present analysis, we have used the metapatterns notion of a conflicting binary acting as a center. Although "attractor" is certainly a useful concept, adding a more specific and in-depth notion of conflicting binary not only provides more information about the initiating and self-maintaining center, but also provides information about the nature of such stimulating centers, which can be used in instructional design and implementation. In addition to this central conflict, we have identified, in the present analysis, another central factor, which was required for the argument to occur and continue over time. As in chaotic systems, some source of energy is required (Capra, 1996) for self-initiating, self-generating, and self-maintaining. The energy center for this argument involved a triadic synergy between (a) ownership over the ideas, (b) passion for engagement, and (c) an emotional commitment to ones' ideas. As opposed to biological and physical systems, this social system was energized by psychological-emotional factors. The in-depth analysis of this particular energizing center was not addressed in the original paper (Bloom, 2001). In addition, it is worth mentioning that yet another center is embedded in this particular argument. This center involves a sense of goal, which, in this case, has do with "winning" the argument and which acted to motivate students to maintain their engagement.

During each of the subsequent days after the initial start of the argument, students re-initiated the argument by introducing new ideas and "evidence." The argument also increased in emotional intensity and conceptual complexity. The volume of students' voices increased to the point of screaming. Students started standing up and talking to emphasize points with occasional trips to the chalkboard, in order to draw diagrams

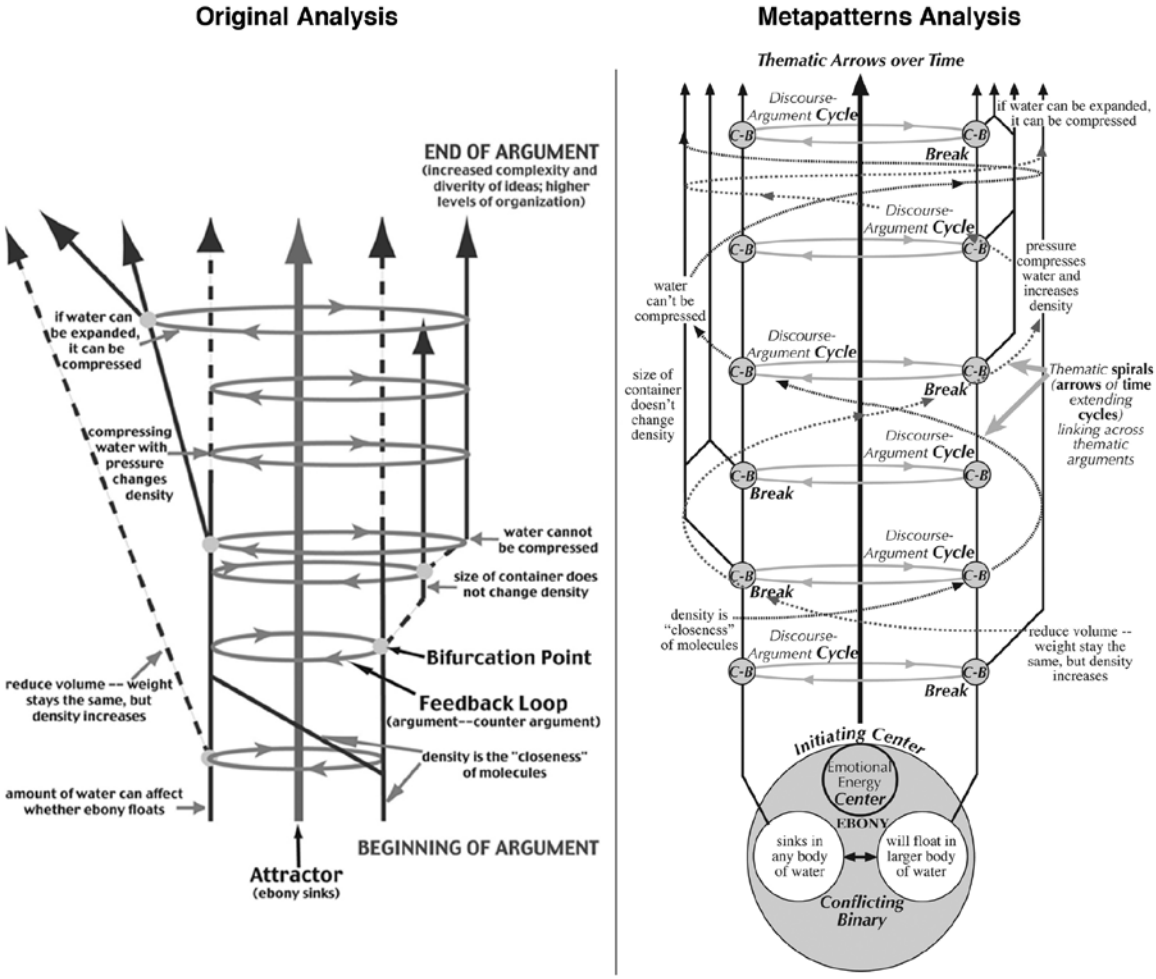

Figure 8. The original complexity theory analysis (Bloom, 2001, p. 461) and the metapatterns analysis of complexity in students' argument about density.

to make their points. As can be seen in figure 8, the conceptual complexity increased as new ideas were introduced (depicted as the branching of thematic arrows). These new ideas, in turn, became new binary-based centers for breaks. Such breaks added new thematic patterns, which continued to be addressed through the argumentative discourse cycles. In the original analysis (Bloom, 2001), the thematic arrows and cycles ("feedback loops" in the original analysis) were depicted in the same way. However, the breaks, which were referred to as "bifurcation points," were not shown as being comprised of conflicting binary-based centers. In the new analysis, thematic helices (i.e., cycles extended by the arrows of

time) have been added to depict how the same basic thematic arguments extended throughout the entire episode and acted to hold together the entire "system."

The thematic development during this argument began with a statement that ebony probably would float if the piece of ebony was placed in a larger body of water. During the initial phase of the argument, students attempted to clarify their claims, while trying to counter the claims of others. As this initial phase progressed, the ebony-would-float side of the argument appeared as if the students' conceptions involved a Piagetian conservation of volume issue. However, as the students moved to the next phases the conceptual issue developed into one of pressure and density, with the introduction of a molecular concept from the opposing side. Each new introduction of evidence or related knowledge claim formed a new binary-based center and thematic break. By the end of the argument, students on ebony-would-float side were stating the water can be compressed with enough pressure based on the logic that if water can be "decompressurized," as with steam, then water can be "compressurized" (thus increasing density). The molecular and oppositional side of the argument added little new information, while maintaining that water cannot be "compressurized."

The concepts comprising both sides of the argument were partly accurate and partly inaccurate. Certainly, the molecular structures and weights of substances affect density. However, the student's understandings of molecules, as depicted in figure 5, involved an inaccurate concept of molecules: molecules tended to be the same size and weight across substances. The notion of pressure, which could increase the density of certain substances (i.e., gases), was not one that depicts pressure as omni-directional, but one that depicts pressure as a unidirectional force (see figure 3). Both of these inaccurate concepts appear to be what diSessa (1993) refers to as p-prims (i.e., phenomenological primitives). Both concepts are situated in common everyday experiences and uses of language (i.e., pressure and molecule as a building block). In addition, both concepts have become subconscious (or pre-conscious) interpretive frameworks that appear to be self-evident truths. Such p-prims create obstacles or borders to developing accurate conceptual understandings by influencing how phenomena, such as floating, are interpreted.

The previous paragraphs demonstrate an analysis that goes into depth in examining the kinds of patterns that contributed to the particular ongoing argument. The significant features involve a synergy of initiating, organizing, and energizing centers that provide for the continuity of cyclic patterns of argument. During these cyclic patterns of argumentation new binary-based centers occur, which, in turn, lead to the emergence of new thematic patterns and increasingly complex concepts.

Extent

The consideration of extent was not addressed in the original publication (Bloom, 2001), other than to make suggestions within the level of classroom scientific arguments. In our present analysis of extent, we consider the broad applicability of metapatterns to be one of the advantages of using a metapatterns-based framework. So, if we consider the previous metapatterns of the analysis, we can apply them to other contexts. Figure 9 depicts a generalized pattern of extension across contexts. For example, we can take the patterns from the density argument analysis ("A" in Figure 9) and apply them to classroom arguments ("B" in Figure 9), in general. As a proposition to be tested, we can assume classroom arguments that allow children to take ownership over their ideas and to express their ideas freely involve similar initiating binary-based centers. Some sort of conflicting binary of two opposing ideas, as the minimum system for a disagreement, will most likely be involved, as well as some combination psychological and emotional factors that comprise an energizing center. The result is a triad of centers: (a) a conflicting binary of ideas (i.e., the argument content binary), (b) an emotional-psychological or energizing center, and (c) a goal center. Any argument forces individuals to return to their own understandings and either seek out new supporting ideas and examples or develop a more cohesive rationale for their stance. As a result, unique thematic patterns can emerge from the introduction of such new material that becomes incorporated into the formation of new binary-based centers.

The same pattern applies to non-argumentative patterns of discourse ("C" in Figure 9), as well. However, rather than possessing a conflicting binary as an initiating center, the emergence and maintenance of extended classroom discourse may involve an initiating center that can be comprised of a commiserate or shared binary (or larger groupings) of ideas. For instance, in the same setting in which the density argument occurred, the students engaged in extended discourse within their groups as they worked on developing a prototype boat during the first class, as well as when they focused all of their class time on developing their portfolio proposals for the boat designs. In these situations, the initiating center was the simulation itself, where they took on the roles of scientists to develop a boat design. The center in this situation took on the characteristics of a unifying binary of present status and goal, in which the present status was continually compared against the goal. In addition, the energizing center was again a triadic binary of ownership, imagination, and emotional stake in the simulation. As they proceeded with their work, the cyclical patterns of discourse took on new thematic patterns that included not only the scientific concepts involved in their boat designs, but also imaginative elaborations on the characteristics of their boats. These imaginative elaborations included various entertainment facilities on the boats with sometimes quite humorous aspects, such as a bar and casino with a drinking age of 10.

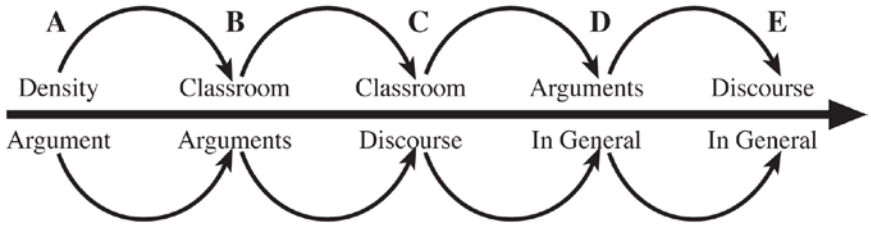

Figure 9. Recursive extension across contexts.

As we extend our analysis to other contexts, we find that similar patterns are required in any argument ("D" in Figure 10) or discourse ("E" in Figure 10) context. Our proposition suggests that some sort of binary-based center is required for discourse to occur. At the same time, our proposition also suggests that a psychological-emotional center is required for any kind of mutual give-and-take discourse to occur and extend over a period of time. Whether we engage in an argument or discussion with a family member, a friend, co-worker, or even a complete stranger, the same sorts of centers may be required for cyclical discourse to occur. The longer the discourse, the more new information will be introduced, which, in turn, leads to the emergence of new layers of thematic patterns.

However, not all social contexts are conducive to extended arguments and discourse. Some contexts are too restrictive in terms of the ability of participants to engage in more free-flowing arguments and discourse. Such restrictive contexts generally occur in hierarchically structured situations, where power and control move from the top layer to the bottom. In classrooms that are controlled by the teacher, arguments, such as the one described here, do not occur. Students are required to raise their hands. Each statement is evaluated by the teacher, and emotional outbursts (i.e., passionate expressions of ideas and stances) lead to reprimands. In hierarchically structured corporate contexts, the same sort of repression of work-related arguments and discourse between the layers of the hierarchy do not occur. The power and control of those in higher layers lead to pressures to conform, obey, and not question those in authority (Wood, 1990). However, if students or co-workers residing in the same layer are not involved in competing for higher status, they may engage in arguments and discourse. However, at this point, the particular context for such conversations moves along a continuum from hierarchy to holarchy. Holarchies are embedded layers where power and control are distributed and shared among participants in the particular context. Obedience, conformity, and not questioning authority are no longer issues in a holarchic context, where individuality, responsibility for oneself and the group, and questioning authority of any kind are valued.

Abstraction

As we consider all of the points that have been made thus far in this section, we come to a stage where we can simplify and generate working hypotheses and principles about arguments and discourse. Figure 10 depicts five generalized principles of discourse. At the top of figure 10, context is depicted as a set of embedded spheres. Spheres denote a sense of containment, as well as a sense of equanimity. The embedded spheres become a holarchy, where the layers denote levels of participation or engagement in the particular context. In this case, the context refers to community, such as a classroom community. A community conceived of as a holarchy is one where power and control are distributed, shared, and negotiated, as opposed to the centralization of power and control at the top of a hierarchy. Holarchic communities provide a sense of equanimity and a safe atmosphere where participants feel free to express their individuality, challenge authority, and develop a sense of responsibility for and ownership of the particular community. However, as mentioned previously, the sense of holarchy lies at one end of a continuum with the sense of hierarchy at the other end. In other words, most situations, whether they are classrooms, small businesses, social organizations, or political entities, lie along the continuum between centralized and distributed power and control. The more the situation lies towards the distributed power end of the continuum, the more conducive the situation is for productive argument and discourse. Even a layer in a hierarchy may take on more of a holarchic sense, depending upon the way in which the particular supervisor or boss for that layer (in the immediately above layer) develops the atmosphere and operation of the layer. In addition, discourse and argument may arise in highly structured hierarchic layers, as when two or more workers may start a lengthy discussion while working. However, in such a case, the discourse usually does not involve the work at hand, but involves some other topic, whether sports or some other common interest. In such cases, we tap into overlapping contexts or communities. Such conversations do not really occur in the hierarchy (in terms of the purpose of that community), but do occur in the community of individuals outside of the work-related hierarchy. The conversations may physically occur in the setting of the hierarchy, but psychologically occur in the context of friendship, which in itself connotes a sense of holarchy. Basically, we can generate a guiding hypothesis or principle that states:

> Our proposition at this level of abstraction suggests that argumentation and discourse, which are meaningful and relevant to a particular community, need to be situated in a holarchically-oriented context. In such a context, participants do not perceive a threat from a higher authority and feel free to express their individuality, question authority, and feel a sense of responsibility and ownership over the ideas and operations associated with the community. Examples of such holarchic communities, include

Google (Ignatius, 2006), W. L. Gore & Associates (W. L. Gore & Associates, 2006), and The Body Shop (Goleman, Kaufman, & Ray, 1992; The Body Shop, 2006).

The move from peripheral participation to full participation may not take a direct path and once participants move through layers of participation towards the center, they may move back and forth towards the center and towards the periphery. Such moves may depend on contextual factors in the community or on a variety of personal factors.

In the original analysis (Bloom, 2001), the notion of providing student control vs. teacher control was discussed. However, the notion of control was not embedded in a generalized or abstract context of a holarchic community. The utilization of holarchic communities as a context has allowed us to develop broader principles and models of the types of contexts that are conducive to argument and discourse.

The three representations in the middle of figure 10 (next page) depict three types of centers required in arguments and discourse, which have been abstracted from our analysis of the data. The first of these centers (from the top) depict the types of binary components of centers required for initiating and maintaining discourse where thematic complexity increases over time. In general, binaries unify or separate. In relationships among people, binaries based on negotiation and sharing tend to unify over time, while binaries based on competition for power or control and on domination-submission tend to initiate conflict, which tend to separate or disconnect over time (Bateson, 1972; personal communication, August 4, 1975). In the argument described in this paper, a conflicting binary acted to initiate the argument. However, the overarching friendships among the students provided a deeper unification, which prevented a dissolution of the relationships and aided in the continuation of the argument over five days. In general, argumentation is initiated by binaries that separate. In other words, our hypothesis suggests that some sort of conflicting binary needs to act as the initiating center for arguments. On the other hand, extended non-argumentative discourse can be based on a negotiative (reciprocal) binary, where participants share some particular idea, belief, emotional reaction, and so forth.

The energy center for initiating and maintaining extended arguments and discourse involves a psychological and emotional connection to the particular topic. Such psychological and emotional connections may involve a number of factors, such as (a) ownership over the ideas generated, (b) anger, (c) inspiration or other stimulating emotion, (d) some connection to the material being discussed, (e) a sense of intrigue, and (f) any of a variety of other psychological and emotional factors involving some sense of passion. In general, psychological "energy" is needed for participants to engage and continue in extended conversations.

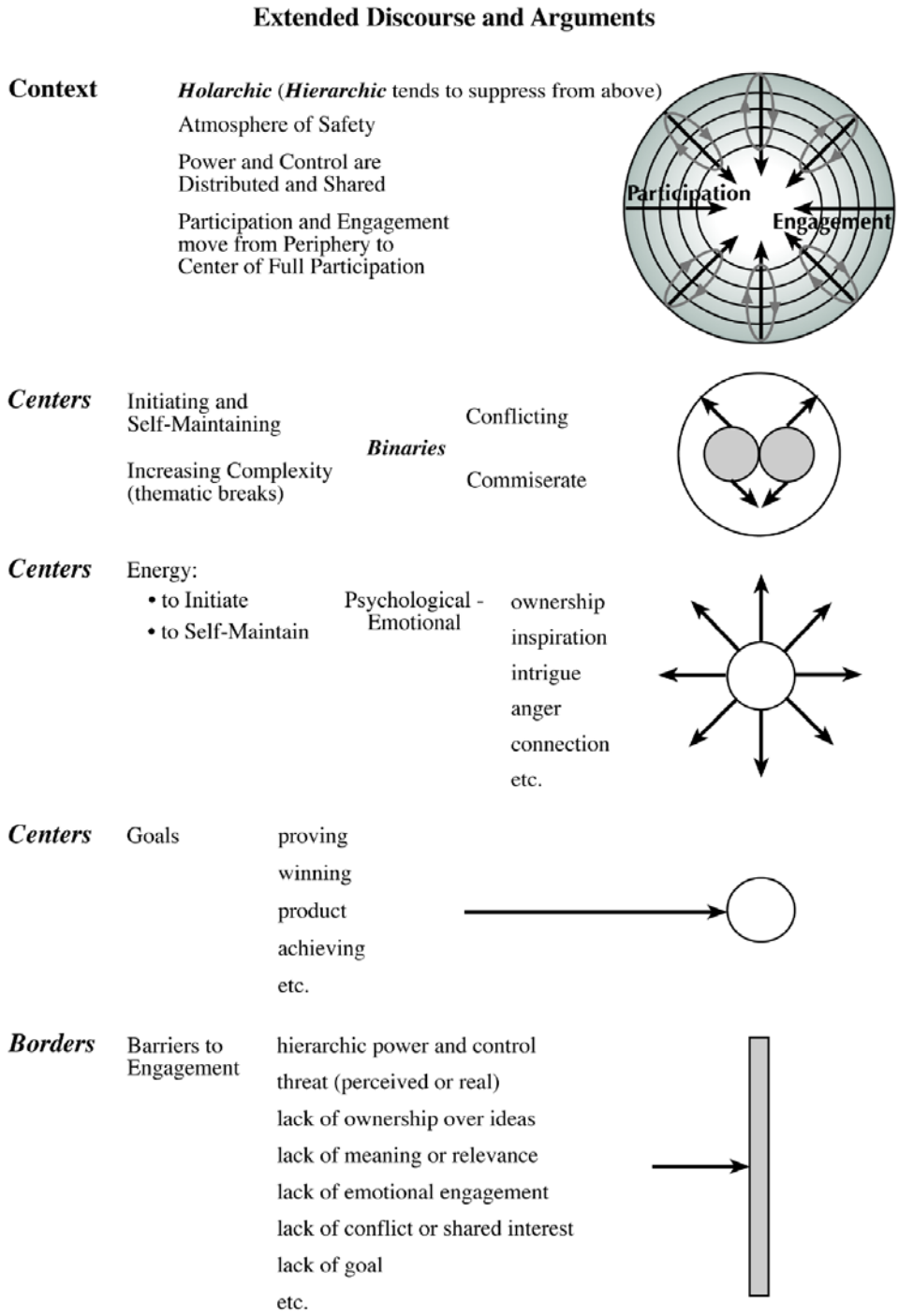

Figure 10. Generalized hypotheses or principles of argument and discourse.

The third type of center required for extended engagement in discourse involves a sense of goal. The goal may lie somewhere along a continuum from a vague sense of sharing one's ideas or winning an argument to a specific achievement, such as the development of a particular product. Everyday chats, where people talk about one thing after another with no clearly apparent goal, generally have an embedded goal of maintaining a friendship or sharing something about oneself. In other situations, competing and conflicting goals may lead to initiating and sustaining discourse. In general, goals as centers serve to initiate and maintain the dynamics of complex activity and discourse, and may even lead to further complexity. In other words, goal-centers can fuel the dynamic processes of much of human activity. Although goals-centers may not be involved in all of human activity, the extent and influence of such centers can be the focus of further research.

These three types of centers—initiating and self-maintaining, energy, and goal—are necessary components to any type of extended discourse. These three centers can form a kind of unified triadic center, which may be composed of various binaries**.** Such a triadic center is a synergy of cognition, emotion, and relationship that serves, for the most part, to engage and connect people during extended discourse. However, there may be instances where extended arguments may result in disconnection among participants. If the initial conflicting binary is not resolved in some way, a disconnection in the relationship may occur. Resolving a conflicting binary generally involves negotiating an agreement, even if the agreement is explicitly or implicitly agreeing to disagree. In the original analysis, the sinking of ebony acted as the attractor, which we are now referring to as a center.

The last hypothesis or principle depicted in figure 10 involves the types of borders or obstacles to extended discourse. Some of these obstacles include not having one or more of the centers discussed previously (e.g., conflicting or commiserate binary-based center, emotional energy center, and goal focused center), where the lack of any one of these centers could prevent engagement. Other obstacles include those related to the context in which discourse occurs. As mentioned, hierarchical structures tend to create obstacles, such as power and control from above that creates an atmosphere that threatens self-expression or the questioning of authority. In addition, if the topics or themes lack meaning or relevance to individuals, extended discourse will not occur. In the example argument discussed previously, the concept of density holds great potential for not being meaningful or relevant to students. However, in this particular case, the students generated ideas that were their own; they had ownership and therefore the ideas were personally meaningful and relevant. So, the notion of meaning and relevance does not lie just in the conceptual or thematic material itself, but in a context in which there is an interplay between the thematic material, the notions of ownership, and the atmosphere that supports discourse.

Summary

In this section, an example of how metapatterns were used in the recursive analysis of a student argument has been used for an *in-depth* analysis of the argument. Following this analysis, the example depicted how such an analysis can be *extended* across contexts to those not specifically involved in science classrooms. The final part of this section provided an example of how the analytical results of the previous two approaches (depth and extension) can be used to simplify and develop *abstractions* in the form of generalized hypotheses, models, or principles. In the final section of this paper, the implications for such a triadic approach to the use of metapatterns and other broad concepts will be discussed.

Discussion

From the previous discussion and example of how metapatterns can be used as an analytical framework, we can see how the use of metapatterns and other broadly applicable concepts provide important tools for analyzing descriptive, naturalistic data. The following points summarize the major advantages of such an approach. In considering these points, it is important to keep in mind that although the term "metapatterns" is being used, other concepts can be used in the same way.

1. ***Metapatterns provide a set of conceptual patterns that are applicable to a wide range of contexts or research topics.*** Since metapatterns appear and share fundamental meanings across all contexts of human experience and subject matter disciplines, they can be applied to a wide variety of research topics (see Volk and Bloom, part I of this paper set).
2. ***Metapatterns act as tools for exposing and identifying a variety of subtle patterns in data that could be easily overlooked.*** As we analyze data, it is often difficult to identify deeply embedded, subtle or implicit patterns that can be working beneath the surface of discourse, interactions among individuals, socio-cultural contexts, and so forth. As we work with metapatterns, we begin to see how particular patterns and the interactions among patterns come into play, where such implicit patterns were not obvious.
3. ***Metapatterns can be used to visually represent patterns and interactions among patterns.*** Since most metapatterns have structural forms as well as functional features, they lend themselves to iconic representations. Non-structural forms, such as time, can be represented with arrows, cycles, or a series of stages.
4. ***Metapatterns provide tools for exposing deeper understandings of data.*** As is evident from the example discussed in this paper, metapatterns can be used to expose more subtle levels of interactions, processes, and other factors. Such deeper levels of understanding in specific contexts are particularly salient in complex systems and situations.

5. ***Metapatterns provide tools for comparing patterns across contexts.*** Where such patterns occur across contexts (as in number 1, above), they also can be used for cross-contextual comparisons of specific sets of patterns. As particular patterns of interactions are elucidated in one context, similar patterns can be identified in contexts ranging from those that are similar to those that are quite dissimilar. Such a process can be described as a transfer of knowledge. Such comparison extend from near transfer to far transfer (Haskell, 2001).
6. ***Metapatterns provide a way for simplifying and abstracting in ways that allow us to develop generalized hypotheses and principles.*** As we identify context specific patterns and their complex interactions, we can simplify the meanings inherent in these patterns in ways that allow us to develop abstract generalizations, hypotheses, and principles.
7. ***The triadic application of metapatterns to depth, extent, and abstraction in data analysis and interpretation provides a way for supporting the validity and reliability of such analysis and interpretation.*** Bateson's (1979, 1991) notion of metapatterns involves patterns that connect across contexts as an epistemology that spans disciplines. As such, metapatterns as an epistemological framework provides a way to both simplify our approach to abstracting basic principles and elucidate highly complex interrelationships. In addition, the recursive approach to depth, extent, and abstraction provides an approach to addressing concerns of generalizability (Denzin and Lincoln, 1998, 2005), since such an approach involves extending the abstractions and deeper patterns of understanding across contexts. If such a process works, the explanations generated in one context may be applicable to other contexts, as well. In other words, as we develop generalized patterns of complex interactions in one context, we may find that such generalized patterns can be found in other contexts, such as competing binary-based centers initiating and maintaining an argument in a classroom, as well as at scientific conferences, business meetings, and multi-national negotiations.

In general, the use of a metapatterns framework in data analysis is a valuable tool for analyzing and interpreting data collected from complex systems. This framework is equally useful in studies of cognition, discourse, social and cultural systems (e.g., classroom and school communities, professional communities), the interaction of physical environments and social systems, educational policy and administrative structures, and almost any other context.

In addition, we can utilize this framework as a basis for generating research questions. Although the specific questions we ask are determined by our specific interests, contexts, and paradigms, a generalized set of questions are presented in Table 1.

In general, such a recursive, metapatterns-based approach provides qualitative researchers with a set of tools that will aid in the depth of analysis and provide a means for developing abstracted principles and models. As emergent properties with functional descriptions, metapatterns have the

Context
• What contexts affect or are affected by the research project?
• How do these contexts interact in the specific situation of this project?
• How is each participant affected by these contexts?
• What patterns characterize each of these contexts?
• How do these contexts conflict with or converge with one another?
• What are the sources (patterns) that serve as conflicting or converging frameworks?
Depth
• What generalized patterns do we see in the data?
• How do these patterns interact?
• Are these patterns comprised of even more specific or subtle patterns?
• How do all of these patterns interact in ways that create a system of interactions?
Extent
• Does this system of interactions appear and operate in other contexts?
• What are the effects of this system of interactions in other contexts?
• What context-specific differences are evident?
• What commonalities occur across contexts?
Abstraction
• Can a generalized model of interactions be constructed that applies to one or more contexts?
• What generalized principles can be formulated to explain and/or predict a particular system of interactions in one or more contexts?

Table 1. A generalized set of research questions based on our metapatterns analytical framework

potential to increase the robustness of our approaches to understanding of the complex systems involved in learning, thinking, classrooms, teaching, and schooling, in general.

In the first paper of this set, we mention the educational value of metapatterns. Certainly, we can conceive of research as a mode of learning. It is not a huge leap to conceive of metapatterns as a focus for learning at all age levels. Although it was not the topic of this paper, such implications for the use of metapatterns need to be considered as we further investigate the utility of metapatterns in our own work as researchers and educators.

Acknowledgements

A version of this paper was presented at the 2004 Complexity Science and Education Research Conference (available in the Proceedings online at: http://www.complexityandeducation.ca).

References

Bateson, G. 1972. *Steps to an ecology of mind: The new information sciences can lead to a new understanding of man.* New York: Ballantine Books.

Bateson, G. 1979. *Mind and nature: A necessary unity.* New York: Bantam Books.
Bateson, G. 1991. *A sacred unity: Further steps to an ecology of mind,* edited by R. E. Donaldson. New York: Cornelia & Michael Bessie Book/Harper Collins.
Bloom, J. W. 2001. Discourse, cognition, and chaotic systems: An examination of students' argument about density. *Journal of the Learning Sciences* 10 (4): 447–492.
Capra, F. 1996. *The web of life: A new scientific understanding of living systems.* New York: Anchor/Doubleday.
Davis, B. 2005. Interrupting frameworks: Interpreting geometries of epistemology and curriculum. In *Chaos, complexity, curriculum, and culture: A conversation* edited by W. E. Doll, M. J. Fleener, D. Trueit, and J. St. Julien. New York: Peter Lang.
Davis, B. and R. Phelps. 2005. Exploring the commons spaces of education and complexity: transphenomenality, transdisciplinarity, and interdiscursivity. *Complicity: An International Journal of Complexity and Education*. 2(1): 1–4.
Denzin, N. K. and Y. S. Lincoln. 1998. *The landscape of qualitative research.* Thousand Oaks, CA: Sage Publishing.
Denzin, N. K. and Y. S. Lincoln. 2005. Introduction: The discipline and practice of qualitative research. In *The Sage handbook of qualitative research (3rd ed.)* edited by N. K. Denzin and Y. S. Lincoln. Thousand Oaks, CA: Sage Publications.
diSessa, A. A. 1993. Toward an epistemology of physics. *Cognition and Instruction* 10 (2 & 3): 105–225.
Doll, W. E. 2003. Modes of thought. *Proceedings of the 2003 Complexity Science and Educational Research Conference*, October 16-18, Edmonton, Alberta (available online at http://www.complexityandeducation.ualberta.ca/conferences/2003/Documents/CSER_Doll.pdf)
Engström, Y. 1996. Interobjectivity, ideality, and dialectics. *Mind, Culture, and Activity* 3 (4): 259–265.
Engström, Y. 1999. Expansive visibilization of work: An activity-theoretical perspective. *Computer Supported Cooperative Work* 8: 63–93.
Engström, Y. 2000. Activity theory as a framework for analyzing and redesigning work. *Ergonomics* 43 (7): 960–974.
Engström, Y. 2001. Expansive learning at work: Toward an activity theoretical reconceptualization. *Journal of Education and Work* 14 (1): 133–156.
Fleener, M. J. 2002. *Curriculum dynamics: Recreating heart.* New York: Peter Lang.
Gitomer, D. and R. A. Duschl. 1995. Moving toward a portfolio culture in science education. In *Learning science in the schools: Research reforming practice*, edited by S. M. Glynn and R. Duit, 299-326. Mahwah, NJ: Lawrence Erlbaum Associates.
Goleman, D., P. Kaufman, and M. Ray. 1992. *The creative spirit.* NY: Dutton.
Haskell, R. E. 2001. *Transfer of learning: Cognition, instruction, and reasoning.* San Diego, CA: Academic Press.
Ignatius, A. 2006. Google: In search of the real Google. *Time Magazine* 167 (8): 36-49.
Maturana, H. R. and F. J. Varela. 1998. *The tree of knowledge: The biological roots of human understanding* (rev. ed.). Boston: Shambhala.
The Body Shop. 2006. Online at: http://www.thebodyshopinternational.com/web/tbsgl/about_reason.jsp.
Volk, T. 1995. *Metapatterns: Across space, time, and mind.* New York: Columbia University Press.

W. L. Gore & Associates. 2006. Online at: http://www.gore.com/en_xx/aboutus/culture/index.html.

Wenger, E. 1998. Communities of practice: Learning, meaning, and identity. New York: Cambridge University Press.

Wood, G. H. 1990. Teachers as curriculum workers. In *Teaching and thinking about curriculum: Critical inquiries* (pp. 97–109), edited by J. T. Sears and J. D. Marshall. New York: Teachers College Press

About the Authors

Tyler Volk is associate professor of biology and science director of the environmental studies program at New York University. Address: Biology Department, 1009 Silver Center, 100 Washington Square East, New York University, New York, NY, 10003-6688. He has a long-standing interest in the structures and functions of systems at all levels, and, in addition to the book *Metapatterns Across Space, Time, and Mind* is the author of *Gaia's Body: Towards a Physiology of Earth* and *What is Death?: A Scientist Looks at the Cycles of Life*. Phone: 212-998-3736. Email: tyler.volk@nyu.edu. Website: http://www.nyu.edu/fas/biology/faculty/volk/index.html

Jeffrey W. Bloom is professor in the Department of Teaching and Learning, College of Education, Northern Arizona University, Flagstaff, AZ 86011. He specializes in elementary science education. His research interests involve complexity in thinking and learning, teaching for complex learning, and classroom and school communities. He can be reached at 928-523-0665 or at jeff.bloom@nau.edu. His personal website is at: http://jan.ucc.nau.edu/~jwb2. His project website is the Exploring Science Site at: http://elsci.coe.nau.edu.