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Emergent Pedagogy: Learning to Enjoy the Uncontrollable— and Make it Productive

Anne Dalke, Kim Cassidy, Paul Grobstein, and Douglas Blank

Departments of English, Psychology, Biology, and Computer Science
Bryn Mawr College

Despite all the work done in progressive education, many teachers continue to imagine, and are often encouraged to believe, that the most effective and efficient method involves a structured environment, in which the instructor imparts carefully packaged information to students, to digest and incorporate into their existing knowledge base. Much of our frustration as teachers may arise from the effort it takes to achieve such a classroom; we are trying to fit ourselves and our students into a pattern that, we will argue here, may be in conflict with others that develop more spontaneously and could be better suited to a range of pedagogical objectives.

There has, of course, long been extensive discussion within the pedagogical community about ideal teaching and learning environments. Contemporary educators who presume that their primary task is to help students enhance their abilities to think independently have followed the strong arguments of Dewey (1938) and Freire (2000) for less centralized and less rigid structures, including hands-on practices, multiple ways of knowing and thinking, group interactions, flexible specification of desired outcomes, and astute editing and feedback by teachers (see, for example, Duckworth, 1996). Particular attention has been paid, in recent years, to the ways in which classrooms networked for computers and internet access have contributed to collaborative work (Corcoran, 1997). While some environments and educational communities have been made more

interactive, high stakes testing such as that instituted by “No Child Left Behind” has created a push back against these approaches and renewed calls for quantitative measurements of achievement. New arguments are needed to ensure that interactive teaching is not just pursued, but strengthened.

What we have to add to this conversation is a novel rationale for such a position. It derives from rapidly developing interdisciplinary inquiries in the sciences and social sciences into what are known as "complex" or "emergent" systems (Minsky,1986; Waldrop, 1992; Resnick, 1994; Johnson, 2001; Buchanan, 2002; see also “Complex Systems” and “Emergent Systems: A Discussion”). Emergence is by now a well-developed intellectual perspective, and courses in the topic are increasingly being offered at the collegiate level, such as one currently cross-listed at our college in the biology and computer science departments (see “Emergence Course”). Materials to illustrate emergence are also beginning to be made available for curricular use at pre-college levels (Wilensky, 1999). What we are offering here is the notion that emergence is relevant to pedagogy itself. Emergence nicely illuminates and can further advance the discourse of experiential learning.

We first provide an introduction to the concepts of "emergence" that are relevant to discussions of pedagogy, and make explicit their implications for classroom practice. Using emergent systems as a model of teaching and learning makes at least three significant contributions to our thinking about teaching, in three very different dimensions:

- It invites us into awareness that the brains of individual students and teachers operate as emergent systems that are neither possible nor desirable to control fully.

- It helps us appreciate as well that the activities and benefits of a classroom are not limited to individual interactions between teacher and student. Interactions among students are equally important; students and teachers are collectively contributing to a somewhat unpredictable project with an insistently social dimension, which is in turn crucial to the individual learning of all involved.
- Finally, emergent pedagogy encourages us to consider more carefully the relations between the individual classroom and the larger educational community of which it is a component. The need for re-thinking in this realm is particularly obvious for matters of assessment and its relation to the current focus on testing.

In the middle sections of the paper, we describe and reflect on our own experiences of teaching in these terms, focusing on a Summer Institute on "Exploration and Emergence" that was explicitly aimed at exploring the relevance of this conceptual framework for pre-college education. We consider ways to deal with some of the challenges emergent pedagogy raises for the assessment and evaluation of student learning.

We conclude with a critical overview of how well emergence works as a framework for understanding and facilitating both individual learners and classroom structures. We consider the degree to which less deliberately structured classrooms can be effectively implemented in the current educational climate and make some suggestions for how to deal with such problems. Throughout this essay, our voices (those of a psychologist, biologist, literary scholar and computer scientist) are blended with those of our pre-college partners in the Summer Institute, as we emergently explore together the unique benefits and challenges of emergent pedagogy.

I. Emergence As A Contemporary Conceptual and Pedagogical Perspective

The advent of easily available and usable computing technology—like the development of earlier scientific tools such as the telescope and the microscope—has enabled a whole host of new observations. Because of the rapidity with which computers can perform well-defined calculations, they enable the exploration of the consequences of relatively simple interactions between relatively simple things in ways that were not previously possible. For example, animal migration can be studied by examining the patterns of habitation that emerge when large numbers of simulated animals each adopt a certain rule, such as "move to a new feeding patch when the food drops below a certain density." These parameters can then be experimented with to see what happens. Often we are able to quickly discover that what at first looks like complicated patterns of coordinated movement created by an organizer might in fact be the result of a simple, non-centralized set of interactions. In a variety of different disciplines, this new computer-based capacity for observations has generated significant insights into phenomena long believed too complex for serious analysis.

Out of these observations comes a new and quite general conceptual framework that can be used to explain phenomena ranging from the boiling of water to the branching of trees to the evolution of consciousness. This framework explains phenomena by way of emergence, a pragmatic perspective on puzzle solving that assumes no conductor (no one anticipating future outcomes), but only an originally -- and still largely-- undirected play of entities, which become parts of larger entities which become parts of still larger entities (and so on). These are some essential, common, and perhaps surprising

characteristics of emergent systems (Minsky, 1986; Waldrop, 1992; Resnick, 1994; Johnson, 2001; Buchanan, 2002):

- Systems of this kind frequently evolve effectively “on their own”: relatively simple bi-directional interactions between relatively simple elements produce patterns of coordination and a substantial degree of organization.
- Some degree of autonomy and "randomness" in the behavior of the elements is an important ingredient in the establishment, function and continuing evolution of ordered complexity.
- The future of such systems can be determined only by playing them out. There is no formula for completely predicting in advance what the system will look like in the future.

These principles of emergence hold in a wide variety of different situations, and have been examined in fields ranging from physics and biology to psychology and animal behavior. They are also relevant to pedagogy, challenging us to think about education not in terms of carefully pre-planned, hierarchical structures, but rather with an understanding that complex organization has a high probability of arising out of the bi-directional interactions of autonomous, somewhat randomly behaving elements. To put it differently, hierarchy is not the only conceivable form of organization in educational environments. It may be neither necessary nor preferable in these interactive systems that can achieve substantial organization and evolution without the direction of a central authority.

This claim has immediate implications for classroom teaching. An awareness of emergent process might enable those of us currently committed to clearly structured and

centralized classrooms to understand why it is difficult to achieve our "optimal" organizational structure: we may be working within (and against) an emergent system that is moving towards quite a different pattern than the one we have in mind. Acknowledging the operation of a distributed process may make it possible to leave some of the work of effective organization for learning to the system itself, rather than placing the sole obligation for it on ourselves.

In short, the emergence perspective offers a potential framework and theoretical support for a rethinking of pedagogy that begins, not with a concept of pre-planned structure and hierarchy that we then, in the face of difficulty, relax, but rather with the notion that the interaction of autonomous elements can lead to a productive, self-organizing structure. We do not at all suggest that teachers are irrelevant in an "emergent" classroom, nor that emergent pedagogy makes teachers indistinguishable from students. Nor do we believe that the emergence perspective is a license for a lack of teacher preparation or inattention to other responsibilities of teaching. We do think, however, that the roles of teachers can be quite profitably re-imagined from the perspective of distributed organization.

In an interactive system, the teacher's primary task is not to conceive and implement organization *de novo,* or in isolation from other participants in the classroom. Instead, the teacher's distinctive role is to create the kind of rich environment within which productive organizations can emerge from the interactions of all participants. The teacher has the additional task of encouraging, facilitating and nudging a process of emergence, of helping to assure that it evolves in directions that are engaging and productive for all. Finally, the teacher is the major synthesizer and reflector, the one who

has primary responsibility for making classroom activities visible and meaningful to all participants.

The demands on the teacher may actually be greater in an emergent classroom than they are in a hierarchical one. Preparation requires anticipation of a wide range of possible directions. Implementation requires close on-going interaction with students, as well as a substantial degree of flexibility. On the other hand, taking emergence as the norm rather than as something to be fought against offers teachers themselves the opportunity to participate in and enjoy the extraordinarily rich and generative capabilities of a distributed system. Planning then becomes a process of imagining experiences and facilitating interactions that will lead to relevant, but to some extent unknown, outcomes. The classroom thus becomes a place for discovery not only by students, but by teachers as well. Most importantly, teachers become role models for the kinds of inquiry in which we want our students themselves to be engaged.

Another important contribution of emergent thinking to pedagogy is the way it broadens the lens to include the group level. When we think only in terms of enhancing students' ability to think independently, the focus of teachers and students tends to become narrowed to individual achievement. Recognizing that growth and change occur because of *interactions* among elements highlights the importance of contact among individuals, and of overall group dynamics. Students need these interactions to provide experiences, viewpoints and stories alternative to their own, which will enable them to alter their individual stories in new ways. Conceptualizing the classroom environment in terms of emergent thinking highlights its inherent social nature, and invites us to attend to

the role of the group in individual performance, as well as to the contributions individuals can and should make to the learning of other participants.

In addition to its significance for rethinking both the classroom and interpersonal dynamics within it, emergence helps us to see individuals in new ways. Brains, which constitute the agents in the emergent system that is the classroom, are themselves well described as emergent systems. They can be seen as having two somewhat distinct information-gathering systems, each with its own particular style (Grobstein, 2003b; Grobstein, 2005a). The two styles correspond, roughly, to conscious analytical processing and unconscious intuitive learning. The latter is the more fundamental, in the sense that it is always active whether or not one is aware of it (in oneself or others); both students and teachers are always, intentionally or unintentionally, learning this way. Intuitive processing may also be better than analytic work in situations involving larger numbers of variables and uncertain cause-effect relationships (Damasio, 1995).

Conscious analytic processing is the "reflective" system, the one that works in terms of ideas, principles, and simple cause-effect relationships. It comes into play when students (and teachers) are encouraged to "think about" what has been experienced, and are able to generate new insights from them. It may, however, also be the system that is responsible for much of the "in one ear, out the other" phenomenon that results from "by rote" pedagogies that fail to productively engage intuitive processes. "Understanding," as the goal of the educational process, is frequently equated with analytic processing, but may be better understood as the outcome of a dialogue between the intuitive and the analytic systems, a shared effort to generate a common story (Dalke & Grobstein, 2006; Grobstein, 2005a). It is the dynamic interaction between the two systems that yields

learning in its richest sense. The bi-partite character of the brain implies that understanding is itself an emergent process, the result of an essential interplay between experience and reflection. The objective of an emergent classroom is to facilitate continuing interaction between intuitive and analytic aspects of thinking as a fundamental aspect of the learning process.

Several additional characteristics of brains are highly relevant in the present context, and may contribute to our understanding of why an emergent classroom organization is effective (Grobstein, 1994; Grobstein, 2003a; Grobstein, 2005b):

- Brains have evolved as active information-gathering devices: they simultaneously act and make predictions about the consequences of their actions based on internal models. In its most fundamental sense, learning occurs when the observed consequences of actions are inconsistent with the predictions of the models, and so require change.
- Information-gathering capability of this kind, built into the brain, is an intrinsic property of all learners and of all teachers.
- Information-gathering capability of this kind has an unpredictable character and will proceed differently in different individuals.
- The information-gathering capability is a widely distributed property of the brain and so can not easily be deleted. It can, however, be inhibited by experiences that suggest it is unproductive. The educational task is to sustain and make use of this intrinsic capability rather than to suppress it.

Emergent classrooms, with their emphasis on autonomous, explorative interactions, may be particularly inviting to these information-gathering brains.

Thinking about the minds in our classrooms as emergent systems has several important implications for pedagogy. As emergent phenomena with different (genetic) starting points and subsequent (experiential) influences, individuals differ from one another to varying degrees, have their own inclinations to organization that may or may not accord with the inclinations of others or the collective organization, and reflect a degree of autonomy and randomness. Accordingly, they evolve in ways that cannot be fully predicted in advance.

Several additional pedagogical principles follow from these basic characteristics of brains as emergent systems:

- Both students and their teachers need to have space, opportunity, and room to "explore”-- that is, for active learning.
- Students and teachers are co-learners and co-teachers.
- Teachers have a distinctive role to play in assuring that all idiosyncratic learners are supported.
- What is essential is not outcome but developmental process.
- An important criteria for content selection should be its usefulness in facilitating exploration.

Just as the emergent perspective alters but does not eliminate the role of the teacher, so too does it alter but not eliminate the significance of course content, by placing it in context. Rich content is essential for the dynamics of the emergent classroom, and should be selected in order to facilitate the exploratory process of education. An important presumption here is that the point of education is to help students become more effective independent inquirers, rather than to train them in

particular specialized skills, or to infuse them with sets of information or particular ideas. This presumption has important implications for the broader educational context, including issues of assessment, within which successful emergent pedagogy needs to be pursued.

II. Case Study: Trying It Out With Teachers as Students (and Vice Versa)

During the summer of 2003, we convened a Summer Institute for urban public school teachers called "Emergence and Exploration: Bridging Cultures in K-12 Curricula." While the Institute was advertised on the web, most participants came to it either from word-of-mouth recommendation or their own previous attendance at teacher institutes at Bryn Mawr College. The teachers taught different subject matters, at all grade levels, at a wide variety of school sites. They received a small stipend, a small grant to their classroom for materials, and continuing education credit. Most participants were self-selected and participated primarily because of an interest in improving their classrooms. (For Institute materials, including the extensive work and comments of participants, see “Emergence and Exploration Institute”).

While we had multiple goals for the Institute, our central intention was to introduce teachers to the idea of emergence so that they could engage the concept in ways that would be helpful in their own classrooms. We imagined that emergence might be useful to them in at least two forms. One was as a viable, alternative explanation of phenomena formerly explained with a more centralized, top-down causal structure. This was the content dimension of our seminar; it included presentations on topics as diverse as tree branching, ant behavior, evolution, problem solving, emergent art and writing, and

racial segregation. Our second goal was to use emergence as a language for talking about pedagogical strategies. We invited teachers to use an emergent structure for their own curricula and classrooms, providing an alternative to the "banking" method (cf. Freire, 2000), in which the teacher functions as the sole director of learning, from whom knowledge is “efficiently” passed in a downward direction.

We attempted to accomplish these goals in several different and interrelated ways. We showed teachers how emergent models might be used to explain various phenomena. For example, a biologist demonstrated how the apparently "intelligent," goal-directed branching of plants could be explained using a very simple rule in a series of local interactions. A mathematician invited participants to imagine themselves as a colony of social insects: how would they organize themselves to achieve a task, such as randomly gathering food into a single pile? Most of their initial solutions involved a hierarchical structure, with a director, a plan, and assigned roles for each member.

Playing with a computer program from the Netlogo Model Library (Wilensky, 1999), which simulated the action of an ant colony, participants then learned how the "swarm intelligence" of an insect colony gives rise to a complicated social structure, in which various tasks are completed without any of the ants "understanding the larger picture." The computer-generated "ants" created a single pile of food, for instance, without a foreman, a designated spot, a shared vision, or even a description of the task to be accomplished.

Participants learned that similar processes -- simple set of rules governing individual behavior -- enable social insect colonies to find food, build nests, efficiently divide labor, feed their brood, and so forth. They learned about the characteristics of self-

organization: the uses of both negative and positive feedback (rules that promote or discourage insects to form structures, such as pheromone trails) and the effects of stigmergy (altering the environment in order to signal others). They learned about the amplification of fluctuations (the ways in which random exploration can enable the discovery of new solutions). And they learned how productive multiple interactions -- of many ants in a swarm, as well as their many direct and indirect interactions -- can be. Afterwards, participants described the analogous behavior of their students, who "followed certain patterns of behavior" without instruction, "attracted certain individuals in their cooperative groups," and "seemed to know instinctively which groupings are best for them."

We also exposed teachers to ways that emergence might be useful outside of scientific disciplines. We invited our participants into "stop-action" dramatic performances, in which the audience could re-direct the plot. In this small group activity, participants crafted a scenario to demonstrate a difficult behavioral problem that they had encountered in their school, including its resolution. As the scenario was performed, members of the audience could stop the action, either to change or question the behaviors of the actors, or in order to articulate what was going on in their heads. As a result of the interventions, the scenarios went in unanticipated directions and new complexities were raised; participants felt that the scenarios often ended in new and better places. The performances, the audience participation, and our conversation with them afterwards clearly highlighted two central themes of emergent pedagogy: how we often act based on intuitive feelings, without knowing exactly what they are or what will follow from them; and how a very small local intervention can make a big difference in the classroom.

In another session, we explored with participants a variety of ways in which both painting and poetry-writing might be generated spontaneously by an interactive process that “loops” between the analytic and intuitive processes of an artist’s brain, as well as interactively among brains in a group of collaborators. We learned about "Renga," a new digital method of image creation in which artists exchange images simultaneously and repeatedly, altering one another's work as they go along (see “Project Renga”). Using applets such as "Exquisite Corpses" (see “Exquisite Corpse”), we experimented with similar methods of generating our own "emergent writing," in which a phrase written by one writer was used to call forth an intuitive association in another. As participants "quoted" from or added to their colleagues' work, the new "poems" that emerged from the interaction were sometimes delightfully random, sometimes surprisingly organic and cohesive.

In addition, we provided the opportunity for participants to play with computer models of emergent systems so that they could see how they worked and explore themselves how they could be used as part of a curriculum to facilitate discovery of the properties of emergent systems. The character of the computer simulations itself is worth some explanation, since it helps to illustrate the concept of emergence and is a good and easily accessible way both to learn more about it and to implement it in classrooms.

The system we used is the most recent descendant of a long line of educational computer tools. Logo, the original of these, is a simplified programming environment for children and was designed in the 1960s by a team lead by Wally Feurzeig at MIT. Later, Seymour Papert added the concept of a small robot that, using the Logo language, could be instructed to draw simple and complex pictures on a piece of paper. The robot came to

be called a “turtle.” Much later, Mitchel Resnick applied the Logo philosophy to thousands of graphical turtles, each moving independently and simultaneously on a computer screen. His system, StarLogo, was specifically designed to allow children to explore ideas in emergence.

In our workshop we used a more recent implementation of StarLogo, Uri Wilensky’s NetLogo. NetLogo is free for educational use (Wilensky, 1999). Since NetLogo is written in the Java programming language, it will run on most computers over the World Wide Web. NetLogo comes with many "case studies" that allow students and teachers to load a predefined model, pose questions about it, create new experiments, and make predictions about what may happen.

For example, in one session of the Institute, we explored patterns of racial segregation using a model developed in the Netlogo environment (see “Racial Segregation Model”). In this model, two thousand red and green turtles are randomly distributed on a grid. Each turtle has a slight “preference” for being around like-colored turtles: A red turtle that finds its neighbors to be at least 30% red-colored will be “happy.” If its neighbors are more than 70% green-colored, it is “unhappy.” As students click on the “go” button to start the simulation, all “unhappy” turtles move to a random location. The process repeats until all turtles are happy. Even though these turtles prefer just 30% of their neighbors to be like-colored, the surprising result is neighborhoods that are sharply segregated.

Using this model enabled our participants to see how unexpected outcomes arise out of individual decisions: choices made on the "small, local” level get translated into unexpected patterns on the “city” or "global" level. We talked at length with the teachers

about the ways in which decisions based on preference (for neighbors like ourselves, for instance, or for teachers who could recognize our children's potential) could end up creating fixed patterns of discrimination in which people refuse to recognize the worth of people different from themselves.

Our modeling of emergent systems in the Summer Institute was not limited, however, to computer simulations. We also tried to model forms of pedagogy that were emergent, both in the structure of our sessions and in our interactions with participants. We were particularly responsive to new concerns and interests, setting aside planned lessons, for instance, in order to make room for the exploration of “tangents” as they arose. Because we gave the unique perspective of each participant a good deal of autonomy, sessions sometimes went in unexpected and enriching ways. We also asked participants to prepare a final project, using the ideas of emergence either in its structure or content, which they could take back for use in their schools.

Our ways of structuring work times and our uses of particular technology were also intended as models of emergence. For instance, we asked the teachers to create their take-home project using a *wiki wiki web (*"*wiki*" for short): a set of web pages that operates as a meeting place for working on common interests. *Wiki* systems are fundamentally editable web pages that encourage comments and updates. Simple to learn and use, they aim to provide an accessible and transparent way to publish, collaborate, and exchange ideas with others over the web. A deliberate attempt to move beyond having a "webmaster" who has centralized control of a website, *wiki* is intended to enable distributed teams to work together productively.

Wiki had several advantages for our purposes, the biggest of which was that it allowed for easy editing and collaboration. Formatting a web page in *wiki* is more transparent than traditional languages for web-creation, and therefore easier for teachers to use right away. *Wiki* pages are also available on the web as soon as they are made, and thus accessible to others without delay. By having teachers always active both during "informational" sessions and in creating projects of their own, we were providing them both with direct experiences of the benefits of active learning and tangible experiences of the intrinsic nature of active exploration. When sessions were more interactive, participants were more engaged and didn't notice that they were working well beyond the allotted time.

III. What Emerged

On the final day of the Institute, when our participants presented the wide range of projects they had designed to take back to their classrooms, it was heartening for us to see how each one demonstrated an understanding of possible applications of emergence. Their projects included an "emergent" lesson on teaching parts of speech (by asking students to play with different words and "morph" nonsense sentences); an invitation into "new ways of expressing yourself" (for students in special education); pages called "surprised by learning" (which showcased a range of hands-on activities), "interacting with the text" and "digging in deeper" (using multiple strategies in the science classroom). There were also projects on "teaching techniques for student motivation," "pond ecology," "emerging scene" (designed to allow students to create a visual and written interpretation of a photograph), and "genealogy" (which explored the relationship

between that topic and diversity, while attempting to balance literacy, science, mathematics, social studies and technology).

As we expected, the projects varied in how much participants embraced the topic of emergence. Almost all seemed to incorporate at least some aspect of emergent pedagogy in a meaningful way. Many incorporated hands-on activities that involved interactions among their students. A good proportion included activities where the outcome was not pre-determined, but would come about from the unique interactions of groups or individuals. Of note, however, was that most teachers imposed more structure than would be consistent with a completely emergent approach. Almost universally, they assigned members to groups, and roles or tasks for each person within each group. The lesson designs also tended to be rather prescriptive in terms of process, rather than letting the process emerge freely from the group's interactions.

It is probably not surprising that a two-week exposure to emergence did not eliminate all hierarchical structures in lesson plans. The incomplete but nonetheless significant impact of the emergent perspective was clear, for instance, in one particularly strong project involving pond ecology for a high school biology class. This curriculum involved a series of interactive mini-labs, in which small groups of students would design a series of experiments to determine the biotic and abiotic factors that kept a pond functioning. The information to be gathered and how to gather it was left to the group. Candidate ideas included identifying plant and animal species, performing tests of water quality and measuring water temperature and pH. Students would also be assigned to create a virtual biome on NetLogo, where they would identify relevant biotic and abiotic dimensions of the pond, play with settings of these dimensions in repeated simulations,

and then look at how these simulations compared to their “real life” observations. Both the approach to content in this curriculum and the approach to the processes that were allowed to unfold were fine examples of how concepts of emergence might be transferred to a high school classroom.

Even more striking than such projects (and, in line with emergent thinking, a far better index to the value of the time we spent together) were the very rich discussions generated throughout the two weeks of the Institute. Given our emergent framework, the theme of patterns arose frequently. We had laid the groundwork by asking a series of abstract questions about where patterns come from: Do we impose them on the world, or are they there for our perceiving? Can we be open to surprising patterns, ones we don't expect to see? Or can we only see the patterns we look for? Are all the patterns we recognize good ones? (What about the categories -- especially the labels of disability -- that school systems assign to kids?) Do we have more free will in "bottom-up" systems, such as those described in emergence, than when an architect designs or controls what is happening?

One afternoon we presented participants with an abstract painting and asked each of them to interpret it. As we expected, unique individuals interacting with the environment produced an unpredictable set of responses, which we then compared and discussed. (For the image and participants’ reactions see “Emergence and Exploration Institute Forum”). Quite significant was the recognition, early in this session, that the patterns we identified were revisable, and that it is the task of education to promote such activity. As one participant said, “I will go out on a limb and suggest that the patterns we

impose on the world are the ones we can change if we want to. I will also suggest that changing patterns is the most important work we do as educators."

This insistence that patterns, randomly generated, could be altered by education became a *leitmotif* of the Institute. By inviting teachers to be active (by "experiencing" life as an ant, or reading a picture) and then asking them to reflect on those experiences through discussion and written work, we were inviting them into the interplay between the two different, complementary aspects of learning: intuitive experience and analytical reflection.

Teachers were able to experience first-hand how each one of them brought a distinctive perspective to the interaction and how they (and the students in their classrooms) might be altered by sharing these distinct perspectives. As one put it,

> What I liked most about yesterday's class was . . . how we all looked at the same image, yet came away from it with such varied responses. The idea that the picture represented some aspect of life for so many fascinated me as well. As the participants read their comments I saw a pattern emerging. Was the seed for finding a pattern in the picture planted and did I miss it?

The teachers readily observed how the patterns they perceived were affected by their interactions with others.

IV. Reflections on our Experiences

For some of us, taking an emergent approach to pedagogy was a long-time practice; for others it represented a significant departure from our usual teaching style -- so we were watching with a particularly critical eye as the Institute unfolded. One

concern which arose over the two-week period was that the teachers were not truly collaborating, not really working together to create new ideas and approaches that resulted from building on one another's ideas or from the synergistic interaction of different ideas. Their collaborations seemed to some of us largely limited to helping one another master aspects of technology, dividing up labor ("I'll look for links about genealogy, while you find a good image"), or editing for spelling and grammar.

It was particularly difficult to get the teachers to take advantage of the collaborative properties of the *wiki* philosophy. For example, on the second afternoon of project work, the teachers' assignment was to go onto each other's *wiki* pages and make suggestions for changes. But -- with various degrees of politeness -- the participants refused to alter one another's work. Many of them were plainly uncomfortable doing so. While scientists and social scientists frequently collaborate in such ways at the collegiate level, such activities are not part of the pre-college education culture. Some teachers, clearly intimidated by others in the group, were particularly reluctant to touch others' work for fear of rebuke.

Most of the teachers really did **not** want to have their work played with by others. This reluctance seemed largely to have to do with the public nature of the *wiki* documents: because the pages were so easily accessible to others, and because we had identified their pages with their names, participants wanted to control the public face of their creations. (We had a similar experience as we wrote this paper: one of us was quite eager to use *wiki* as the site for crafting multiple drafts of the essay; another was equally reluctant to have the thinking-aloud of others attributed to him and accessible to others for alteration in a public forum, before he had reviewed and approved the draft.)

This resistance to web collaboration formed a sharp contrast to participants' high level of interaction and eager exchange during our discussions. In fact, participants reported being "struck by the many ways that learning took place in collaboration": "I liked the interaction with the system, but, I enjoyed the interaction with my neighbors and instructors as well."

It seems that when little was at stake -- little or no evaluation, no giving up of control, no "final" product to which a name was attached, no alteration of ideas without the consent of their originator, no pressure to accept changes -- then the participants liked to collaborate and did so with enthusiasm. But when the stakes were raised -- when participants expected to be held individually responsible for their work, or evaluated for it -- then they resisted collaboration.

The pattern we observed also highlights some of the problems in instituting an emergent pedagogy. It is easier to achieve a more emergent classroom when the goals are not narrowly defined and based on individual outcomes, and when there is less emphasis on a final project. In addition, emergence requires a good deal of trust, both in the idea of emergence itself, and in one's collaborators. Participants need to believe that the product of their interactions with others will be better than what would have occurred without them. This in turn entails trusting that their partners bring something worthwhile to the interaction. We know we were successful in engendering this trust in both the process and its practitioners for at least some of the participants in the Institute. As one of them said,

> How will the past two weeks affect my classroom? Well, I think I am more respectful and appreciative of the emergence of each person. I can view, not only

> the evolving child as a special and beautiful process, but also how that process influences the evolution of the class. This process is not 100% under my control (not even 50%), but that is fine. I can trust that the process will lead to a more creative class.

Some of us were also worried about our use of easily manipulatable web technology. The teachers were not required to work exclusively on *wiki* in the creation of their final projects, but all of them did. Afternoons were largely spent tinkering with web pages: their primary activities included finding images and links, and manipulating images and font color. Participants seemed to thoroughly enjoy the aesthetic dimensions of easily creating attractive pages. These activities are not trivial, but we found ourselves asking whether they came at the expense of deeper thinking about pedagogical change. Had we invited the teachers to avoid hard conceptual work by replacing it with the playful work of technical logistics? Some of these web-based projects demonstrate little evidence of engagement with emergence; they were just a collection of images and links. Other projects, however, embraced emergence in the curricular design, and the web tools became an effective way to encourage those interactions.

The teachers' own perspectives did not reflect our concerns about the value of using web technology for teaching. They described a great deal of pleasure and satisfaction in playing with new software. Learning to reconcile our views on emergence with the experiences of the participants has helped us to rethink the ways in which we evaluate the outcomes of the work we are doing as teachers. Perhaps emergent pedagogy really does work even -- **or only?** -- if what we intend doesn't fully come to pass quite as we intended it**.**

Another interesting finding that emerged from our examination of the final projects was that we had been more successful in teaching emergence as pedagogy than as content. While most of the web projects incorporated emergence in their style of pedagogy, almost none of them used emergence to explain phenomena, either in science or writing. Perhaps this was because participants rejected emergence as a satisfactory explanation of the content, rather than the process, of what they were teaching. One teacher observed, for instance,

> I was a little curious about what was driving the behavior of the images depicted in NetLogo. It is interesting to note that out of the chaotic behaviors demonstrated by similar entities an almost harmonic behavior emerges in the presence of a group. What I found lacking was the absence of an accompanying explanation that would satisfy my curiosity about why entities behave in this manner. I mean if the programming that mimics the action is based on simple human observation, it still does not offer an adequate explanation of behavior.

V. Matters of Assessment and Evaluation

A pedagogical approach that identifies learning as the product of local interactions between unique, independent agents -- and so, by design, produces results that are not fully predictable in advance -- raises a number of important questions about how to assess and to evaluate what has occurred. It is in this realm that classroom practices and broader educational policies importantly interact. Assessment is commonly described as a formative process designed to support the learning of meaningful academic content. It differs from evaluation, where the focus is summative and involves judgment

about the attainment of some standard level of performance. Assessment can be used to determine how well educational goals are being met and how to alter instruction to meet those goals more effectively. Evaluation, on the other hand, is an effort to pass a definitive judgment on the achievements of particular students and, in many cases, on particular teachers and pedagogical practices as well.

Emergent pedagogy certainly is consonant with the goals of assessment, although it may pose some unique challenges in the development of effective forms of doing so. For instance: who determines the outcomes of learning? Pre-service teachers are specifically taught to articulate learning objectives for their classrooms as part of the lesson plan, and these objectives form the basis of their assessment at the end of a unit of study. Using an emergent approach -- in which goals are not entirely pre-defined -- means that assessment cannot be based entirely on the comparison of outcomes to a fully pre-specified set of objectives. To the extent that both teachers and students take responsibility for the outcomes of their learning, that those outcomes are indeterminate, and that knowledge emerges from the distributed system of the classroom, there is a need to think more deeply about whether outcomes can both be articulated beforehand and evaluated afterwards.

The key here, we believe, is to recognize that there are ways to define both "objectives" and "outcomes" in terms other than the acquisition of particular content knowledge and specific skills. Emergent pedagogy involves an acknowledgement that engaging in a process of open-ended exploration may itself have benefits in terms of developing more general inquiry skills. In these terms, one needs to recognize and be prepared to assess in students (and teachers) increasing sophistication in the processes of

inquiry themselves. This approach is consistent with a current movement known as “dynamic assessment," in which the most accurate evaluation of students occurs through the observation of their learning process. In this type of approach, students are given some sort of baseline measure, and then taught a new skill. Dynamic assessment involves an ongoing evaluation of how students respond to instruction and, more importantly, how they apply newly acquired specific skills to new problems (Lidz & Elliott, 2000).

We would add to this two additional ideas. Specific skills themselves may take new and unexpected forms. What one is looking for is what has been acquired, expectedly or not. There is also a general skill, which is the principal concern of emergent pedagogy: that of becoming a more effective inquirer. Its development itself requires encouraging exploration of novel forms of specific skills.

Emergent approaches also seem to call for students' input in assessing their own progress. Thus we recommend that self-assessment be an important part of formal and informal assessment. “Progress” may sometimes only be discernible in those who are living it, not to those who are observing it. One objection to the idea of student assessment is a current body of research suggesting that students are poor at assessing their own learning. Some research has shown that college students are frequently overconfident in their estimations of their own performance (Bornstein & Zickafoose, 1999; West & Stanovich, 1997). However, we do not think that the accuracy of self-assessment in emergent approaches has been tested empirically. In addition, while students may turn out to be inaccurate in evaluating the cognitive aspects of learning (“how well did I learn this?”), no one can dispute their accuracy in reporting their attitudes. Such attitudinal changes are important outcomes of emergent approaches.

Listening to students' self-assessments is in keeping with a larger progressive movement in education to give greater weight to student voices in educational reform (Cook-Sather & Shultz, 2001).

However, some aspects of "progress" in emergent approaches may not be evident to students. Evaluation should include some measures of actual behavior, although the effects of learning on behavior may only become evident with the passage of time. Assessment should not be limited to the time frame of the learning experience itself, but should extend to some reasonable future time.

It is also important to recognize that some students will be uncomfortable without firm goals and a definite plan of action. These students may benefit from the establishment of intermediate goals, and they may be helped by periodic reflections on where they have come from and where they are, even if they cannot know, ahead of time, exactly where they are going. Emergent approaches that emphasize the moment of local interaction may sometimes make it difficult for students to see the bigger picture, which may make it hard for them to mark their progress. We recommend interim reflections where progress is viewed together, where needs are stated and goals are revised. Such times of reflection are important moments to highlight progress for both those students and their teachers.

Ongoing, in-the-moment reflections on learning may provide altogether a richer forum for evaluation than more traditional end-of-process, product-focused approaches. Our own experience in the Summer Institute was consistent with this idea. Throughout the Institute, on various web forums and in many classroom discussions, we asked participants to reflect on what they were learning, where the group was, how they were

responding to the process, and how they saw the Institute affecting their future behavior. Such queries provoked deep reflections and rich dialogues about what was going on. In sharp contrast, when we asked participants to evaluate the Institute at its conclusion, using a traditional rating scale and open-ended questions, we received very high "objective" marks, but very little feedback that was particularly meaningful. Participants observed simply that "it was interesting," or made brief comments such as, "I learned that people have unique viewpoints."

Assessment in an emergent system should also be multi-dimensional; it is not reducible to a single rubric or axis. Indeed, the evaluator may even have difficulty articulating the standard used to judge progress. (We have all had the experience, as instructors, of "knowing it when we see it.") A chief argument against this tacit approach is that it is somehow unfair or mysterious, but even our most "objective" way of evaluation entails a tremendous amount of subjectivity. It is our experience that when this type of subjective evaluation occurs within the context of a rich process of dialogue, trusting interaction and openness to input, both faculty and students are more than satisfied, because they have mutually authored a shared tacit understanding of the work they have done together.

Finally, we recommend adopting goals and assessing progress at the level of the group for both teachers and students. Success or failure may be judged, at least in part, by how well the group interacted and progressed. It also may be useful to invite students to reflect on their participation in the group. They may need help in seeing the value in saying things that are not thought out, of exposure to perspectives different from their own, of relying on others, and of feeling responsibility toward others in turn.

Emergent pedagogy is particularly ill suited to traditional forms of evaluation. Clearly an exclusive focus on how well students have mastered (that is, can report back) particular content is not appropriate in this case. Emergent pedagogy has a different orientation: content becomes the product of unique interactions, which may take students far afield of their ostensible task. The learning objectives of an emergent approach have less to do with content than with process, growth and development. The specifics of what is taught are often secondary to the acquisition of learning methods and processes of inquiry. For example, in our Summer Institute, we did not expect that most of our participants would be teaching about ants or plants in their own classrooms. These were topics for engaging them in learning NetLogo, so that they could apply that emergent tool, using other contents, in their own classrooms. What is needed is an evaluation process that focuses less on the acquisition of particular content and more on the development of skills that are effective in new contexts.

Standard practices of evaluation tend to focus on individual outcomes. We worry about how individuals will fare and (particularly at the collegiate level) think little about how the group works together. We judge our own success and the success of our students largely by how each has performed independently, rather than focusing on how well each one has done within the interactions of the group, or how the group itself has progressed as a whole. This can create problems both for the implementation of the emergent approach and for the process of evaluation, which needs to reflect not only individual measures of learning but also measures of interpersonal and group function.

It is important to remind ourselves that individuals benefit in important ways from positive group functioning. Fundamental to the emergent approach is the idea that

individuals are altered by their interactions with others. A group that engages in significant interactions increases everyone's learning opportunities. Functioning productively in a group is also a skill that individuals can carry forward to new educational environments, creating future valuable experiences. Evaluation should entail a review of group processes and of the relationships between the individuals and the group.

Some of the most exciting outcomes of emergent styles of pedagogy may be particularly tricky to measure because effects unfold over time. The satisfying paradox of the emergent approach is that it facilitates both independent and collaborative thinking, teaching students to initiate and sustain their own learning through interactions with others who enrich and stimulate their learning environment. But such important and valuable outcomes are difficult to evaluate over such short time spans as the duration of a class. They are likely to be most evident across greater periods of time, and may only be apparent in future behavior, rather than in the particular product of any given class session. One may need to develop evaluation mechanisms that involve long-term as well as short-term judgments.

Other benefits of emergent pedagogy may be less tangible or occur in dimensions typically not measured by evaluation. For instance, one of the most important and positive outcomes of our Summer Institute came in the form of an increase in positive affect and self-esteem in our participants. Many of them remarked on how important it was to them that they were treated as authors of their own learning. They were impressed that we recognized their contributions to our interaction. Being treated as valuable

colleagues may have been for them the most important and long-lasting outcome of the Institute. As one teacher remarked,

> When I am working with other professionals, using the resources of a college or university, most importantly the staff of those institutions, when I feel valued as a teacher and as a human being, I am motivated to try a little harder. And the results -- those free ideas -- are priceless.

Many of the participants mentioned “collaboration,” “connecting linkages,” and “discussing our thoughts with our peers” as significant aspects of the Institute. Teachers who feel empowered by this form of respectful interaction can return to their own classrooms more able to empower their students to engage in the same form of respectful interaction. As one of them reflected on the last day of the Institute,

> Just imagine! Giving students the opportunity to take ownership of their ideas, creations, and opinions. Allowing them the confidence to feel comfortable with their thoughts . . . The concept of "EMERGENCE" relates to this approach to education. Also as an educator this approach would allow me to identify the various ways in which students learn. Just Imagine!!!!

Clearly a successful movement toward more emergent pedagogy requires not only a commitment to new ways of acting in classrooms, but also to the development of new ways of both assessing and evaluating classroom activities. For some, this may appear to be a barrier to movement in such directions. We think it instead part of the significance of the emergent perspective on pedagogy. One does not give up goals and objectives, but rather sets them in a larger context of promoting sophistication of inquiry, seen as flexible and themselves open to continuing revision. Teachers should of course continue

to have a sense of the general area within which they expect exploration to occur, but become free to follow whatever lines of development seem most productive at the time. By making goal-setting itself an emergent process, both students and teachers can have constant access to goal formation and revision, feel shared satisfactions in their accomplishments, and have always in front of them the excitement of new possibilities.

VI. Conclusions

Participants in the 2003 Summer Institute came to understand intellectual inquiry as an intelligent response to exceptions, to the conflict generated when what is expected to happen does not, but something else occurs instead. The compelling argument for emergent pedagogy is that all the individuals in our classrooms are themselves emergent systems, designed to explore, and designed—if one direction of exploration fails—to back up and try a different direction. Such blockages can always be productive, if they are understood not as failures, but as invitations to try a new path. Our job as teachers in such a system is at least three-fold: to create rich environments, so that multiple possibilities are always available; to function as a node for sharing information among our students, so that they are aware of such possibilities; and to summarize and abstract the variety of insights students bring to their work, so that all can build out again from that reduction. Sociality increases the possibility that novel approaches are always at hand — and socializing with the Philadelphia public school teachers certainly increased the range of our own.

In our report, here, about teaching emergence in an emergent manner to a group of K-12 teachers, we've already recorded a number of "blockages." All of us were also

concerned that it would be difficult for the participants to reconcile the principles of emergence, however successful they may have been in our Institute, with the realities of teaching in urban, public school classrooms. The teachers themselves helped us identify a number of possible problems in application:

- How does one respond, in a collaborative learning environment, to students' needs to identify individually with their own work?
- How does one respond to student concerns that others will take advantage of them, or hurt them (what one participant called "cutting off the legs" of another)?
- A larger set of questions has to do with behavior management: To what degree are discipline problems exacerbated or alleviated by the emergent approach? How much of student behavior "comes into" the classroom with them? How much of it is "turned on" (and how much of it can be “turned off") by what happens there?
- A particular challenge for our participants was the tension between the allegedly inefficient explorative methods of emergence and the "need to test so much": How could these public school teachers cross the distance between playful creative classroom work and the assessment imperative of "no child left behind"?
- An equal challenge was the question of expense: Participants understood how exhilarating hands-on work could be, but also how expensive it was. We spent a lot of time discussing the matter of "consumable items" with these teachers who work in a large, inadequately funded urban public system. How can they possibly negotiate the material costs of interactive work?

These are all significant barriers to implementing emergent pedagogy. However, in the light of the potential benefits of emergent pedagogy, each barrier -- like the matter

of assessment -- can also be regarded as an opportunity to reflect productively on current educational practice. For example, is it actually the case that "playful, creative classroom work" will necessarily be less effective and less "efficient" at preparing students for the kinds of tests being used in the current environment? We are not persuaded that this would in fact prove to be so. We claim that very real savings can achieved by creating classroom environments in which students are encouraged to take greater personal responsibility for their own education and the education of those around them. We are quite certain that students learn better when they are encouraged to master material in a context in which that material is relevant to their own interests. Given the current realities of economics and evaluation, it might well turn out that emergent pedagogy is the optimal route to better student performance.

It would be irresponsible of us, however, to assure teachers interested in adopting the emergent approach to pedagogy that it *guarantees* success in the present educational climate. Indeed, doing so would be inconsistent with the deep message of this essay: There are no guarantees, only a process of learning. At the same time, emergent pedagogy represents a particularly promising path for future exploration, not only for our students, but also for ourselves and for the educational enterprise as a whole.

Emergent pedagogy encourages our students to see themselves in the classroom as the creative shapers of their own lives. As a practice and a potential, emergent pedagogy also encourages teachers to be creative shapers: we too have the capabilities we want our students to recognize and strengthen in themselves. We are "designed to explore, and designed — if one direction of exploration fails — to back up and try a different direction."

Our exploration of emergent pedagogy raised a number of questions, both for us and for our pre-college partners, for which we have not yet found answers. But writing up this account of all that we have most enjoyably learned has led us to trust that new paths will, in time and interaction with others, emerge. Exploring and encountering barriers that lead us to new explorations constitutes the excitement of the educational enterprise for us, as it should be for our students.

We end this essay by encouraging our fellow educators to try out some forms of emergent pedagogy themselves. In so doing we have in mind not only the health and well-being of our students and ourselves, but of the educational enterprise of which we are all a part -- as well as the national and world communities which depend on that educational enterprise. Education serves a variety of functions. We think none is more important than assuring that all humans have the capacity to think for themselves, in order to function effectively in the local, national, and world contexts that are themselves complex emergent systems. For educators like us who see a significant need for effective renewal of the educational enterprise, we offer emergent pedagogy as a pedagogical style for the classroom, as an avenue to meaningful change throughout the educational system, and beyond it as well.

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