Sustainable Living, Ecological Literacy, and the Breath of Life

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Abstract
This paper discusses the conceptual foundations for "Education for Sustainable Patterns of Living," the mission of the Center for Ecoliteracy in California. It offers an operational definition of ecological sustainability, and proposes study of living systems as a framework for understanding ecology. It considers key concepts for understanding living systems and their implications for educators. The paper addresses experiences that foster emotional connections with nature within a pedagogy for education for sustainable living. This paper is paired with Michael Stone's paper in this issue, "Rethinking School Lunch," which discusses practical applications of this conceptual grounding.

Résumé
Cet article examine les bases conceptuelles de la mission du Center for Ecoliteracy *de Californie, « Éducation en vue d'un mode de vie durable ». Il suggère une définition opérationnelle de la durabilité écologique et propose une analyse des modes de vie à titre de plans-cadres pour comprendre l'écologie. Il se penche sur des concepts clés pour comprendre les modes de vie et leurs conséquences pour les éducateurs. L'article aborde des expériences qui stimulent les relations émotionnelles avec la nature à l'intérieur d'une pédagogie d'éducation visant un mode de vie durable. Cet article s'inscrit dans le sens de celui de Michael Stone dans ce numéro, « Rethinking School Lunch », lequel débat des applications pratiques de ces assises conceptuelles.*

Keywords: ecological systems; sustainability; emergence; metabolism

One of the great challenges facing environmental educators is preparing students to participate effectively as members of sustainable communities in an ecologically healthy world. Since 1995, my colleagues and I at the Center for Ecoliteracy in Berkeley have sought to develop and explore concepts and practices for cultivating in children the competencies of mind, hands, and heart that they will need to create sustainable communities. "Education for Sustainable Patterns of Living," our name for this process, is intended to facilitate understanding of nature's principles, while fostering a deep respect for living nature through an experiential, participatory, and multidisciplinary approach.

This essay addresses the conceptual grounding of our work. The essay by Michael Stone in this issue, "Rethinking School Lunch: Education for Sustainability in Practice" explores the practical application of these concepts.

We are sometimes asked, why such complexity? Why not just teach ecology? An examination of the theoretical foundations of our approach will show that its complexities and subtleties are inherent in a full understanding of ecology and sustainability, and of life itself.

In recent years, the term "sustainable" has been used so frequently, and often so imprecisely, that the concept has become confusing or empty to many, more a rhetorical refrain than a source of practical guidance. The definition that we encounter most often was given by Lester Brown, the founder of the Worldwatch Institute, who wrote in the early 1980s that a sustainable society is one that can fulfill its needs without diminishing the chances of future generations. That was taken up by the 1987 United Nations report, the so-called Brundtland Report, which defined sustainable development as development that meets the needs of the present without compromising the ability of future generations to meet their own needs. These are important moral exhortations, in spite of evident limitations (speaking only of human needs, for example, without reference to the natural world). They do remind us of our responsibility to pass on to our children and grandchildren a world with as many opportunities as we inherited, but they do not tell us anything about how to actually build a sustainable society.

We need an operational definition of ecological sustainability. A key to such a definition is the realization that we do not need to invent sustainable human communities from scratch. First, we can learn from comparing the practices of societies that have sustained themselves for centuries on a limited resource base with those that have not managed to do so. At the Center for Ecoliteracy, we have been profoundly influenced by the work of Okanagan wisdom keeper Jeannette Armstrong from the En'owkin Centre in British Columbia (for more, see her essay "Let Us Begin with Courage," on the Center for Ecoliteracy website: www.ecoliteracy.org).

Second, we can model human communities after nature's ecosystems, which *are* sustainable communities of plants, animals, and microorganisms. The outstanding characteristic of the biosphere is its inherent ability to sustain life. To be sustainable, a human community must be designed so that its ways of life, technologies, and social institutions honour, support, and cooperate with nature's ability to sustain life.

This definition of sustainability implies that in order to build sustainable communities, we must understand the principles of organization that have evolved in ecosystems over billions of years. This understanding is what we call "ecological literacy." In the coming decades, the survival of humanity will depend on our ability to understand the basic principles of ecology and to live accordingly.

The most useful framework for understanding ecology today is the theory of living systems, which is still emerging and whose roots include organismic biology, gestalt psychology, general systems theory, and complexity theory (or nonlinear dynamics). Of particular importance in my application of this thinking, which is explicated in my book *The Web of Life* (1996), are autopoesis, as defined by Humberto Maturana and Francisco Varela (1980) as the pattern of the organization of living systems; dissipative structure, as defined by Ilya Prigogine and Isabelle Stengers (1984) as the structure of living systems; and cognition, as defined originally by Gregory Bateson (1979) and more fully by Maturana and Varela (1980) as the process of life.

When we walk out into nature, living systems are what we see. First, every living organism, from the smallest bacterium to all the varieties of plants and animals (including humans), is a living system. Next, the parts of living systems are themselves living systems. A leaf is a living system. Every cell in our bodies is a living system. Finally, communities of organisms, including both ecosystems and human social systems such as families, schools, and other human communities, are living systems.

Thinking in terms of complex systems is now at the very forefront of science. It is also, of course, very like the ancient thinking that enabled traditional peoples to sustain themselves for millennia. But although the modern version of this tradition is almost a hundred years old, it has still not taken hold in our mainstream culture.

I've concluded that there are two main reasons that people find systems thinking so difficult. One is that living systems are nonlinear—they are networks—while our scientific tradition is based on linear thinking, chains of cause and effect. In linear thinking, when something works, more of the same will be better. This has important consequences as we seek to develop sustainable cultures. For instance, we often assume that a "healthy" economy will show strong, indefinite economic growth, but we live in a world that cannot sustain indefinite expansion of our resource use. Successful living systems, on the other hand, are highly nonlinear. They don't maximize their variables; they optimize them. When something is good, more of the same will not necessarily be better, because things go in cycles, not along straight lines. Quality, not quantity, matters.

The second reason we find systems thinking difficult is that we live in a culture that is materialist in both its values and its fundamental worldview. For example, consider the fundamental question, what is life? What is the difference between a rock and a plant, animal, or microorganism? Many biologists will tell you that the essence of life lies in the macromolecules—the DNA, proteins, enzymes, and other material structures in living cells. In fact, this is sometimes narrowed to the definition that a living system is a chemical system that contains DNA.

This sounds quite simple, but the problem is that when an organism dies, its DNA does not disappear. Dead organisms, too, contain DNA. So at the very least, we would have to modify the definition to say, "A living system is a chemical system that contains DNA, and which is not dead." This, of course, is just a tautology. The point here is that, to understand the nature of life, it is not enough to understand material DNA, proteins, and the other molecular structures that are the building blocks of living organisms. The difference between a living organism and a dead organism lies in the patterns and processes through which these structures interact.

Shifts in Emphasis

Because living systems are nonlinear and rooted in patterns of relationships, understanding the principles of ecology requires a new way of seeing the world and of thinking—in terms of *relationships, connectedness, and context*—that goes against the grain of traditional Western science and education. Such "contextual" or "systemic" thinking involves several shifts of perception. These shifts are never absolute; they are, rather, shifts in emphasis, more like movement along an axis than either/or leaps. In our work with schools we have repeatedly observed several shifts that have important implications for pedagogy. Among them are the following:

From the parts to the whole. Living systems are integrated wholes whose properties cannot be reduced to those of their smaller parts. Their "systemic" properties are properties of the whole that none of the parts has. Pedagogically, one corresponding shift is to an emphasis on integrated curricula, rather than isolated single subjects.

From objects to relationships. An ecosystem is not just a collection of species, but is a community. Communities, whether ecosystems or human systems, are characterized by sets, or networks, of relationships. A school that is organized around this principle is more likely to put a premium on relationship-based processes such as co-operation and decision-making by consensus.

From objective knowledge to contextual knowledge. The shift of focus from the parts to the whole implies a shift from analytical thinking to contextual thinking. The properties of the parts are not intrinsic, but can be understood only within the context of the whole. Since explaining things in terms of their contexts means explaining them in terms of their environments, all systems thinking is environmental thinking.

From quantity to quality. Western science has always maintained that only the things that can be measured and quantified can be expressed in scientific models. It's often been implied that phenomena that can be measured and quantified are more important—and maybe even that what cannot be measured and quantified doesn't exist at all. If we want to educate using this principle, we are challenged to design evaluation processes more adequate than the standardized testing that is becoming the norm in so many places.

From structure to process. Systems develop and evolve. Thus, the understanding of living structures is inextricably linked to understanding renewal, change, and transformation. This shift is embodied in project-based learning, which emphasizes the application of knowledge within evolving real-life contexts.

From contents to patterns. When we draw maps of relationships, we discover certain configurations of relationships that appear again and again. We call these configurations patterns. Instead of focusing on what a living system is made of, we study its patterns. Pedagogically, the shift reminds us of the importance of integrating art into programs of study. There's hardly anything more effective than art for developing and refining a child's natural ability to recognize and express patterns, whether we talk about literature and poetry, the visual arts, music, or the performing arts.

The Breath of Life

By applying systems thinking to the multiple relationships interlinking the members of the Earth household, we can identify core concepts that describe the patterns and processes by which nature sustains life. These concepts, the foundation for creating sustainable communities, may be called principles of ecology, principles of sustainability, principles of community, or even the basic facts of life. We need curricula that teach our children these fundamental facts of life.

As noted above, the difference between a living organism and a dead organism lies in the basic process of life—in what sages and poets throughout the ages have called the "breath of life." In modern scientific language, this process is called "metabolism." It is the ceaseless flow of energy and matter through a network of chemical reactions that enables a living organism to continually generate, repair, and perpetuate itself.

Understanding metabolism, the breath of life, includes two basic aspects. One is the continual flow of energy and the cycling of matter. All living systems need energy and food to sustain themselves, and all living systems produce waste. But life has evolved in such a way that organisms form communities—the ecosystems—in which the waste of one species is food for the next, so that matter cycles continually through the ecosystem. The second aspect of metabolism is the network of chemical reactions that processes the food and forms the biochemical basis of all biological structures, functions, and behaviour. The emphasis here is on "network."

These aspects of metabolism bring us back to our operational definition of a sustainable community as one whose institutions and practices cooperate with the processes by which nature sustains life. These have been identified by scientists after observing hundreds of ecosystems. We have developed a short list of those that are of particular importance to sustaining life, and we continue to modify and refine it in response to feedback as we endeavor to communicate it to educators. These closely related concepts are different aspects of a single pattern of organization: nature sustains life by creating and nurturing communities. Our present formulation includes the following: *networks, nested systems, interdependence, diversity, cycles, flows, development, and dynamic balance.*

Networks

One of the most important insights of the systemic understanding of life is the recognition that networks are the basic pattern of organization of all living systems.

Metabolism is a network of chemical reactions. Ecosystems can be understood in terms of food webs (networks of organisms); organisms are networks of cells, organs, and organ systems; and cells are networks of molecules. Wherever we see life, we see networks. Sustainability is not an individual property but a property of an entire network.

At the Center for Ecoliteracy, we have learned that solving problems in an enduring way requires bringing the people addressing parts of the problem together in networks of support and conversation. Each part of the network makes its own contribution to the project, the efforts of each are enhanced by the work of all, and the network has the resilience to keep the project alive, even when individual members leave or move on.

Nested Systems

At all scales of nature, we find living systems nesting within other living systems—networks within networks. Although the same basic principles of organization operate at each scale, the different systems represent levels of differing complexity.

Within social systems such as schools, the individual child's learning experiences are shaped by what happens in the classroom, which is nested within the school, which is embedded in the school district, and then in the surrounding education systems, ecosystems, and political systems. At each level phenomena exhibit properties that do not exist at lower levels. Choosing strategies to affect those systems requires simultaneously addressing the multiple levels and recognizing which strategies are appropriate for different levels.

Interdependence

Nature sustains life by creating and nurturing communities. No individual organism can exist in isolation. Animals depend on the photosynthesis of plants for their energy needs; plants depend on the carbon dioxide produced by animals and on the nitrogen fixed by bacteria at their roots. Together, plants, animals, and microorganisms regulate the entire biosphere and maintain the conditions conducive to life.

Sustainability always involves a whole community. This is one of the profound lessons we need to learn from nature. The exchanges of energy and resources in an ecosystem are sustained by pervasive co-operation. Life did not take over the planet by combat, but by co-operation, partnership, and networking. Community is essential for understanding sustainability, and it is also essential for teaching ecology in the multidisciplinary way that it requires. The conceptual relationships among the various disciplines can be made explicit only if there are corresponding human relationships among the teachers and administrators.

Diversity

The role of diversity is closely connected with systems' network structures. A diverse ecosystem will be resilient, because it contains many species with overlapping ecological functions that can partially replace one another. When a particular species is destroyed by a severe disturbance so that a link in the network is broken, a diverse community will be able to survive and reorganize itself, because other links can at least partially fulfill the function of the destroyed species. The more complex the network's patterns of interconnections are, the more resilient it will be.

On the other hand, in communities lacking diversity, such as monocrop agriculture devoted to a single species of corn or wheat, a pest to which that species is vulnerable can threaten the entire ecosystem. In human communities, ethnic and cultural diversity may play the same role as does biodiversity in an ecosystem. At the Center for Ecoliteracy, we have learned that there is no "one-size-fits-all" sustainability curriculum. We encourage and support multiple approaches to any issue, with people in different places adapting the teaching of principles of ecology to differing and changing situations.

Cycles

Matter cycles continually through the web of life. Water, the oxygen in the air, and all the nutrients are constantly recycled. Mutual dependence is much more existential in ecosystems than in social systems, because the members of an ecosystem actually eat one another. Because one species' waste becomes another species' food, a healthy ecosystem generates no waste.

The lesson for human communities is obvious. A conflict between economics and ecology arises because nature is cyclical, while industrial processes are linear. Businesses transform resources into products plus waste, and sell the products to consumers, who discard more waste after consuming the products. The ecological principle "waste equals food" means that—if an industrial system is to be sustainable—all manufactured products and materials, as well as the wastes generated in the manufacturing processes, must eventually provide nourishment for something new.

Flows

All living systems, from organisms through ecosystems, are open systems. Solar energy, transformed into chemical energy by the photosynthesis of green plants, drives most ecological cycles, but energy itself does not cycle. As it is converted from one form of energy to another, some of it inevitably flows out and is dispersed as heat. We are therefore dependent on a constant inflow of energy.

A sustainable society would use only as much energy as it could capture from the sun: reducing its energy demands, using energy more efficiently, and capturing the flow of solar energy more effectively through solar heating, photovoltaic electricity, wind, hydropower, biomass, and so on—the only forms of energy that are renewable, efficient, and environmentally benign.

Development

All living systems develop, and all development invokes learning. During its development, an ecosystem passes through a series of successive stages, from a rapidly growing, changing, and expanding pioneer community to slower ecological cycles and a more stable, fully exploited ecosystem. Each stage in this ecological succession represents a distinctive community in its own right.

In an ecosystem, evolution is not limited to the gradual adaptation of organisms to their environment, because the environment is itself a network of living organisms capable of adaptation and creativity. Individuals and environment adapt to one another—they coevolve in an ongoing dance. Because development and coevolution are nonlinear, we can never fully predict or control how the processes that we start will turn out. Small changes can have profound effects. Nonlinear processes can lead to unanticipated disasters, as occurred with DDT and the development of "superorganisms" resistant to antibiotics, and as some scientists fear could happen with genetic modification of organisms. A sustainable society will exercise caution about committing itself to practices with unknown outcomes.

Dynamic Balance and Emergence

All ecological cycles act as feedback loops, so that the ecological community continually regulates and organizes itself. When one link in an ecological cycle is disturbed, the entire cycle brings the situation back into balance. Since environmental changes and disturbances happen all the time, ecological cycles continually fluctuate. During the last 20 years, the dynamics of metabolism have been studied in great detail and have led to a very important discovery. Living systems generally remain in a stable state, even though energy and matter flow through them and their structures are continually changing. But every now and then such an "open system" will encounter a point of instability where there is either a breakdown or, more frequently, a spontaneous emergence of new forms of order.

This spontaneous emergence of order at critical points of instability, often referred to simply as "emergence," is one of the hallmarks of life. It has been recognized as the dynamic origin of development, learning, and evolution.

In other words, creativity—the generation of new forms—is a key property of all living systems, and more specifically of their metabolism, the basic process of life. Whether instability leads to the emergence of creativity or to collapse often depends on the system's flexibility. Lack of flexibility manifests itself as stress. Temporary stress is essential to life, but prolonged stress is harmful and destructive to the system. These considerations lead to the important realization that managing a social system—a company, a city, a school district, or an economy—means finding the *optimal* values for the system's variables. Trying to maximize any single variable instead of optimizing it will invariably lead to the destruction of the system as a whole.

A Sense of Wonder

When we teach these principles in our schools, it is important to us that the children not only *understand* ecology, but also *experience* it in nature—in a school garden, on a beach, or in a riverbed. Otherwise, they could leave school and be first-rate theoretical ecologists, but care very little about nature, about the Earth.

Pedagogy oriented toward connecting actions with full appreciation of nature's processes—the breath of life—is therefore more than just a matter of teaching about biology and chemistry. The Latin *spiritus,* breath, is also the root of "spiritual." In the schools and programs that the Center for Ecoliteracy supports, we want to create possibilities for developing abiding relationships with the natural world.

David W. Orr, chair of the Department of Environmental Studies at Oberlin College and a member of the Center for Ecoliteracy board of trustees, describes this process in "A Sense of Wonder," an essay that may be found on the Center for Ecoliteracy website:

> We all have an affinity for the natural world, what Harvard biologist Edward O. Wilson calls, "biophilia." This tug toward life is strongest at an early age when we are most alert and impressionable. Before their minds have been marinated in the culture of television, consumerism, shopping malls, computers, and freeways, children can find the magic in trees, water, animals, landscapes, and their own places. Properly cultivated and validated by caring and knowledgeable adults, fascination with nature can mature into ecological literacy and eventually into more purposeful lives. (Orr, 2000, p. 19)

These affinities develop out of engagement. Experiencing and understanding the principles of ecology in a school garden or a creek restoration project are examples of what educators sometimes call "project-based learning"—experiences that engage students in complex real-world projects, reminiscent of the age-old tradition of apprenticeship. Project-based learning not only provides students with important experiences—co-operation, mentorship, integration of various intelligences—but also makes for better learning.

In the conventional view of education, students are seen as passive learners and the curriculum is a set of predetermined, decontextualized information. Our pedagogy of education for sustainable living breaks completely with this convention. Engagement with projects in which their actions have consequences generates in students a strong motivation and emotional connection. Instead of presenting predetermined, decontextualized information, we encourage critical thinking, questioning, and experimentation.

The pedagogy described here arises from understanding ecology, sustainability, and the breath of life in all their rich dimensions. Close study of the principles and processes by which nature sustains life teaches us that sustainable systems are possible, and that nature is both our model and our mentor. Through this multifaceted pedagogy we seek to foster in learners an understanding of nature's principles, a deep respect for living nature, and long-lasting relationships with the natural world, out of which they may gain the passion, knowledge, and ability to design sustainable communities for themselves, their children, and their children's children.

Notes on Contributor

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