systems thinking: shifts of emphasis

In *Science for All Americans*, the American Association for the Advancement of Science defines a "system" simply as "any collection of things that have some influence on each other.... The things can be almost anything, including objects, organisms, machines, processes, ideas, numbers, or organizations. Thinking of a collection of things as a system draws our attention to what needs to be included among the parts to make sense of it, to how its parts interact with one another, and to how the system as a whole relates to other systems."

Individual "things" (plants, people, schools, watersheds) are themselves systems, and are not sustainable separate from the larger systems in which they exist. The Center for Ecoliteracy recognizes that learning to think systemically is critical to education for sustainability. One of the ways that teachers and schools teach systemic thinking is to model it themselves.

According to Fritjof Capra, systems thinking requires thinking in terms of relationships, connectedness, and context. Thinking systemically also requires several shifts in perception, which lead in turn to different ways to teach, and different ways to organize society:

From parts to the whole

Systems are integrated wholes whose properties cannot be reduced to those of smaller parts. Their "systemic" properties are properties of the whole which none of the parts has.

From objects to relationships

An ecosystem is not just a collection of species, but is a community. Communities, whether ecosystems or human systems, are made up of sets, or networks, of relationships. In the systems view, the "objects" of study are networks of relationships. Organizations, including schools, which adopt this perspective are more likely to emphasize relationship-based processes such as cooperation and decision-making by consensus.

From objective knowledge to contextual knowledge

Shifting focus from the parts to the whole implies shifting from analytical thinking to contextual thinking. The properties of the whole are not intrinsic, but can be understood only with 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

Through much of the history of Western science, many of its practitioners have maintained that only things that can be measured and quantified can be expressed in scientific models. It has sometimes been implied that phenomena that can be measured and quantified are more important—and perhaps even that what cannot be measured and quantified doesn't exist at all. Relationships and context, however, cannot be put on a scale or measured with a ruler.

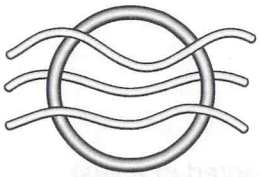
From structure to process

Living systems develop and evolve. This understanding is inextricably linked to understanding renewal, change, and transformation.

From contents to patterns

When we draw maps of relationships, we discover that certain configurations of relationships appear again and again. We call these configurations patterns.

Flows

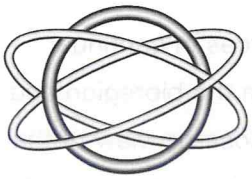


All organisms are open systems, which means that they need a continual flow of energy to stay alive. The constant flow of solar energy sustains life and drives most ecological cycles, as seen in a food web. A blade of grass converts energy from the sun to chemical energy through photosynthesis. A mouse eats the blade of grass, a garden snake eats the mouse, and a hawk swoops down and eats the snake. In each transfer of energy, some is lost to the universe as heat, requiring an ongoing energy flow into the system.

Development

The unfolding of life, manifesting as development and learning at the individual level and as evolution at the species level, involves interplay of creativity and mutual adaptation in which organisms and environment coevolve. For example, hummingbirds and certain flowers have evolved in ways that are mutually beneficial, as the hummingbird's color vision and slender bill coincide with the colors and shapes of the flowers.

Dynamic Balance



All ecological cycles act as feedback loops, so the ecological community regulates and organizes itself, maintaining a state of dynamic balance characterized by continual fluctuations. For example, ladybugs help keep aphids under control. Otherwise, aphids might destroy the leaves of trees that other insects depend on. When the aphid population falls, some ladybugs die off, which permits the aphid population to rise again, which supports more ladybugs. When the ecosystem is healthy, the numbers of individuals of each species fluctuate, but a balance within the system allows species to thrive together.

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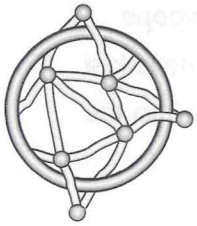
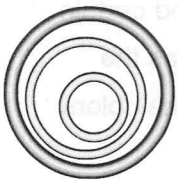
principles of ecology

Networks



All members of an ecological community are interconnected in a vast and intricate network of relationships, the web of life. They derive their essential properties and, in fact, their very existence from these relationships. For example, in a garden, a network of pollinators promotes genetic diversity; plants, in turn, provide nectar and pollen to the pollinators.

Nested Systems



Throughout nature we find multileveled structures of systems nesting within systems. Each of these forms an integrated whole within a boundary, while at the same time being a part of a larger whole. For example, cells in an animal are nested within organs, which are nested within systems such as respiration or digestion within individual organs. Organisms in turn are nested in ecosystems, along with other living organisms and nonliving components such as air and water. Ecosystems are nested within larger systems such as watersheds.

Cycles

Members of an ecological community exchange resources in continual cycles. Ecosystem cycles intersect with larger cycles in the bioregion and the planetary biosphere. In a garden, students see a close-up view of the water cycle when they collect rainwater, mimic precipitation when watering the garden, and observe condensation and evaporation as water appears and disappears on leaves and flowers.

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smart by nature competencies

Preparing young people for sustainable living requires educators who can touch and influence the whole student, including his or her values, abilities, and relationship to the natural world. The Center has identified a set of fifteen core competencies that young people need to develop for living in sustainable communities—the ability to:

Head (Cognitive)

- Approach issues and situations from a systems perspective
- Understand fundamental ecological principles
- Think critically, solve problems creatively, and apply knowledge to new situations
- Assess the impacts and ethical effects of human technologies and actions
- Envision the long-term consequences of decisions

Heart (Emotional)

- Feel concern, empathy, and respect for other people and living things
- See from and appreciate multiple perspectives; work with and value others with different backgrounds, motivations, and intentions
- Commit to equity, justice, inclusivity, and respect for all people

Hands (Active)

- Create and use tools, objects, and procedures required by sustainable communities
- Turn convictions into practical and effective action, and apply ecological knowledge to the practice of ecological design
- Assess and adjust uses of energy and resources

Spirit (Connectional)

- Experience wonder and awe toward nature
- Revere the earth and all living things
- Feel a strong bond with and deep appreciation of place
- Feel kinship with the natural world.