ABSTRACT

Design education is built on a combination of historical models that have little to do with ecological design or contemporary understandings of whole systems. In order to educate designers for ecologically and socially responsible practice, design schools will need to be radically redesigned in their structure, content, and methods. This paper uses a model from the natural sciences, Systems Theory, as a potential model for a foundational framework of design education. Basic tenets of systems thinking are outlined, along with principles of ecosystem function and organization. A series of fifteen suggested shifts in design education, eight as implications of ecosystem principles and seven derived from principles of ecosystem organization, are proposed.

2. SYSTEMS THINKING

In the most general terms, a “system” is any entity with emergent qualities at the scale of the whole, which are not present in the individual parts. A system can be a cell, an organism, a school, or society. Systems Theory is a post-industrial, post reduction, post-mechanist, holistic evolutionary paradigm of reality. Systems Theory treats wholes (systems) as made up not only of parts, but also of relationships. Therefore the study of the interconnections (in space, time, and process) between parts is critical. Relationships are at least as important as the elements themselves.

Systems theory may be a powerful tool for creating a curriculum of wholeness. Systems thinking is now becoming the basis for integrative and synthetic theories in many fields. They are beginning to recognize that a systems approach offers the opportunity to integrate and unify what appear to be (what are framed as) isolated and fragmented aspects of both their own discipline and its relationships to other realms of knowledge. And so, it is very practical.

2.1 Basic Premises of Systems Theory

In addition to a perceptual shift from objects to relationships, some of the basic premises of General Systems Theory are (1, 2):

- Systems occur at a series of interrelated scales, with similarities between levels of organization.
- On closer inspection, everything that appears at a larger scale to be an object, is seen to be a series of interrelationships (down to the quantum level).
- Systems behavior can be described though a series of interrelated sources, throughput (transformations), sinks, and feedback (informational loops).
- Systems exhibit dynamic, adaptive, goal-seeking, self-preserving, and evolutionary behavior.

2.2 Living Systems Theory

Miller, in his Living Systems (3) extended General Systems Theory to create a general theory of living systems. He iden-
tified living systems as open, concrete, energy/matter/information processing systems located in particular places. Some of the most important concepts of this approach are:

- **Flexibility.** “All members of an ecosystem are interconnected in a web of relationships in which all life processes depend on one another. The success of the whole depends on the success of its individual members, while the success of each member depends upon the success of the system as a whole.”
- **Energy Flow.** “Solar energy, transformed into chemical energy by the photosynthesis of green plants, drives all ecological cycles.”
- **Diversity.** “The stability of an ecosystem depends crucially on the degree of complexity of its networks of relationships; in other words, on the diversity of the ecosystem.”
- **Partnership.** “All living members of an ecosystem are engaged in a subtle interplay of competition and cooperation, involving countless forms of partnership.”
- **Interdependence.** “All members of an ecosystem are interrelated in a web of relationships in which all life processes depend on one another. The success of the whole depends on the success of its individual members, while the success of each member depends upon the success of the system as a whole.”
- **Cycles.** “The interdependencies among the members of an ecosystem involve the exchange of matter and energy in continual cycles. These ecological cycles function as feedback loops.”
- **Coevolution.** “Most species in an ecosystem coevolve through an interplay of creation and mutual adaptation. The creative reaching out into novelty is a fundamental property of life, manifest also in the processes of development and learning.”
- **Sustainability.** “The long term survival (sustainability) of each species in an ecosystem depends on a limited resource base.”

The Center uses ecosystems, understood from a systems perspective, as a model for successful human systems – in particular, for the design of learning communities. “The link between ecological communities and human communities exists because both are living systems” (4).

### 2.4 Organizational Patterns of Living Systems

Capra, building on the work of Prigogine and others, goes further to develop a theory for the organizational patterns of living systems (5). Some of these organizational patterns include:

- **Networks.** Patterns of nonlinear relationships of nested systems within systems.
- **Feedback.** Some messages travel in cycles to return to their origin, thus influencing future system behavior.
- **Self-regulation.** Using feedback, systems can keep themselves in dynamic balance.
- **Self-organization.** Because life is a network, it can organize itself, including its own direction, purpose, and creative self-transcendence.

### 3. SHIFTS BASED ON PRINCIPLES OF ECOSYSTEMS

Based on the principles of ecosystems, the following possibilities for the evolution of design schools, summarized in figure 1, are suggested.

#### 3.1 Re-Membered Curriculum

The root structure of most schools and curricula can be described as one of “dualistic fragmentation.” Architecture, in this view is divided between “Design” and non-design “Other.” Form, the statics of design, is able to be considered without thought of Process (flows), the dynamic forces interacting in and around form.

It has become self-evident that the biosphere and its processes can not be understood fully in terms of the fragment ed atomism of contemporary knowledge disciplines. Worse, according to David Orr (6):

> “The great ecological issues of our time have to do with our failure to see things in their entirety. The failure occurs when minds are taught to think in boxes and not taught to transcend those boxes. We educate lots of in-the-box thinkers.... And there is a connection between knowledge in organized boxes, minds that stay in those boxes, and degraded ecologies and global imbalances.”
3.2 Connectedness

In living systems, relationships reign. We have to look for the connections, relationships and flows within our school, and then, design the structure of the school and the curriculum to support and fit those important relationships. We would discover how (and what kind of) knowledge flows between studios and other courses and assess the barriers to this flow. We would create network process maps to visualize the various routes students take to, through, and from our schools, etc...

If, as systems theory proposes, the relationships are equally as important as the elements, then the elements must be correctly identified if the relationships are to be meaningful. This is a fundamental structural question. Topical divisions currently reinforce a fragmentary view of design reality. We can then identify sets of hierarchical organizational levels of curricular relationship sets; each constellation of internally related processes can be thought of as an “element” in relation to other elements.

An obvious and immediate action in most schools would be to re-evaluate the divisions between studio and “support courses,” and in particular focus on the interconnections. The root of the lack-of-integration problem is the initial conceptual separation of theory and utility (typically lecture courses) from application and exploration (typically studio courses).

3.3 Knowledge Ecology

Design schools can develop systems of knowledge, representation, and communication based on varying systemic levels and on diverse, richly connected ecosystems. Jere Clark (8) introduced the term “general ecology of knowledge” to describe the totality of the knowledge systems organized along the principles of general systems theory. Knowledge conceived in this way is part...
of a living system that includes humans, their communications systems and social memory systems. Seen in this way, the often divisive intellectual realm can become coordinative. Diversity creates systemic health when it serves a larger purpose and when relationships are complex. Rich, connected diversity builds in stability and adaptability to changing conditions. Redundancy needs to be built-in to our curricula, so that important lessons are encountered in many ways. The efficient curricular machine delivers appropriate knowledge at the critical moment, while a knowledge ecology creates an environment for potential growth by maintaining cyclical information flows.

3.4 Collaborative Learning Community

Our educational systems express the sovereignty of individuals; competition is the game. Intelligence and learning are thought to be the province of individual will and talent. In truth, learning is almost always a collaborative event, whether from author to reader, teacher to student, or student to student. Further, much of our knowledge is communicated tacitly through the culture of the classroom, the unconscious messages of the larger society, the attitudes of the professional press, and the embodied knowledge and values of music, buildings, and the design of institutions (9). Essentially, we learn in dialogue, in relationship — in community. So, we must re-think what our idea of a design school means, in light of creating a learning community. It might mean to create more team-oriented projects, to emphasize peer teaching, to re-assess individual grades to reflect relationships in evaluation, and to more directly enroll the professional and neighborhood communities in the educational process.

3.5 Design of Process

An ecologist can not separate form from process, structure from function. Taking note of how structure in nature expresses underlying processes, design educators would change the focus of design education from the design of structures and artifacts to the design of processes. From a systems perspective, the formal-geometric-elemental conception of design is far from accurate. It lacks both an understanding of process and the progression (order) of process. Encouragingly, we are beginning to see the consideration of process in some areas of architectural knowledge, such as life cycle costing and “cradle to grave” analysis of materials choices.

Designing process is what John Lyle calls “shaping form to guide flow” (10). It means that designers first have to understand the basic life processes in which buildings and landscapes participate. This approach to design would create form as a manifestation of all the energy, materials, and information flows interacting with buildings: light, water, wastes, electricity, heat, gravity, functional human activity, economic cycles, social patterns, site forces, and human perception and meaning.

3.6 Fluid Academic Structures

Because natural processes are dynamic, ecosystem structures often are fluid. Yet, academic structures can be some of the most rigid of human creations. To become living, rather than mechanical systems, schools should question both the semester (or quarter) system and the conventional course credit system as the fundamental academic structures, or building blocks for our programs. Instead, we would create correspondence between the content, magnitude (credits), and duration of our academic “units.” For instance, a school might decide that 9-12 credit “meta-studios” are best for an introductory core program and that six week studios are best for upper levels. Or a faculty might decide to run studios on a 15 week calendar and stop other courses at week 12, leaving the final three weeks do devote to studio work alone. There are many other possibilities. One of the recurring reasons for not having students involved in real projects, and involved with the act of building in particular, is the observation that the schedule of most “real-world” projects does not fit the academic calendar. The tail of academic structures wags the pedagogical learning-process dog.

3.7 Reiterative Complexity

In living systems, information, energy, and materials flow in cyclical exchanges between all members of an ecosystem. In learning communities, education is both repetitive and progressive, that is, meaningful knowledge is constructed by individuals over time as consciousness is built through reiterative engagement. This insight asks educators to design the students’ progressive engagement of any knowledge set with respect to time. Thus “iterative wholeness” could become a new dictum of design education, representing the necessity to build systemic consciousness through pattern recognition while facing the mental limits of complexity when learning new “languages.” Students learn about ecological cycles in cycles of learning.

3.8 Ecological Literacy

The creation of sustainable environments requires ecological literacy. Ecological literacy, according to Capra, involves both an understanding of ecological principles and taking action based on ecological values. To build such an awareness, almost every aspect of schools will have to be examined and redesigned. To be ecologically literate means to have a systemic consciousness, to understand the interrelatedness of life, to know the state of the world and the state of your neighborhood, and to know how rapidly they are changing. In his book Ecological Literacy, David Orr identifies six foundations for an ecological education (11): 1) “All education is environmental education;” 2) Interdisciplinary approaches to complex issues; 3) Groundedness in place; 4) Participatory, experiential methods based in real issues; 5) Direct experience of the natural world; and 6) Practical competence with the design of human systems based on principles of natural systems. We have a lot of work to do.

4. SHIFTS BASED ON PRINCIPLES OF ECOSYSTEM ORGANIZATION

Based on principles of ecosystem organization, the following possibilities for the evolution of design schools, summarized in figure 2, are suggested:

4.1 Patterns of Interconnections
4.2 Interconnections of Scale

In many ways, including processing functions, and often, in spatial patterning (i.e. fractal geometry), systems are found to exhibit similar characteristics between larger and smaller scales. Applied to re-conceptualizing design schools, this thinking would lead us to present similar, congruent “intellectual universes” at several hierarchical system levels. This means that the important ideas, themes, and relationships, in similar patterns and at a range of scales, can be read and understood, and that they are built into each of our programs. This similarity has not to do with consistency, but rather understood, and that they are built into each of our programs. This similarity has not to do with consistency, but rather

4.3 Systems Within Systems

Living systems are organized as networks within networks. Following from this, design schools can begin to look for the connections, relationships and flows between the school and system organizational levels above and below it. Then, design the structure of the school and the curriculum to support and fit those important relationships. We could examine the disciplinary and professional divisions of the built environment (interior, landscape, and building architecture, urban design, urban and regional planning) in relation to a systems theoretical organization. These contemporary distinctions reinforce our perceptions of separations between inside and outside, between “built” and “living.” Regenerative designs mediate, filter, and control a complex series of relationships between inside and outside, while forging an alliance between plants, animals, humans, and static form. Regenerative design employs cross-disciplinary knowledge. Eventually, we will be required to reconfigure our disciplines to meet these new realities. We could also develop

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**Pattern of Interconnections**

Living systems are organized in recurring sets of process-defined relationships. Schools can be configured for repeated events and flows. Patterns languages have an ecological basis.

**Interconnections of Scale**

Design a school with self-similarity through varying organizational levels; Themes reoccur in similar patterns at a range of scales. “As above, so below” builds systemic consciousness.

**Systems Within Systems**

Systems are integrated wholes that are also part of larger wholes, and contain a network of smaller wholes within them. The purpose of design is to create environments of networked wholeness.

**Design of Institutions**

Humans are unique by participating in many institutions (social systems). Design focuses on institutions, technologies, and relationships, that control growth & evolutionary processes of form.

**Information Webs**

Feedback is a critical function of learning and constructing meaning. It is also critical to any form of regulation. Schools can facilitate error management by building–in communication channels.

**Open Systems**

Living systems maintain their form while energy, information, and materials move through it. Schools need a flow of energy, students, and ideas to live. Closed systems (& minds) die.

**Collective Consciousness**

Self-organizing living systems create order spontaneously out of chaos. Purposeful and inventive behavior are their highest expression. The school-system’s self-awareness is an ideal.
more clear functional relationships with the larger knowledge and social systems of the university.

4.4 Design of Institutions

Humans are members of many systems, both natural and cultural. This multiple membership in many overlapping systems makes design challenging. Yet, the instrumentalties of these institutions often control the context, nature, and development of the “built” environment. Design has historically focused on the physical realm, particularly at the scale of buildings and below. Systems thinking asks us to see form of every type as a manifestation of process and to see similarity between scales of nested networks. We can then see that design thinking applies equally to all of the non-physical elements that help to create the physical realm. Schools could expand the focus of design from the design of structures and artifacts to the design of human institutions, technologies, and relationships, including: 1) Planning and design processes; 2) Development of rule structures and policies that control the context of design elements; 3) Growth and evolutionary processes of urban form; and 4) Technological and informational instrumentalities of construction and development processes.

4.5 Information Webs

Feedback is made possible through the pattern of network structures. In order to learn, any system must have clear, accurate, timely feedback. Information flow is also the driver of regulatory functions and makes possible coordinative activity of parts. How many design schools pay attention to the free flow of information between all of its members? We can begin to conceptually and graphically map school processes by viewing the school’s activities as examples of recurring natural functions common to all systems. Memory is individual and institutional; materials are “ingested,” in gulps of several hundred dollars per term per student; information, energy, and money are “distributed;” knowledge, papers, waste, and art are “produced;” and millions of large and small questions are “decided.”

4.6 Open Systems

Open systems maintain their pattern of organization while energy, materials, and information flow through them. They require inputs from outside in order to survive. The human body, for instance, keeps its pattern intact over time, while continuously eating, breathing, and eliminating. Schools, as living learning systems, need flows of students, money, and fresh ideas to keep themselves alive and maintain their pattern of networked relationships. Through the management of feedback, schools can self-regulate themselves in a dynamic economic and intellectual balance. But structures are useful only as long as they are useful. The vortex structure in a wash basin disappears when all of the water flows down the drain. For an open system, dogma equals death. Institutionally, it’s learn or lose.

4.7 Collective Consciousness

According to advanced evolutionary theory, organizations and institutions are systems with the characteristics of purposeful, self-organized evolution. In their highest development, this evolution becomes conscious. Harrison Owen argues that “learning, at its root, is nothing more nor less than the evolution of consciousness” (12). Following from this, he sees that the role of organizations is one of a learning community with the purpose of fostering that evolution. Schools then are a special form of learning community. The growth in consciousness that Owen identifies is both individual and collective, what he calls “organizational consciousness.” He proposes that we are moving toward the “Inter-Active organization,” which “continuously interacts with the world at large, and playfully invents and destroys structure to correlate with that world” (12).

5. CONCLUSION

Design education is at a crossroads. We can either continue to prolong the life of an educational system whose educated graduates have created the ecological crisis – or we can reorganize the academic institutions at a higher level of evolutionary sophistication, designed along the principles of ecosystems. These are the principles developed through four billion years of evolution, the principles by which the rest of the world works, the principles of the only known sustainable systems.

6. REFERENCES

(11) Orr, David W., Ecological Literacy, education and the transition to a postmodern world, Albany: SUNY Press, 1992