Influences of the Complexity Sciences on Landscape Design

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Abstract

Since the early 1970s landscape architecture has adopted post-modern, poststructuralist, and deconstruction approaches on the one side, and has been strongly influenced by theories of self-organization and complexity on the other. In this paper, the first theses point to the emergences of the Complexity Sciences and their connections to landscape architecture. At least three of them have emerged in the last decades: direct influence of new technologies (based on Complexity Sciences) on landscape design, contemporary landscape design approaches theoretically dependent on Theory of Complexity, and the influence of environmental psychology, based on visual complexity. Secondly, the theses on how Complexity Sciences are rapidly changing the digital technologies and their huge influence on landscape design, structural and functional complexity and perceptions of the landscape are demonstrated. Finally, some theses on possible influences of the virtual reality (VR) on human perception and landscapes are set.

1 Introduction

The variety of contemporary landscapes, natural or cultural, is continuously changing, and in most of the examples, increasing enormously in its diversity of numbers, relations and connections on all society levels. This has different influences on the environment and the designed landscape. The past simple usage of landscapes for agricultural and other purposes has changed into heterogeneous spaces of megalopolises, quickly-modifying traffic infrastructures, multifunctional and virtual landscapes, which have been designed by humans for their personal needs, challenges, visions and development. It can be assumed that all of the landscape design practices after the second half of the 20th century have been somehow influenced by contemporary sciences. The merit of exploring this genre of work lies in its contribution as a mediating theme between scientific approach of complexity studies and its materialization into the practice and theory of landscape design. Complexity sciences are changing the landscape.

2 Contemporary Sciences and Landscape Design

Complexity Theory has really only taken off with the advent of the computer, which can undertake the massive numbers of calculations required for investigating complex phenomena. The theory is concerned with self-organizing phenomena and the effect of one subsystem’s behaviour on another. Stephen Hawking has said, “Complexity will be the science of the 21st Century.” Complexity Sciences that emerged in the 20th century have overtaken the world of science. They have become one of the main issues over the last
quarter century, shifted from a fringe issue to a central theme in cultural consciousness and research discourse in Physics, Biology, Sociology, and Psychology and all the way to Architecture, Arts and Landscape Architecture.

How is Complexity Science changing the landscape architecture? Our recent understanding of the universe is quite unique. We know the approximate principles of increasing complexity: the main lines of its history and major laws of its development, its beauty, its creativity and the catastrophe that it brings. Traditional religions emphasize constancy. The Modernists with their mechanistic models emphasize predictability. But the cosmos is much more dynamic than either a pre-designed world or a dead machine (Jencks 1997). By contrast, the post-modern ‘sciences of complexity’ explain a more creative world, a picture filled out by many emergent sciences such as fractals, Chaos Theory, nonlinear dynamics and Complexity Theory itself.

A brief overview of the contemporary sciences and complexity characteristics has already shown two basic distinctions – Sciences of Complexity in Complexity Theory and their contribution to the open space theory. A new language of science has influenced the contemporary landscape architecture theory. In the late 1950s, the sociologist Herbert Hans showed the complexity of different lifestyles in ‘urban villages’. Jane Jacobs wrote an important manifesto of Post-Modernism, The Death and Life of Great American Cities (1961). Robert Ventury also absorbs lessons from new complexity sciences in his book Complexity and Contradiction (1966). On the large scale, new way of thinking about urban life has been identified. Michael Batty and Paul Longley have described the dynamic, pulsating form in city growth and death in their book Fractal Cities (1994). They focused on London and Los Angeles as typical fractal cities, star-shaped blobs that seem to flicker and grow along electric lines of communication. Another form-language is growing besides the fractal, an aesthetic based on waves, folds and undulation. Often this form-language is derived, by analogy, from the wave motion that underlies solutions and the quantum world and perhaps, from Superstrings – those minuscule vibrating units of substance – which underlie the universe itself (Jencks 1997). Another part of the new repertoire are the twist and warp, characteristic motifs of dramatic change which Catastrophe Theory has illuminated in emerging shapes that we often call nonlinear. A new shared language of expression is growing, changing the aesthetics of undulating movement, surprising crystals, fractured planes, spiraling growth of waves, twist and fold, and dynamic nonlinear forms that have emerged from the contemporary sciences. In the new sciences and arts, the fundamental ideas relate to feedback and self-organizing change, both of which the computer is well-adapted to portray.

**History of Complexity Theory.**

- Dynamical systems theory founded by Poincare ca 1882
- Gestalt theory created Berlin ca 1920
- Cybernetics created by Norbert Wiener ca 1942
- General Systems Theory created by Von Bertalanffy ca 1950
- System dynamics founded by Jay Forrester ca 1950
- Morphogenesis founded by Alan Turing ca 1952
- Catastrophe theory created by Rene Thom ca 1966
- General Evolution Theory due to Ervin Laszlo ca 1985
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**Sciences of Complexity**

- 1962, Herbert Simon article, The Architecture of Complexity
- 1984, the Santa Fe Institute created to study the Sciences of Complexity

This influence has inserted complexity principles into the design process in many places - in programming, site analysis and interpretation, form grammars, and construction techniques. This impulse has also challenged the tenet of modern form as an isolated, bounded form or space experienced by a detached, contemplative observer by focusing on the construction of aesthetic experiences bound to, and enmeshed in, their specific cultural and ecological context. Discussions of contemporary urban theories, including Chaos, Complexity, Bio-urbanism and Non-hierarchical urbanisms, introduced methods in which contemporary urban form is conceptualized with the intention of developing both their ability to critique and formulate urban strategies and effectively responding to complex urban processes. Writings also showed contemporary urban concepts and design strategies including: complexity and chaos theories, congestion, fractals, folding, bifurcation, hyper-surfacing, superimposition, the bio-city, zoning for aesthetics, the sustainable city and digital modelling.

The urban form is becoming dynamic, ever-changing, influenced simultaneously by a diverse range of human needs and contemporary sciences. It is a distinction from modernism to a new way of landscape design processes which brings back life. The new form that has emerged is active, open, dynamic, surprising. Characteristically, landscape design represents those processes in different ways: by translating aspects of the changing and growing world directly into the new language of landscape design, or by reflecting the scientific results abstractly.

2.1 **Self-similarity (fractals) and strange attractors**

A new language of form based on a fractal design is beginning to permeate our landscape (JENCKS 1997). Fractals, the traditional dimensions lying between the customary one-, two- and three-dimensions, can be found throughout the nature. Clouds, coastlines, snowflakes, ferns and trees are fractals showing an important quality: self-similarity. In a typical fractal object, parts resemble not only other parts, but the whole. The perfect transformation of the self-similarity theory into space design was shown by Bruce Goff in his Joe Price Studio Project (OKLAHOMA 1956). The self-similarity which all fractals show is not self-sameness. Here triangles, hexagons, lozenges and other shapes transform the same angles at all scales and in different materials.
2.2 Nonlinearity
The complexity sciences have shown the importance of dynamical processes, the concept of feedback: the nonlinear variety, which relays back information into itself. Most of the scientists of the Theory of Complexity, such as Joseph Ford, believe that most of nature is nonlinear (JENCKS 1997): ‘non-chaotic systems are very nearly as scarce as hen’s teeth, despite the fact that our physical understanding of nature is largely based upon their study.’

2.3 The form of waves and twists
The smooth growth of a wave form represents the continuity of nature, its unity and harmony, whereas the sudden twist represents the catastrophes of nature, the flip from one system to another, or the creative bifurcations which can bring process as well as despair. The wave motion, like nonlinearity, is crucial and omnipresent in nature.

2.4 Folding – catastrophe and continuity
Another related wave form, the fold, has also emerged from recent science and the Catastrophe Theory of René Thom. Catastrophe Theory is not primarily concerned with what we call catastrophes but, rather, the more prosaic ‘phase transitions’ that are visible everywhere in nature: the dramatic transformation of water into ice or into steam, the sudden transformation of the corn kernel into popcorn; the sudden emergence of a rainbow. (JENCKS 1997) In landscape, the fold is used to orient movement of form or people.

2.5 Superposition
Plural design, eclecticism and ad hocism have become the main post-modern methods for building in organizational depth and the equivalence of time. Superposition is the aesthetics of layering, ambiguity, transparency and juxtaposition. It is a kind of ultimate democratic method, a bottom-up design where the landscape designer provides the systems, but they do the significant self-organization, (JENCKS 1997).

3 Between Environmentalism and Land Art
Over the last quarter century, environmentalism has shifted from a fringe issue to a central theme in American cultural consciousness and political discourse (MEYER 2000). Motivated by environmental values, landscape architects became increasingly knowledgeable about ecological principles and systems. The associated types of design practices were not monolithic, representing a single school of thought, but diverse, ranging from “scientific” restoration ecology to site-specific “artistic” interventions, from projects that simulated nature to those that revealed the act of human creativity and construction. Environmental or ecological design emerged from the writings and teachings of educators such as Ian McHarg. His primary contribution to the design process was to structure the preconceptual design phase according to a more defensible, scientific method. The second model, landscape architecture as art, emerged from the teachings and practice of educators
such as Peter Walker, who were concerned that the design process had become so beholden to analyses – ecological, social, and behavioural – that the art of making the landscape visible, beautiful, and memorable had been made subservient to the landscape’s function (Meyer 2000). These two models existed in isolated opposition to one another, cognizant of the other but operating in separate worlds, based on separate value systems and vocabularies. This isolation troubled, even confounded, those landscape architects drawn to the discipline in the aftermath of the 1970s environmental movement.

How could one give form to dynamic processes and fluctuating systems, but not resort to the modern design codes that have privilege to static, bounded, ideal objects in art and architecture and often relegated landscape to visual scenery, a stripped-down version of the pastoral? For a designer, one conundrum presented by the environmental movement was the disconnection between site analysis and design expression or, in other words, between environmental values and form generation. Purely ecologically-oriented, scientifically-legitimated landscape design has, in recent years, become paralyzed in a dry academic approach, which led at best to mere imitation of nature but even more frequently to inarticulacy in design (Weilacher 2001).

“The change of paradigm from artistic to ecological aesthetics in the early 70’s, as well as the considerable time-lapses that occur before innovations in art and culture become generally accepted in landscape architecture ...” (Weilacher 2001). The motto Design with Nature, based on a heliocentric concept of nature, was used well into the 80s to demand that design be abandoned in favor of ecology, as nature was seen as the better designer and would take care of the aesthetic quality of the project herself. A body of work has emerged that not only translates ecological environmental values into a design language, but also suggests a strategy for breaking out of the restrictive tenets of modern art that have so marginalized the landscape as a medium and subject. Ecologically planned or not, these landscapes did not look managed or designed to most people. They allowed the public as well as developers and designers to ignore the actual impact of construction and sprawl.

This simultaneous look to art, science, and to theories of site specificity and phenomenology as well as ecology was critical to the successful integration of environmentalism into landscape architectural design. Some sought to emphasize nature’s forms, others to make nature’s subtle and transitory processes palpable and visible, and still others to reveal a site’s entire history of cultural and ecological agents. These varied goals placed the landscape architect in a position of being a site perceiver, reader, and interpreter. Straddling the line between conception and reception, controlling and initiating, the landscape architectural design process anticipated the audience’s reactions, perceptions, and experiences of place (Meyer 2000).

3.1 Virtual Reality and Landscape of Participation

The history of civilization through understanding and use of human senses shifted from the world of hearing (ear) to the world of visualization (eye) with the development of first writings 3000 years ago. All the other senses were in the background waiting for their expansion in the 20th century, when the body took its place in the hierarchy of human senses (Strehovec 1995). The status of transforming the passive viewer into an active one
was the main issue already in the 19th century arts. The function of body in visual perception emerged after the expansion of virtual reality. The terms like ‘cyborg’, ‘cyber space’ and ‘virtual world’ emerged. The term ‘cyborg’ was coined in 1960 as a definition of a ‘self-regulating man-machine system’, but every period has imaged such ‘human-things’, entities which test or define the contemporary sense of intrinsic human value over against its simulacrum (TOMAS 1989). New technologies and acknowledgements of virtual reality also changed the perception of landscape. Emergences of virtual worlds, breakdown of realism, blurred boundaries between reality and the figural world and development of ‘another artificial life’ (cyber space), are the main reasons for changed perception. In the medial age ‘visual landscapes’ have turned into multifunctional, diverse programming landscapes, based on four dimensional perceptions, generated by structural design approach of the human body. The contemporary landscape is no longer a place for visualization; it is a place of human participation. Hans Magnus Enzensberger analyzes (WEILACHER 2001): ‘The luxury of the future will say goodbye to excess and strive towards the necessary, which, it is to be feared, will be available only to very few. Elementary necessities of life like freely disposable time, free definition of interest, space for free movement, calm, an intact environment, and security will be among the luxury goods of the future.’

3.2 Digital age: the Landscape of Attraction

Reality, as Paul Virilio has observed, ‘is always generated, never given; it is built by the way a society develops, by the way a society learns. Each reality is followed by another. We are living in a degenerated reality, a reality of the moment. It is a matter of the virtual regenerating the real.’

Spurred on by the digital revolution and the changing nature and decentralization of work, the landscape is becoming increasingly mixed-use. Computer simulation techniques are Changing the virtual world into reality. The digital revolution re-interprets the meaning of time and space. With the lack of experimental architectural, industrial and art projects dealing with digital design, it seems that the landscape still hasn’t adressed the whole potential of the digital age. Digital form of contemporary landscape patterns, computer based techniques and usage of computer simulations is not enough. Landscape projects, based on a variety of digital forms have reached their only goal – to fascinate the observer. If we perceive a digital screen in the Millennium Park in Chicago, digital fountains of Barcelona, or the computer-based forms of elements of the Schouwburgplein Square in Rotterdam or La Villette in Paris, there is always the familiar fascination of a place – the feeling of attraction.

3.3 Computer Design: Breaking the Boundaries

Computers have revolutionized landscape architecture, raising deep philosophical issues that are forcing a paradigm shift in the profession. The fascination about computer based design explores the theory behind cyberspace and traces the effects that the worship of technology has had on society. One of the most powerful revolutionized issues that complexity sciences had on society was the breaking of boundaries. It can be seen in different aspects. Landscape is no longer a pure cultural space of production. It is mixed in programming, interpretation, form grammars, and construction techniques. The boundaries
between disciplines no longer exist. In two essays on ‘The Allegorical Impulse’ published in 1980, the American critic Craig Owen proposed six strategies which might characterize post-modern art practice. These were: appropriation, site specificity, impermanence, accumulation, discursivity, and hybridization. Kenneth Clark’s Civilisation (1969) narrative covered the development of architecture, painting and sculpture from the classical period onwards. The ‘Post-object’ artist produces more intangible kinds of work such as performance pieces, subtle modulations to the landscape as in land art, film and video texts, conceptual accounts of projected works, and installations which are site-specific and cannot be so appropriated by private ownership. The post-modernism has changed the boundaries of previous work. The distinctive order of modernism has transformed into multifunctional, interdisciplinary structure, where it is hard to draw a distinction between professions, techniques or media. The Complexity Sciences with their multi-functioning elements, self-organized, nonlinear dynamical processes and living forms have changed the meaning of boundaries. The fall of the boundaries has changed the meaning of landscape. There are some new designing approaches that redefine the boundary between architecture and landscape: Green architecture, Architecture as Landform, Organic-Tech Architecture, Bio-Urbanism and Non-hierarchical Urbanisms.

4 Conclusion

The materialization in contemporary landscape design practice reveals two different approaches in the interpretation of the Complexity Sciences. The first one is based on direct scientific results of materialization, usually generated as landscape patterns of fractals, blobs, folds, waves or twists. The second one uses the scientific approach to determine design grammar by signifying aspects of the changing and growing world into a new language of landscape design by reflecting scientific results abstractly to its programming, site interpretation and environmental evaluation. Both of them have left an indelible trace in the people’s consciousness and landscape design history.

However, the question of where the future landscape design will turn is a question of society development and scientific research. Will it turn to the virtual world of cyborgs, digital environment of computers and four-dimensional spaces of technologies, or rather back to nature? Complexity Sciences will certainly lead us to explore future landscapes.

References


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The original NK model [6] assumes a landscape where one can modify the complexity by varying the interdependence of elements (K of the NK). This ability to vary the interdependence is the model’s great strength, compared to less flexible simulation frameworks such as armed bandits [9]. Furthermore, the model also assumes that the searcher primarily engages in local-search akin to the one-bit-flip mutations of a gene. Ratios as measures of landscape ruggedness (the common approach in the social sciences) as well as identifying features that can impede any classifications of ruggedness. While it is clear that influences how an agent is to search a given landscape, it is not clear how much epistasis is needed to make a problem difficult [62].

If garden and landscape design is concerned with the relations between humankind and nature, it is largely determined by one or the other of the conflicting philosophies about how human beings do or should relate to nature. People know that they are biologically and physiologically the products of natural evolution, yet their great technological accomplishments lead them to feel that they are above, beyond, or outside nature, that they have conquered and dominated the wilderness and have it now within their power to remake the world. Every work of garden and landscape design reflects one or the other complexity science as it stands at the present day is a collection of ideas and principles, many of which have been influenced by other bodies of knowledge. Increasing attention is now being paid to how these concepts can help researchers and practitioners understand and influence social, economic and political phenomena.

This breadth of coverage means that few fields of scientific endeavour have not been examined, in one way or another, by use of the concepts of complexity science. There are even dedicated research institutes, such as Santa Fe in the US, set up in 1984, where scientists from a range of disciplines collaborate with computing experts to conduct interdisciplinary work on the application of complexity science to new fields and questions (Rosenhead, 2001).