Design Ecology

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Abstract

This paper describes a heuristic for the integrated assessment of design ecologies and an explanation for the maintenance of these complex networks. The assessment model builds upon interpretations from cultural anthropology and ecology to create a heuristic for characterizing the distribution, abundance, and interaction of design concerns at different scales and for multiple actors. I employ information theory and the evolution of cooperation to provide a mechanism for the stickiness of integrated ecological, social, and material-based networks and the degree to which these factors influence design decisions. The examples allude to alternative social roles for artists and designers than have been emphasized in the past for their part in catalyzing cooperative networks and solving difficult problems.

1. Introduction

The title of this paper refers to its purpose, which is to attempt to organize an integrated assessment for the ecology of design. The term *ecology* comes from the Greek word *oikos* meaning 'house' or 'home'. Correspondingly, this paper aims to locate the place of design at multiple scales and across heterogeneous actors using a framework of integrated assessment (e.g. Ravetz, 2000). My intent is not to specify a framework for ecologically sustainable design work, but I do suspect that recognizing other relevant actors and participants will allow sustainable propositions to follow. In another vein, my aim is to encourage an expansion of the problem space where artists and designers can contribute. This begins with the ways problems are defined.

We tend to encounter a certain type of problems in the news every day as controversies over resource availability and demand, peace and conflict, adaptation and complex coordination, and how best to achieve equity among individuals and groups. Solutions to these problems have been especially elusive in history. Urban planners Rittel and Webber (1973) call these "wicked problems" because their social dimensions mean they cannot be adequately described, falsified, or optimized. This description places wicked problems in stark contrast to the relatively tame problems for which science and engineering are equipped. This is because the practices in science and engineering are organized to claim certainty and exclude many of the social dimensions that would otherwise complicate things.

Funtowicz and Ravetz (1993) categorize different kinds of problems using the degree of uncertainty–how much information one has about the nature of the problem–and the stakes involved. The stakes usually refer to the consequences for failure, which was also a distinguishing characteristic of Rittel and Webber's wicked problems. Funtowicz and Ravetz use the degree of uncertainty and stakes to invoke an expanded set of methodologies resulting in what they call *post-normal science*. Their expanded methodology calls for the inclusion of extended peer communities from outside of "expert" disciplines to help lend legitimacy and quality control to these high uncertainty and high stakes problems. This is a move towards greater democratic participation, information transparency, and increased assurance that the output of scientific work is valuable for policy and action in a dynamic world. It also suggests that changing our perspectives about how these problems are approached and by whom may facilitate the development of more robust social, ecological and technological systems.

My goal here is to offer an alternative view of the disciplinary space that artists and designers can call home. I have a second goal to insinuate designers as agents of the extended peer communities referred to by Funtowicz and Ravetz where the job of the artist and designer is to mediate collections of people, places, and things that can contribute solutions to wicked problems. However, in order to do this, I need to put forth a few points about diversity.

1.1 Diversity

When it comes to both tame and wicked problems, diversity is important to our ability to make small improvements to existing situations. Groups composed of individuals with different sets of cognitive perspectives yield better solutions than more homogenous groups for the sorts of tame problems encountered in science and engineering (Page, 2007). Their perspectives are mappings from objects, events, or situations to mental representations that come from our experiences with information, locations, and relationships. However, diversity only really works for these tame problems when the participants have similar mental models, or fundamental preferences, of how the world operates (Page, 2007). The difference between fundamental preferences and perspectives is important because it helps us see why wicked problems are so much more difficult to solve than tame ones. Tame problems are characterized by elements and perspectives that, when properly identified and ordered in the correct configuration, may allow us to solve the problem. With heterogeneous actors and scales involved, wicked problems tend to be much more complex. Consequently, we often suffer from the inability to agree on the source or nature of the problem in the first place, not to mention the identity and order of possible responses. This is because our differences in experience, learning, expertise, and perception do not necessarily overlap.

We also have rational and irrational preferences that contribute substantially to our development of the diversity needed to solve problems because they admit different ways of ordering things and of interacting with the environment. Rational preferences limit the number of alternatives one has to take into account in order to reach a decision—i.e. only "sensible" options are relevant. Because "nonsensical" alternatives make so many more combinations possible under irrationality, a large amount of processing power is needed even beyond the capability of today's computers in order to analyze the dynamics of diversity using a model or simulation. This creates a limitation for our understanding of diversity and why it matters for problem solving. This is especially true for modeling difficult problems that require multiple alternatives, simultaneously.

Consequently, it is sometimes argued that irrational preferences result from unclear thinking (e.g. Page, 2007). However, an alternative perspective is that cognitive biases, risky or riskless contexts, the choices themselves, and the information we receive affect our assessment of preferences, judgment, similarity, and beliefs (Tversky and Shafir, 2003). Previously, behavior was thought to be predictable because people make choices in their own interest. We now know that we neither have access to all of the available information about a choice nor the ability to process that information meaningfully all of the time. Economists Richard Thaler and Cass Sunstein explain how *choice architecture,* the infrastructure of decision making, is shaped by the form and arrangement of information and can help people make better choices in line with their own preferences (2008). The principles they describe are aimed at helping people simplify alternatives and make decisions under more meaningful and less information-dense circumstances. That is, they show how diverse perspectives can be adapted to each other using the elements of visual and interactive form: typography, ordering, scale, repetition, and other elements. This is where I believe artists and designers can play a renewed and proactive role in civil society.

When artists and designers are trained to recognize and value their roles as brokers of information and meaning, they can be the agents who bring diverse people, social groups, and choices together to solve wicked problems. My proposition is that artists and designers open the landscape to new solutions to these problems 1) by augmenting peoples' understanding of their own fundamental preferences, effectively allowing them to find common ground, and 2) by adding design processes that will allow people to make meaningful choices and reduce the cognitive dissonance and uncertainty associated with wicked problems. However, in order to do this we may need some additional levers and institutional arrangements to perform this work.

1.2 From Interdisciplinarity to Transdiscipinarity

Interdisciplinary practices can integrate diverse ways of working and interacting. Julie Thompson Klein describes interdisciplinary learning as "neither a subject matter nor a body of content. It is a process for achieving an interpretive synthesis, a process that usually begins with a problem, question, topic, or issue" (1990). Boix Mansilla elaborates, describing interdisciplinarity as "the capacity to integrate knowledge and modes of thinking in two or more disciplines to produce a cognitive advancement – e.g., explaining a phenomenon, solving a problem, creating a product, raising a new question – in ways that would have been unlikely through single disciplinary means. … the integration of disciplinary perspectives is a means to a purpose, not an end in itself" (2005).

While interdisciplinarity might be viewed as a form of cognitive integration, transdisciplinarity is the application of interdisciplinary solution finding when applied to wicked problems. It can be thought of in terms of its cognitive *and* its practical integration. When concepts, theories and methods are applied across disciplines and groups working to solve wicked problems, they are effectively being tested for their robustness and value for multiple communities. Extended peer communities such as those outside a discipline are therefore important for the propagation of transdisciplinary work and for negotiating its value in multiple instances, places, and forms. However, in moving information, tools, ideas, practices, and meaning from one community to another, a great deal of translation must occur if these transplanted practices are going to make any sense in their new context.

I compare interdisciplinarity and transdisciplinarity because students and teachers face critical decisions about how to apply forms of knowledge and the basic patterns they describe, as well as the arrays of artifacts they put up as candidates for everyday use. Social networks are shifting rapidly, if only due to the rapid urbanization of many of the world's inhabitants. I also believe students and teachers face a mounting challenge and responsibility to increase the number of participants in the design process. If you consider the multiple scales of design, from the nano scale to the planetary scale, negotiation is paramount for the successful deployment of sustainable technology in these social and ecological systems.

This paper then is an attempt to complicate the matter of design when it interacts with social and ecological systems. By conflating two sets of interpretations from the fields of cultural anthropology and ecology, I hope to stimulate discovery of predictive models and courses of action based on the specifics of actors or individuals involved. The goal here is to manage uncertainty by enhancing students' capacity to integrate diverse perspectives and to synthesize different implementations across communities. The benefit is posed as the invocation of a larger suite of interactions and solution space for students to consider, along with the emergent and unexpected processes that can result from those interactions. I caution that this is not by itself a predictive model for action. It is a bit like rearranging the shelves in the library so that you can turn around and discover a new book or topic, something you were not expecting given your location in the stacks, your office, or your discipline. It does not tell you what to do, but it might add something useful.

2. A Heuristic for Framing Interactions

A heuristic is a rule applied to an existing solution (in this case, design) that generates new solutions or possibilities (e.g. It answers the question, "who do we consult and who has a stake?"). Heuristics tend to be more valuable when there is uncertainty rather than when preexisting interpretations of the world are already agreed upon. This heuristic developed Russell Bernard's matrix for finding research topics in cultural anthropology, which represents a common interpretation of factors (hereafter, "sources of uncertainty") important to cultural anthropology (1996; Table 1).

Bernard's interpretation works pretty well for humans, but if we rely solely on cultural anthropology we might fail to include the concerns of others like plants, animal, majority perspectives, or even ourselves. If we take as our goal the design and emergence of preferred situations, we need to keep ecological concerns in view if we are going to include a measure of justice for everyone and reduce the amount of risk we face. Drawing from the field of ecology, I have added an additional interpretation to Bernard's matrix that asks how biological, cultural, and material sources of uncertainly matter at different levels of ecological scale (Table 1; column 2). This is relevant because knowledge in these domains is increasing rapidly, and as that knowledge increases, there is often a corresponding series of designed interventions by people. These additional categories allow us to consider the designed interaction, even if they are not standard practice in anthropology or any other discipline. It asks, "What happens when we merge the work of cultural anthropologists, ecologists, and cognitive psychologists, designers, economists, and evolutionary biologists?"

Their interactions between categories may suggest sources of emergent traits or mechanisms of failure. At a minimum, they facilitate thinking and working with these other sources of uncertainty in mind. I have dispersed them across the grid as a simple way of making sure that each interaction is accounted for and considered (Table 2), because accounting is a major way to bring participation and sustainability to the design process (Boyce, 2000; Bebbington et al., 2007; Frame and Brown, 2008; see also Latour, 2006). The grid arrangement also points to areas where the interactions can be particularly relevant for organizational goals. For example, traits that are uniquely human touch on motivations, while the interactions of human-generated 'stuff' seem uniquely qualified to inform us about the robustness of our ecological and technological systems. The grid also helps us recognize that the interactions can be bidirectional, with "arrows" of material or sign/semeiotic causality (i.e. " What is driving what?") arriving from any level or actor (Lemke, 2000).

3. Design Ecology

With this set of interactions in mind, we can see a sort of design ecology begin to emerge. Design ecologists study the distribution and abundance of the design concerns, their interactions, and how their architectures are maintained. Much like ecologists concerned with the distribution, abundance, and interactions among species, design ecologists study biotic, social, abiotic, and technological sources of uncertainty that structure the origin and maintenance of products, infrastructure, and services that support human and non-human flourishing. Ecological models have been used in the past as analogies for design-based systems including theories of competition among firms (Hannan and Freeman, 1977), mimicry or convergent relationships between design systems and natural ones (Beyus, 2002), industrial flows (O'Rourke, et al., 1996; Verhoef, 2004), and artifacts (Krippendorff, 2006). Here, my goal is to start to connect the concerns of each of these together in an integrated fashion so that we can start to enlarge the perspectives needed to design robust systems before we prematurely exclude the ones we need most. To describe and arrange these ecologies, designers and artists may need some "material" to work with. Here I think mutual information, cooperation, and preferences can help.

3.1 Mutual Information

Mutual information is a term from information theory that describes the amount of information one thing tells about another thing. It is the reduction in uncertainty of one thing due to knowledge of another (Cover and Thomas, 1991). If we ask how information is shared between each of the different sources of uncertainty, we may be able to get a sense of how they are connected and how they might respond to each other. Mutual information provides a mechanism for observation and engagement.

3.2 Cooperative Networks

Social networks endure because they are able to maintain mechanisms for stabilizing their interactions. Network reciprocity describes a process that allows entities to form enduring cooperative networks (Ohtsuki et al., 2006). It serves as an example of a strategic game that simulates cooperation in groups where an individual's success in making choices depends on the choices of others. Relationships endure over time from the benefits of interaction. Defectors or cheaters do not pay to a cost to their neighbors, but they nonetheless benefit from the donations of their neighbors. Because it is a network, neighbors form clusters, help each other, and despite those defectors, are expected to persist when the ratio of benefits to costs is greater than its average number of neighbors (Ohtsuki et al., 2006). Networked reciprocity creates heterarchies, or interlinking, between actors and individuals. This allows conditional or power-sharing roles to develop when one's ability to be successful is influenced by the choices of others and vice-versa. Consequently, defining the size of the network of interactions in an important step in being able to determine the likelihood that cooperative design ecologies will form.

3.3 Preferences Redux

If our goal is stronger cooperation and more cohesive networks, it might make sense to reduce the number of participants or actors in that network to those that are going to "work well" with each other. This might mean behavioral coordination, but it may also mean that clear and informed understanding between participants, whether they are people or things. Designers can limit or arrange choices and help focus preferences, effectively limiting the number of actors and uncertainty in a network. By designing information and interactions to increase mutual information and refocus preferences, artists and designers can facilitate cooperation, perhaps even on the most difficult problems.

Consider time as a special example. One of the ways we design and coordinate systems is by arriving and departing at the same time. In whatever shared space we inhabit and work, we are able to communicate and perhaps even reach "common ground." Clocks are visual information sources that help us limit our choices, making it possible for us to connect facets of behavior, artifacts, populations, and cognition together and into the places they need to be to do work or whatever we decide we need them for. When we coordinate our clocks, we increase our mutual information and limit our network size, making cooperation possible by increasing our common ground—sometime figuratively and sometimes literally as well. Clocks are a social technology, invented for the purposes of communication and coordination. My question is, "Are there other social technologies that can be created by artists and designers to provide similar services and that will help us solve some of the more difficult problems of cognitive and social coordination?"

4. Role and Characteristics of the Design Ecologist

In taking together the things I have presented here, there are a few final heuristics for teaching, learning, and designing that I think will become even more valuable in the coming decades.

The first comes from the concept of *interessement*. Sociologist Michel Callon (1986) describes interessement as, "the group of actions by which an entity attempts to impose and stabilize the identity of the other actors it defines through its problematization." This means that a role for artists and designers is in the communication of identities, goals, and avenues of coordination when they get involved and frame problems through their own ways of working. The value they create is arrived at in the way problems are reshaped, assumptions examined, and new channels for communication found when they are made visible for potential stakeholders. Designers can then be thought of as mutual information builders for diverse groups. A further question is, "How do we then design for communication between humans and non-humans?"

Role and identity is important, but what artists and designers make and do is also critical. I like the concept *boundary objects* as a target for the types, forms, and functions of things that exist and interact in social spaces. According to Bowker and Star (1999) boundary objects:

> "... are those objects that both inhabit several communities of practice and satisfy the informational requirements of each of them. Boundary objects are thus both plastic enough to adapt to local needs and constraints of the several parties employing them, yet robust enough to maintain a common identity across sites. They are weakly

structured in common use and become strongly structured in individual-site use. These objects may be abstract or concrete... Such objects have different meanings in different social worlds but their structure is common enough to more than one world to make them recognizable, a means of translation. The creation and management of boundary objects is a key process in developing and maintaining coherence across intersecting communities…Boundary objects arise over time from durable cooperation among communities of practice."

Here again I think artists and designers have a distinct role to play in aiding the development of these objects. Maps offer an excellent example. Within the map's boundaries, real and imagined places or objects can be represented with more or less convention and with changes over time. Different people can use maps for different purposes.

A third heuristic not altogether different from *interessement* is the concept of *network entrepreneurship*. A network entrepreneur is someone who brokers ideas across structural holes in organization and networks (Burt 2004). Structural holes are areas of emptiness or gaps between social groups. The epistemological and methodological gap between the arts and sciences is a good example. According to Burt, individuals (and possibly groups) that provide vision across these gaps create advantages and opportunities that are a form of social capital. The work that these types of individuals do is based on the assumption that within group variation and the diversity of ideas is less than the variation and range of possible solutions achievable between groups. Network entrepreneurs position themselves to draw from these different sources of cognitive or other contextual variation while seeking solutions, ideas, and ways to connect. If an individual is involved in designing a boundary object, the degree to which they engage in network entrepreneurship may increase the suitability of that object across different communities *because* they are communicating with and engaging with those communities.

Interessement, boundary objects, and network entrepreneurship, taken together, suggest a final set of teaching and learning goals. Burt's (2004) characteristics of network entrepreneurs and Rhoten and Pfirman's (2007) interdisciplinary behaviors were the starting points for these guides, but I have reframed them somewhat here. These goals provide questions that can be asked of assignments and projects and may serve as a set of characteristics to encourage in behavior as well.

4.1 Adaptation

Are tools, artifacts, concepts, data, methods, metaphors, or results adapted from different fields and/or disciplines? Are individuals in one or more groups aware of the concerns of the other(s), and does that awareness create common ground? Do these result in the creation of new value chains for social, economic, and epistemological development that can be applied in new contexts and in response to shifting norms, values, and environmental conditions?

4.2 Coordination

Does it promote seeking, exchange, and/or creation of tools, concepts, data, methods, or results across different fields and/or disciplines? Are collaboration, infrastructure, and participation enhanced? Are practices transferred that have the potential to create value from one group in another group?

4.3 Knowledge-Networking

Does the work or play involve engagement in domains that sit at the intersection of or the edges of multiple fields and/or disciplines? Are seemingly unrelated things "drawn together" either out of analogy or other cognitive tool?

4.4 Framing

Is there engagement in topics that not only draw on multiple fields and/or disciplines but also serve multiple stakeholders and broader missions outside of academia? Is there synthesis of new behaviors and beliefs that combine the concerns of diverse groups?

5. Conclusion

The Australian Public Service concluded that the prime skills needed to address the problems of governance include working across organizational boundaries, engaging stakeholders, and influencing citizens' behavior. The Public Service Commissioner's report says that, "People with connecting skills will be increasingly valued—people who can build up relationships across the public, private and non-profit sectors and leverage these relationships to build networks of mutual benefit. There is also a need for policy makers to be aware of and apply behavioural change theory." (Tackling Wicked Problems, 2009). Artists and designers are some of these people, and they should become more directly engaged with these tasks. Training the next generation in these kinds of skills is itself a difficult passage point, but it is also a kind of stimulus to help push us past the current threshold and into a new space of possibility and coordination, perhaps finding new design ecologies along the way. As teachers and mentors, we can help emerging professionals develop these skills, but in order to do so we may need to shed our own biases and assumption. We have taken the first step by showing up here to communicate together. What's next?

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Table 1.
Social Research Methods and Design Ecology Framework Compared.

Social Research Methods Interpretation (Bernard, 2000)	**Design Ecology Interpretation**
	Genetics
Internal States	Cognition
External States	Phenotype
Behavior	Behavior
	Material Aggregations
Artifacts	Artifacts
Environment	Population
	Community
	Landscape
	Ecosystem

Table 2.
Sources of Uncertainty in a Grid Arrangement Help to Integrate and Assess Design Ecologies.

Sources of Uncertainty	Genetic	Cognition	Phenotype	Behavior	Aggregations	Artifacts	Population	Community	Landscape	Ecosystem
Genetic										
Cognition		Motivation			Mediation					
Phenotype								Coordination		
Behavior										
Aggregations					Efficiency			Robustness		
Artifacts										
Population	x2 for Directed Networks							Operation/ Contingency		
Community										
Landscape										
Ecosystem										