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Co-Design for Second-order Effects and Institutional Change

A Case Study in Sustainability

Abstract
Second-order or indirect effects refer to changes within a system that are the result of changes made through direct intervention somewhere else in the system (the first-order effects). Second-order effects can occur at different spatial, temporal, or organizational scales from the original intervention, and can therefore be difficult to predict or control. Some organizational theorists suggest that careful in-situ management of feedback processes can facilitate controlled change from one organizational configuration to another. These structural changes typically occur when a relatively closed and increasingly entropic configuration is reorganized to create a more open and stable configuration, referred to as a dissipative structure. Recognizing that the skill at managing feedback processes is a core competency of design suggests that iterative action-reflection cycles and other design skills are potentially useful tools in achieving organizational change. We describe a case study in which we use a co-design methodology to create and harness the second-order effects resulting from a classroom intervention to produce a dissipative structure at higher scale. We further generalize this approach into a model for achieving systemic change that we refer to as an Instigator Systems approach.

Introduction

Creating change within an organization is a difficult task. Even when an organization recognizes the need for change at all levels, introducing new processes, creating new relationships, and letting go of engrained ways of thinking are difficult to accomplish. There are always inertial forces, some intentional some unintentional, that resist change and attempt to pull the organization back into its previous equilibrium state. These forces can be beneficial if stability will aid in the overall survival of the organization. However, if the surrounding environment is radically different than the one in which the organization grew, inertia toward the previous steady-state can end up destroying an organization.

It is difficult to know which approach is best. Skillful managers and visionary leaders are often called upon to make this determination, and numerous case studies of these success stories abound in the business literature, alongside stories of failed visions and inflexible organizations that could not adapt to or prepare for change. In the Design Way (Stolterman & Nelson, 2012), Nelson and Stolterman identify “desiderata-driven” change as characteristic of design, but only one of five “triggers of change.” The others, management–, problem–, vision–, and crisis–driven change are less human-centred and more in-line with the systems approaches found within the organizational and management literature (Gemmill & Smith, 1985; Leifer, 1989). Regardless of what drives it, is it is clear that sometimes change is necessary, increasingly so in the 21st Century, but how much change is enough to adapt to a changing environment and what role can design play in accomplishing this change?

There is a fundamental tension in the organizational management literature regarding whether transformations from one equilibrium-state to another can be viewed as "evolutionary vs. revolutionary." Both conceivably result in a new organizational configuration capable of meeting the demands placed on it by its environment, and both use the same mechanisms of self-organization. The difference lies in how much the restructured organization resembles its former self. There are no easy metrics for determining the right quantity and quality of organizational change. This literature frequently uses the language of "radical transformation" to describe structural changes to an organization that result in new configurations, and the case studies presented are typically of entire business firms which reorganize to respond to the challenges of a changing business environment. Yet, one of the fundamental precepts of systems theory is that the patterns of organization that emerge from the interactions of components are independent of scale. An example from the popular book *Emergence* (Johnson, 2002) in which a historic map of the city of Berlin bears a striking resemblance to the organization of the human brain demonstrates this principle well, but there are many more examples.

It goes without saying that radical transformation itself can exist at multiple scales. The question we ask here is can a sub-system of a larger organization (a department or division for example) undergo radical transformation without substantially reorganizing the larger-scale organization that contains it? This is an important consideration for a design approach as well. As Nelson and Stolterman also point out, in order for desiderata-driven change to be effective the right context and environment, "a design crucible" or "container, which defines the limits and possibilities of design activity," needs to exist. While those authors advocate for creating such a design culture in all organizations, this is not the current state of the world. What if the container, the design culture, exists on a smaller scale? Perhaps, only in one small unit within a larger organization? Can we still effectively create intentional change?

The benefits of this kind of *radical change at manageable scale* are numerous. For one, it is far easier to radically alter a sub-system than to alter an entire organization. This means less energy is required to do so, and translates into less effort by fewer personnel, making such changes attainable by a few motivated individuals, at least in theory. Second, such changes are less likely to be noticed and counteracted, as they do not have substantial implications for other subsystems. Others in the organization are not being asked to change as radically, or at all, and may potentially benefit if the change helps alleviate pressures that are more widely felt. Third, an organization that can accomplish these changes can potentially outperform others by achieving the benefits of stability and adaptability simultaneously. Stability comes through making only the most minimal changes necessary to maintain equilibrium, while at the same time adapting to changing environments adequately enough to relieve internal and external pressures.

At the heart of this idea is a modular view—that large-scale institutions can be conceived of as collections of relatively independent subsystems whose interfaces to other subsystems are tightly specified, while their internal dynamics are largely isolated from the functioning whole. This is, of course, just one way of mentally modelling an organization. It is likely equally true to conceive of an organization as individuals each obeying their own rules to create collective action, or any number of other configurations. Some organizations lend themselves to different conceptions more readily. The purpose here is not to advocate for one model or another (circumstances differ), but to show how framing a system using this modular view can be productively employed in one particular case. One implication of the modular view that we exploited in our work is that it affords the possibility to reorganize a subsystem while keeping other components of the larger-scale organization unchanged.

In what follows we describe a case study in which we were able to achieve a modest structural change, the creation of new information channels for the exchange of information between campus planners and municipal water authorities. While such a change was in keeping with agreed upon institutional goals of both the university and the municipality at the highest levels, these goals lacked many of the organizational structures to achieve them. This is quite typical of large organizations with long histories. We were able to aid in achieving these organizational goals by creating new connections between campus planners and municipal water authorities using a co-design process integrated into a new course called Sustainability: Theory and Practice. By involving students, faculty, campus planners and city engineers in the semester-long design process for green infrastructure on campus, we were able to open the decision-making process to new sources of information and change the way this sub-system functioned. While it is too soon to tell if our changes themselves are sustainable we believe that this method of creating institutional change is a viable strategy in many contexts.

Background

Dissipative structures arise through thermodynamic processes. Citing the work of Ilya Prigogine, Nobelaureate and originator of the idea of *dissipative structures*, MacIntosh and MacLean (MacIntosh & MacLean, 1999) offer a description that is worth quoting at length:

> Rather than viewing the world as essentially static, with equilibrium only occasionally disturbed, Prigogine regards the world as dynamic and characterized by systems in which normal Newtonian laws may apply, but only in a minority of situations. That is to say that whilst such systems can exist in equilibrium, change and transformation are associated with non-equilibrium conditions, which are subject to a different set of laws. The evolution of non- equilibrium systems is influenced by a combination of a complex network of nonlinear system relationships and random developments, which combine to create new system configurations in a way that is largely indeterminate. In extreme cases, the system can be so far from equilibrium that the structure breaks down and the system becomes chaotic. In such circumstances, the operation of simple rules in conjunction with nonlinear processes (i.e., the action of positive feedback on small and possibly random events) can give rise to the emergence of new, qualitatively different, structures. Since Prigogine's work focused on phenomena such as phase transitions in matter, his work is characterized by descriptions of systems moving progressively further from equilibrium to the point where a 'descent into chaos' ensues and the system structures are broken down. At

> this point the system becomes open to its environment, importing energy and exporting entropy (a measure of disorder) as a new structure takes shape in accordance with the operations of a set of simple order-generating rules. Since, in physics, heat is the most entropic form of energy, the system is said to be dissipative, in that the entropy exportation is characterized by heat loss. The system is thus termed a ‘dissipative structure’.

As a physical scientist, Prigogine is intent on describing and understanding the physical world. A tenet of the systems view of the world however is the notion that physical, biological, and social phenomena obey the same laws of organization (De Landa, 1997, for example). In keeping with this idea, Prigogine’s model of dissipative structures has since been applied to social phenomena at various levels of organization (scales). MacIntosh and MacLean offer one such example along with an extension of the dissipative structures idea that adds an element of human intentionality missing from a purely physical description of self-organization. In their view, management of the transformational process is able to move the organization toward a more favourable stable equilibrium state. The idea is a simple one: all systems undergoing transformation reach a “bifurcation point” where they can move into one or another equilibrium state, social organizations have the addition of human agency and technological tools that can be deployed to influence the change process toward a desired equilibrium state. Their framework referred to as “conditioned emergence,” fits the definition of design as “the creation of intentional change” given by Nelson and Stolterman and is in commensurate with is and it involves three steps:

1. Conditioning—the organization identifies “deep structures” that are present in the current archetype and have guided its historical trajectory. These are often core values, business principles, etc., which are re-evaluated to create a new set of rules to govern and manage the behaviour of the organization going forward. Some of the old deep structures may be kept or modified and new ones are formulated.
2. Creating non-equilibrium—a crisis, either naturally occurring or precipitated forces the organization into chaos, creating entropy within the system and opening the organization up to import energy from the environment.
3. Managing the feedback process—Managers look for small signals consistent with the effects of the new deep structures and attempts to amplify these signals (positive or reinforcing feedback), while at the same time trying to damp out the influence of the old deep structures which try to pull the organization back into its previous equilibrium state (negative or balancing feedback).

The idea behind conditioned emergence is that the processes of self-organization which brings the institution to its new stable configuration, while still dependent on initial conditions like any other complex dynamical system, is not strictly the result of random interactions of system components. Rather a manager or management team can intentionally shepherd the transformation process to bring about the most favourable result through skillful manipulation of the feedback process. What’s more, these activities, while still goal-directed, are not pre- planned, but instead require the ability to perceive and direct feedback processes.

MacIntosh and MacLean, however, are extrapolating on earlier work, by Jantsch (1975), but also by Leifer (1989) and Gemmill & Smith (1985). While MacIntosh and MacLean offer important additional concepts in the three-step process they outline above, the earlier characterization of the dissipative structuring process given by Gemmill and Smith provides a better way of thinking about the overall process, while MacIntosh and MacLean provide a more operationalized view of how to manage that process. This second view becomes more important when we discuss intersections with design below, but understanding the overall process is most important up front. I will briefly define each below.

1. *Disequilibrium conditions* – extreme turbulence, either internal, external or both, creates the initial conditions in which change becomes possible.
2. *Symmetry breaking* – The system's self-replicating or usual autopoetic functioning has become ineffective or has purposely been suppressed in order that new possibilities may emerge (This quotation on page 759 also has connections to the ideas of evolutionary vs. revolutionary change)
3. *Experimentation.* Through the experimentation process, the system creates new possible configurations around which it can eventually reformulate. The system that is best able to transform is one in which such experimentation and retention of variants are encouraged, rather than discouraged, dampened, and discharged.
4. *Reformulation Processes.* In this formative process, new configurations are tested within the new environmental constraints and with respect to the system's previous level of development. For this to take place, the system must be highly resonant, both internally and externally, to both its subsystem alignments and its alignments with the contingencies of the environment. The presence of this resonance and the ability of the system to move as a whole into the configurations it experiments with makes successful transformation more probable.

Our Project

One of the hallmarks of complex systems is their “multileveledness” (Boyatzis, 2006), the fact that they can be described at multiple levels of abstraction or multiple “scales.” For example, a glass of water can be described by detailing the movements of the individual water molecules in the glass—a molecular-scale description. That same system can also be described using the emergent collective variables of temperature and pressure that describe the aggregate interactions of all the water molecules, what is often referred to as a “macro-scale description.” Likewise, complex social systems can also be described at multiple levels of organization. Our project was an experiment at multiple scales. The topmost scale, which we refer to as the *institutional scale*, an intermediate scale at the level of departments, divisions, and working teams within the institution (the *departmental scale*), and a *classroom scale* which describes the individual interactions of students and instructors in the context of our course.

This experiment had goals at every scale. At the classroom scale we tried to implement an innovative pedagogical approach to create a better match between classroom and professional activities. At the institutional scale, we wanted to help the university and the local municipality realize mutual goals around sustainability and community relations that had been agreed to at a series of memoranda. Most importantly though, at the departmental scale, we wanted to create an inter-institutional working group to facilitate the implementation of Green Infrastructure on the campus, to provide a continued source of learning opportunities and professional development for students, and to establish new information channels that could be used to plan and execute future joint ventures. The creation and maintenance of these new information channels, which really amount to personal relationships within formal institutional contexts, are the main dissipative structures we sought to create and sustain. As information flows along these channels, down to students working on projects (lower scale), up to administers to report progress and request resources (higher scale), and across institutions at the departmental level (same scale), the system has new pathways for energy- entropy exchange, around which it can self-organize.

At the institutional scale, we wanted to create new connections between the Georgetown University and the District of Columbia Water and Sewer Authority that would help both institutions advance their sustainability efforts in the short term and create tighter coupling (better information flow, defining mutual goals, etc.) in the long-term. Georgetown University has made many long-term commitments regarding sustainability and community relations. District of Columbia Water and Sewer Authority (DC Water), and particularly one group within DC Water called the Clean Rivers Project, has also made many commitments around reengineering stormwater in the District and using Green Infrastructure (GI) to do so wherever feasible.

The Clean Rivers Project focuses on the alleviating the problems caused by Combined Sewer Overflows. Remnants of pre-industrial development in Washington DC, CSOs are large drainage pipes that drain both stormwater and sewage. In normal conditions these systems funnel the combined sewage/stormwater to water treatment facilities where it is purified and released back into the ecosystem. However, during large rain events this system cannot process all the water and the combined sewage/stormwater enters the region’s waterways untreated through the CSOs. While large-scale engineering solutions are being enacted, the inclusion of GI for long-term stormwater management has additional benefits associated with the triple-bottom-line—reduced costs and added maintenance jobs, increased greenspace, and educational opportunities, to name a few. Large parts of the university campus happen to be located within the boundaries of two major CSOs, suggesting that GI on the Georgetown campus would help meet both the goals of DC Water and the university. However, no structural mechanisms were in place for decision-makers in either institution to even know about each other’s plans or to synergize their activities.

The institutional scale goal of our experimental course was to create information channels that allowed for a reconfiguration of the GU-DC Water system to achieve their sustainability goals. However, while institutional scale goals are set at the top-level, the responsibility to operationalize these goals falls on other entities in the organization. Specifically, the DC Clean Rivers Project is the group within DC Water tasked with the planning and implementation of the GI within CSO boundaries, while GU facilities is responsible for all planning on campus. Through our project, we hoped to create stronger connections, in the form of information flows between these mid-level organizational entities (connections at the departmental-scale). Essentially, we tried to manage the emergence of these connections through a co-design process and create a dissipative structure at the departmental-scale that could help both institutions achieve sustainable structural change.

Our co-design methodology was based on stakeholder meetings between the student teams, the DC Water facilitators and Facilities personnel in which students gave presentations of their on-going work to members of the Facilities team. This furthered the professionalization of the students as they gradually learned to use the technical vocabulary they were learning in class to openly discuss the details of their project. It also gave the students a deeper understanding of how decisions are made within the university, which was a shock to most. Initially, students had a hard time accepting the ways that issues such as fiscal cycles, resource allocations, and competing priorities within the university, needed to be factored into their designs. However, by the end of the course, most had a more innate understanding of how these factors might force design changes over the course of a project and learned much about organizational time scales.

For the Facilities team, they were able to see and hear first-hand what students perceived as important goals and priorities for campus planning. More importantly though, they were able to interact with their counterparts from the DC Water team to learn more about that organization's goals and priorities. Likewise, the DC Water team learned about campus planning priorities in the same context. While the common goal of these meetings was ostensibly to help the students advance their project, the two groups were also informally synchronizing their efforts. The student project was a low-stakes endeavour with all stakeholders genuinely wanting to aid in the education of the students and see their project succeed. As such any negotiation was focused on how the student project could be successfully designed and potentially implemented, rather than all parties trying to get a favourable outcome for themselves, as is often the case, all parties were trying to achieve a favourable outcome for the students. This context was essential for establishing a good working relationship. There were real constraints placed on the project but there was also real effort to find ways to work around these constraints for the sake of the students.

Much came out of these meetings in addition to student learning. When the students asked to see surveys of the campus to identify areas for intervention, it was found that university records and municipal records did not agree and a survey was implemented to identify current drainage patterns and stormwater infrastructure. A plan to implement a small green roof demonstration site on the main university library, within one of the CSOs, using the students' design was integrated into the Campus Sustainability Plan. Most importantly though, conversations between Facilities and DC Water are on-going, and the two groups are working toward larger scale projects that meet mutual goals.

Our project also had goals at the classroom scale. We tried to create a unique combination of instructional approaches that would give students solid theoretical grounding and practical experience in both sustainability and design. Two instructors with overlapping but distinct expertise team-taught the course. We invited the outside experts from the DC Water to assist in classroom activities, including leading discussion about the water cycle and treatment options for urban environments, leading site walks to determine suitable locations for interventions, and leading three design charrettes in addition to their participation in the stakeholder meetings. This gave the course a feeling of professionalization, as students were taught simplified versions of the techniques these professionals used in their daily practice. We used a lecture+studio model for teaching in which students were given short explanations and demonstrations of activities that they were then asked to replicate in the context of their project. These became progressively more focused after each iteration as we converged on designs. We also entered an external design competition, the Campus RainWorks Challenge administered by the U.S. Environmental Protection Agency (we won Honorable Mention), to provide external structure that helped students stay engaged. This competition required the creation of two 3’x4’ design boards and a ten-page project description which were the only deliverables for the course. The students created the design boards in teams of four and each student contributed an individual section to the project narrative.

Back to Systemic Design

It is the historical consistency and continuity of higher education institutions that mark them as what Jantsch might call Equilibrium institutions. Turbulence from the outside or inside of these institutions gets absorbed and adapted to, while the whole institutional structure remains largely unchanged. For example, new departments like media and communications are created in place of journalism to account for the changing environmental landscape of information dissemination. These are evolutionary changes rather than revolutionary ones. Making these kinds of adaptations has allowed the university to continue in basically the same structure–it has remained largely unchanged since the enlightenment–for generations. Still, the fast pace of technological change and the increasing magnitude of social, economic, and environmental stresses have left many contemporary observers wondering if the same strategies are capable of sustaining universities into the future.

It should not be a shock to anyone working in higher education to hear that disequilibrium conditions exist. The growth in for-profit colleges and universities, the availability of “open” courseware and internet-enabled distance learning, the soaring costs of attending colleges and the debt burdens they create for students, are only a few of the pressures being faced by institutions of higher learning. While it may prove to be the case that educational institutions will be able to adapt to these new pressures and maintain a steady-state equilibrium, it is also apparent that some symmetry breaking is occurring. Smaller universities are struggling to survive in this new environment, and many are citing financial difficulties as a symptom that the usual self-sustaining equilibrium processes are breaking down. The move toward MOOCs (Massive Online Open Courses) in traditional universities can be seen, in this context, as an attempt to open the system up and export entropy and import energy. In our own institution we have begun the experimentation stage. New initiatives such as the “Designing the Futures of the University” the “Initiative on Technology Enhanced Learning,” and others are deliberately suppressing the autopoetic processes of the university to allow faculty and departments to explore new structures for research and teaching.

Our project was able to flourish in this atmosphere of open and encouraged experimentation, which allowed us to attach a number of unique features to this project. Having instructors situated in both academic and administrative units provided important benefits to the project. Having facilities and the Director of Sustainability get to interact directly with students and faculty created an opportunity to practice co-design in a way that contrasts with how much university planning is typically done. Having one of the instructors embedded in the Facilities office facilitated communication and ready exchange of information. Students briefed key facilities personnel on three occasions, each time receiving crucial feedback about the feasibility of their project and its relation to on-going planning at the university. At the same time, these briefings allowed students to see how the decisions are made at an institutional scale, and helped them understand the additional complexities and indirect effects their decisions might have. Giving students a look behind the curtain of institutional processes even if they are undergoing radical change helps students grasp and design for the system as a whole. Another benefit of these stakeholder meetings was that they gave officials from DC Water and Facilities the chance to be in the same discussion, understand each other's needs and constraints, and brainstorm possible mutually beneficial paths forward. These stakeholder engagement briefings, with the low-stakes "sacrificial" student work as the topic created an additional channel for information to flow between organizations (at the departmental scale) that we hoped would help both organizations self-organize during the reformulation phase to create a sustained connection.

The work of Argyris and Schön (1989) is considered foundational in the complexity management literature. Schön's notion of reflective practice (Schön, 1983), is also considered an important foundation in the literature on design. Designers, particularly those who explicitly use an iterative process, rely on the management of feedback loops. As the instructors and managers for our course, we were also implicitly designers of the larger dissipative structure we hoped to create within our institution. This required constant reflection and action cycles on our part. We frequently discussed the current state of the project in relation to our multi-scale goals and made adjustments to keep things moving smoothly toward those goals despite many setbacks. We managed not only classroom activities, but institutional politics as well, and the outcomes, although still dynamic appear to be favourable.

Through our reflection we've come to see two new contributions of this work. First the notion of a using a design process to create a dissipative structure at the subsystem level, which we refer to as *radical change at manageable scale.* The purpose of this dissipative structure is to maintain energy-entropy exchange with the environment, hopefully in an on-going sustainable way, and it is embodied in the tighter coupling between DC Water at GU Facilities. Second we introduce the idea of an *instigator system*. The instigator subsystem refers to a system created specifically with the intention of altering another subsystem through second-order effects. In this case the instigator system, our course was the vehicle for creating the higher scale and longer lasting dissipative structure.

We define an instigator system as having two characteristics:

1. It exists for only a finite amount of time that is shorter than the system it attempts to change
2. It acts upon subsystems they are not a part of through second-order effects.

Creating and shepherding an instigator subsystem through to the creation of the second-order system is an act of design. Specifically, it requires the in-situ management of feedback loops to generate a desired outcome through direct application of refection-action cycles.

References

Argyris, C., & Schon, D. A. (1989). Participatory Action Research and Action Science Compared: A Commentary. *American Behavioral Scientist*. doi:10.1177/0002764289032005008

Boyatzis, R. E. (2006). An overview of intentional change from a complexity perspective. *Journal of Management Development*, *25*(7), 607–623. doi:10.1108/02621710610678445

De Landa, M. (1997). A thousand years of nonlinear history. *Swerve Editions*. doi:10.1017/S0022050701005964

Gemmill, G., & Smith, C. (1985). A Dissipative Structure Model of Organization Transformation. *Human Relations*, *38*(8), 751–766. doi:10.1177/001872678503800804

Jantsch, E. (1975). *Design for evolution: self-organization and planning in the life of human systems*. G. Braziller. Retrieved from https://books.google.com/books?id=RMbWAAAAMAAJ

Johnson, S. (2002). *Emergence: The Connected Lives of Ants, Brains, Cities, and Software*. Scribner. Retrieved from https://books.google.com/books?id=qAtgKyaLH4MC

Leifer, R. (1989). Understanding Organizational Transformation Using a Dissipative Structure Model. *Human Relations*, *42*(10), 899. doi:Article

MacIntosh, R., & MacLean, D. (1999). Conditioned Emergence: A Dissipative Structures Approach to Transformation. *Strategic Management Journal*, *20*(4), 297–316. doi:10.2307/3094213

Schön, D. A. (1983). *The Reflective Practitioner*. *Design*. doi:10.1542/peds.2005-0209

Nelson, H.G. & Stolterman, E. (2012). *The design way: Intentional change in an unpredictable world*. Second edition. Cambridge, MA: MIT Press.