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A Problematic Approach to the Science of Sustainable Design

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ABSTRACT:

In industrialised countries the reduction of the consumption of resources is recognised as the first step toward sustainable development. Achieving this will require an economic change which divorces economic success from resource consumption. An emerging trend in design research that is directly concerned with such 'dematerialisation' is for businesses to realign their corporate strategies toward the selling of performance rather than goods through the design of product-service combinations. In such a 'service' economy products cannot be completely defined by an essential and eternal form because product-services change in ways that are unforeseeable to the designer. This paper considers that such an epistemological shift can be conceptualised, following the philosophy of Gilles Deleuze (1925-1995) as the transition from an *axiomatic* to a *problematic* approach to design. This paper will develop and explain the differences and similarities between these two approaches and then draw out the implications for sustainable design and the relation between design and science.

Design knowledge, Design problems, Science of design

1. COMPLEX SYSTEMS AND COMPLEX PROBLEMS

A design project that is faced with the irreducible complexity of a problem such as coaxing the transition from an unsustainable system of production to a sustainable socio-technical system requires a design process that can "negotiate" such complex problems in a generative rather than reductive fashion. The nature of such "messy" design problems have been conceptualised in many ways in design research, for example, from Herbert Simon's (Simon, 1969/1996, 1973; Dorst, 2006) reductionist approach with his distinction between *well-structured* and *ill-structured* problems to Horst Rittel's (Rittel and Webber, 1973; Buchanan, 1995; Coyne, 2005; VanPatter, Conklin and Basadur, 2007) division between *tame* problems and *wicked* problems. Following to Rittel et al. such problems can be described as wicked because they form complex systems which cannot be reduced to an aggregate of points, and any attempt to summarise the workings of a complex system in terms of fundamental, essential principles is bound to fail. As Cilliers (1998) explains "a complex system cannot be reduced to a collection of basic constituents, not because a system is not constituted by them but because too much of the relational information gets lost in the process" (p. 10). This relates to the status of prediction within complex systems where, according to Bonta and Protevi (2004, p. 23), interventions which aim to control complex systems exactly cannot be made, for two reasons. Firstly, because complex systems are sensitive to initial conditions due to the cascading affects of miniscule measurement errors. Secondly, because some complex systems create new behaviours as they go along. This creative aspect renders the reductive analysis and then aggregation of unit behaviours unable to account for emergent effects.

Because complex systems are so sensitive to perturbations, even the slightest disturbance can build up to a major effect. This means that consequently, complex systems have short-term predictability and long-term unpredictability (also called deterministic chaos). A familiar example is the weather. The Meteorological Office has a very complex and detailed mathematical model of the Earth's atmosphere with which it analyses data from weather stations all over the world, which enable them to solve complex differential equations on their computer and so forecast the weather for about a week in advance. If the Earth's weather system was a closed system (in Deleuze's terms a form of *discrete* complexity which would be the domain of well-structured or tame problems), it follows that by simply increasing the number of weather stations and the power of the computers they should be able to extend their forecasts as long as they want. As we know this is not the case due to the fact that the weather system is a complex heterogeneous system that is driven by intensive differences, that can spontaneously produce emergent effects causing the smallest errors in the computer model to quickly build up making it unpredictable in the long-term.

This sensitivity to initial conditions, discovered by Edward Lorenz with his famous butterfly effect, presents a notion of limited unpredictability and not total chaos. I can effectively predict that the temperature in Wellington on Christmas Day 2010 will be between 10-40 degrees centigrade, meaning that the trajectory of the system (the weather pattern) frequently exhibits roughly the same behaviour but never exactly the same and never in exactly the same sequence of events (Mackenzie, 2005). Consequently exact solutions cannot be attained so problems have to be resolved as Deleuze says, in 'real-life operations'. This implies an epistemological shift that Deleuze highlights, in a dichotomy similar to Simon and Rittel, through the distinction between problematic and axiomatic epistemology, the concerns of what he calls minor science and royal science respectively. This distinction in turn reveals the trajectories of two different theories of design problems and design processes.

2. PROBLEMATICS AND AXIOMATICS

We can begin our analysis of the distinction between problematics and axiomatics with the Deleuze's examination of the ontology of mathematics. As Daniel W. Smith (2003) explains, Deleuze's distinction between problematics and axiomatics concerns a tension within the history of mathematics that can be traced back to Greek geometry, where theorems "concern the demonstration from axioms or postulates, of the inherent properties belonging to the figure, [whereas] problems concern the construction of figures using a straightedge and a compass" (p. 415). Accordingly, axiomatics and problematics concern two different forms of deduction.

> [In axiomatics] deduction moves from axioms to theorems that are derived from it, whereas in problematics a deduction moves from the problem to the ideal accidents or events that condition the problems and form the cases that resolve it… [Whereas in axiomatics] a figure is defined statistically, in platonic fashion, in terms of essence and its derived properties, in problematics a figure is defined dynamically by its capacity to be affected – that is by the events that befall it, cutting, projecting, folding, bending, rotating, stretching. (Smith, 2003, p. 415)

Deleuze assimilates axiomatics to the science of the royal societies and the most famous of scientists, whereas Deleuze claims that problematics have their source in 'proletariat' sciences such as metallurgy, carpentry, surveying, stonecutting, and perspective. Such minor sciences are, however, tied to the coding and formalising of royal science, which constantly tries to affect the reduction or repression of problematics to axiomatics, and which "deprives them of their own model, and allows them to exist only in the capacity of 'technologies' or 'applied science'" (Deleuze 1980/1987, p. 373). Minor sciences do not claim an autonomous power like royal science because they subordinate all their operations to the sensible conditions of intuition and construction – *following* the flow of matter.

The minor sciences are concerned with "*inventing problems* whose solution is tied to a whole set of collective, non-scientific activities but whose *scientific solution* depends, on the contrary, on royal science" (Deleuze & Guattari, 1980/1987, p. 374, emphasis in the original). Deleuze is not arguing against axiomatics and indeed claims that the translation of problematics into axiomatics is not only inevitable but scientifically necessary,

> What we have, rather, are two formally different conceptions of science, and, ontologically, a single field of interaction in which royal science [axiomatics] continually appropriates the contents of vague or nomad science [problematics] while nomad science cuts the contents of royal science loose. (1980/1987, p. 367).

Minor sciences are linked to notions such as heterogeneity, dynamism, variation or flows that are "barred" or "banned" by royal science which must then transpose problematic knowledge into axiomatic knowledge "by introducing it into its theorematic apparatus and its organisation of work" (Deleuze & Guattari, 1980/1987, p. 374, emphasis in the original). The minor sciences however, can never be fully reduced to royal science and demand their own status and rigor. When we maintain the primacy of royal science we cannot understand the full relationship between science and technology or science and practice because minor science is not a simple technology or practice but a scientific field in which these relationships are bought out and resolved in an entirely different way (Deleuze & Guattari, 1980/1987, p. 367).

3. VAGUE ESSENCES AND SYMMETRY-BREAKING TRANSITIONS

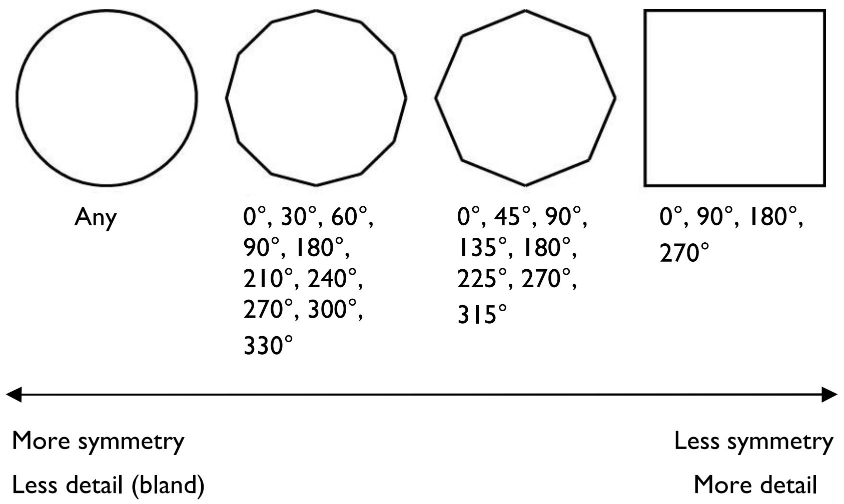
The distinction between the problematics of minor science and the axiomatics of royal science implies that we must understand matter as both in constant variation and carrying implicit forms or *vague essences*. These singularities are potentials for self-ordering inherent in matter that the designer must negotiate in such a manner that the form must be seen as suggested by matter rather than as the pure product of the mind. The axiomatics of royal science are concerned with fixed essences (laws) whereas the problematics of minor science are concerned with vague or morphological essences. For example, axiomatics defines a circle as an organic and fixed essence (πr^2), but the morphological variations of circles (“lens-shaped”, “umbelliform”) form problematic figures that, following Husserl, are *vague yet rigorous.*

Deleuze (1979, para. 17) maintains that vague essences are vague not by chance or by defect but because they are rigorously vague or *anexact*. Nevertheless Deleuze (1979) claims that vague essences possess a *corporeality* (materiality) which is not the same as sensible things (a wheel, a vase) or essences (the circle), but a corporeality that is on one hand “inseparable from processes of deformation of the event type of which it is the site, and on the other hand it is inseparable from types of qualities susceptible to greater or lesser intensities: colour, density, weight etc” (para. 18). A circle is a fixed essence, a plate or a wheel is a sensible formed thing, whereas a vague essence would be roundness, a vague essence that is inseparable from a process it undergoes: “roundness is simply the result, or the passage to the limit, of the process of rounding” (Deleuze, 1979, para. 19). Rounding does not imply a fixed formal essence as described in Euclidean geometry, but a “passage to the limit, for example: the series of polygons of which the circle would be the limit” (Deleuze, 1979, para. 19). Following DeLanda (2004b, p. 372) one way of understanding how vague essence can morphogenetically individuate an actual metric form (for example through a process of rounding), without recourse to the essentialism of royal science, can be thought in geometry through the concept of a *symmetry-breaking transition*. Symmetry is a technical term which we can roughly define as the degree to which an object lacks detail: the blander or less detailed the object, the more symmetry it has. We can make this concept more precise through the mathematical notion of groups of transformations, which can be described as a set of operations (having very specific properties) which when applied to a geometrical object change some of its properties while leaving others unchanged.

The importance of groups of transformations is that they can be used to classify geometric figures by their *invariants*. For example, applying the set of operations consisting of rotations by 90 degrees (that is, a set containing rotations by 0, 90, 180, 270 degrees), to a cube would leave it invariant, meaning that an observer who did not witness the rotation would be unable to tell that any transformation had taken place. It follows that a cube would not remain invariant under a set containing rotations of 45 degrees, but a sphere would. In fact a sphere remains visually unchanged under any amount of degrees. Mathematically this is expressed by saying that the sphere has more *symmetry* than the cube relative to the rotation transformation. In other words the larger the group of transformations leaving the object unchanged, the more symmetry the object is said to possess (relative to that transformation).

Classifying geometrical objects by their degrees of symmetry represents a departure from the *axiomatic* classification of geometrical figures by their essences. While an axiomatic approach would look for a set of properties common to all cubes, or to all spheres, groups do not classify these figures on the basis of their static properties but in terms of how these figures are affected (or not affected) by active transformations, that is, figures are classified by their *response to events that occur to them* (DeLanda, 2002a, p.18). Additionally, this *problematic* approach allows dynamic relations to be classified in a different way. We can imagine an event in which the circle changes into the cube through losing some invariance to some transformations.

Figure 1: Symmetry-Breaking Transition: Invariance under Groups of Rotations

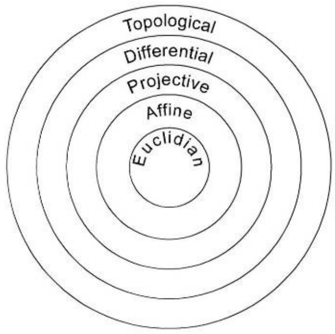


The circle is said to lose symmetry or become less bland, since the original group of transformations would be made smaller, a transition that we can now understand as a process of progressive differentiation through a *symmetry-breaking transition*, a process in which an originally undifferentiated object progressively acquires more and more detail (DeLanda, 2004b, p. 372). The significance of such a process was extended by the important nineteenth-century mathematician Felix Klein, who discovered that not only geometrical figures but geometric systems themselves can be classified by their invariants under transformations (Table 2). As DeLanda explains,

> Euclidian and Non-Euclidian metric geometries, for example, form spaces whose properties remain unaltered by a group containing rotations, translations and reflections. In other words, lengths, angles and shapes are invariant under this group of transformations. In projective spaces, on the other hand, those properties do not remain invariant but others do, such as linearity, collinearity and the property of being a conic section. Moreover, this group of transformations that leave the later invariant is a *larger set,* including rotations, translations and reflections, but also projections… and sections." (2004b, p. 373)

The group characterising Euclidian geometries (less symmetry, more detail) is a *subgroup* of the one characterising projective geometries (more symmetry, less detail). Accordingly, as we move down the classification from Topological to Euclidian geometry, we witness a progressive differentiation of space, with new distinct classes of geometric figures emerging through a process of symmetry-breaking transitions.

Figure 2: Klein's Classification of Geometries



Note: Different geometries as subgroups, classified by invariants under transformations, with topological and differential geometries included.

Although the creators of these classifications saw them in a purely logical construction, in which theorems at one level are automatically valid the levels below it, according to DeLanda (2004b), Deleuze views them as morphogenetic, "as if metric spaces were literally *born* from non-metric ones through a loss of symmetry" (p. 373). Consequently, vague essences are defined by dynamic events, or a symmetry-breaking transition, which Deleuze claims already implies the operation of the hand in constant correction (rectification, straightening) through operations of deformation.

4. METALLURGY AND THE HETEROGENEITY OF MATTER

Deleuze's claim that vague essences possess a materiality that is inseparable from dynamic events, implies that matter is heterogeneous and capable of self-ordering, a concept that is in opposition to the notion (from the classical physics of Newton which can be traced back to Plato) of matter as simply *mass*, that is, as homogenous, mutable, inert and obedient. The distinction between matter as homogenous and inert, and matter as heterogeneous and carrying "implicit forms" or vague essences, also reveals two trajectories of design processes, the transcendent design process of royal science and the immanent design process of minor science.

Deleuze (1980/1987) argues, following the work of philosopher of technology Gilbert Simondon, that the axiomatic method of royal science follows the *hylomorphic* model (hyle meaning matter and morphic meaning form) which follows a production method that implies "both a form that organises matter and a matter prepared for the form… [it] assumes a fixed form and a matter deemed homogenous" (p. 369, 408). Deleuze argues that hylomorphic model is concerned with the idea of the law or command which submits matter to a form. This distinction between royal and minor design processes, according to Protevi (2001) can be understood as the difference between the "transcendent imposition of an architects vision of form on chaotic matter" (p.7) and the artisans approach, which follows the flow of matter by "subordinating all their operations to the sensible conditions of intuition and construction" (Deleuze & Guattari, 1980/1987, p. 373). Deleuze (1980/1987) distinguishes between these two types of design processes as that of a difference between *reproducing* and *following.*

> Reproducing implies the permanence of a fixed point of view that is external to what is reproduced: watching the flow from the bank. But following is something different from the ideal of reproduction. One is obliged to follow when one is in the search for 'singularities' of a matter, or rather of a material, and not out to discover form… when one engages in the continuous variation of variables, instead of extracting constants." (Deleuze & Guattari, 1980/1987, p. 372)

In the hylomorphic method of royal science, the design process is "primarily conceptual or cerebral, something to be generated as a pure thought in isolation from the messy world of matter and energy" (DeLanda, 2001, p. 132). Once conceived, a design can be given form simply by imposing it on a material substrate, which is taken to be homogenous and receptive to the designer's wishes. Modern steel can be seen as such a homogenous and inert material because of its standardised, docile, predictable and routine behaviour. According to James E. Gordon,

> The widespread use of steel for so many purposes on the modern world is only partly due to technical causes. Steel, especially mild steel, might euphemistically be described as a material that facilitates the dilution of skills… Manufacturing processes can be broken down into many separate stages, each requiring a minimum of skill or intelligence… At a higher mental level, the design process becomes a good deal easer and more foolproof by the use of ductile, isotropic, and practically uniform material with which there is already a great deal of accumulated experience. The design of many components, such as gears and wheels, can be reduced to a routine that can be looked up in handbooks. One consequence has been that managers and accountants, rather than engineers [or designers], have become the dominant personalities in large organisations. Creative thinking is directed into rather narrow channels. Steel is archetypically, the material of big business – of large factories, railroads and so on. (James E. Gordon cited in DeLanda, 2001, p. 132)

Deleuze (1979) argues that in fact the homogeneity of modern steel and the routine design processes it imposes is not an essential property of the material but because the expressive capacities of modern steel have become deadened due to the effect of royal science's transcendent illusion of matter as mutable, obedient mass and "its theorematic apparatus and its organisation of work" (Deleuze & Guattari, 1980/1987, p. 374). In fact, Deleuze (1979) claims that metals are "what compels us to think matter in continuous variation…as continuous variation of form and the continuous variation of matter itself" (para. 31). Before the advent of homogenised metals like modern steel, the ancient blacksmith had to work with metals that were always heterogeneous. One week he would get his iron from one mine, another different mine the next week, a meteor later on, meaning that each time he would have to deal with different impurities and mixtures. Consequently this demanded a "sensitivity" that could take the complexity of heterogeneous materials into account, and accordingly, a design process which could not be reduced to a routine. As Cyril Stanley Smith relates

> The craftsman [blacksmith] can compensate for differences in the qualities of his materials, for he can adjust the precise strength and application of his tools to the materials local vagaries. Conversely the constant motion of the machine requires constant materials. (Cited in DeLanda, 2001, p.136)

This presents an immanent philosophy of design where materials are not seen as inert receptacles for the imposition of form, but active participants in the design process. This implies materials that are heterogeneous, meaning that they have variable properties and idiosyncrasies that the designer must respect and make integral to the design process, which it follows cannot itself be reduced to routine. In the hylomorphic model of royal science,

> Operations occur between two thresholds, one of which constitutes the matter prepared for the operation, and the other the form to be incarnated… In metallurgy, on the other hand, the operations are always astride the thresholds, so that the energetic materiality overspills the prepared matter, and a qualitative deformation or transformation overspills the form. (Deleuze & Guattari, 1980/1987, p. 410)

The thresholds Deleuze is referring to are critical points of intensity or vague essences, which by crossing (following a "line of flight") triggers a spontaneous change to occur in the structure of the material (in complexity theory terms, a bifurcation), like phase transitions such as the condensation of steam in liquid droplets, or the crystallisation of water into ice at critical points of temperature. The minor science of the blacksmith knew about phase transitions in metals and that *how* one crosses these critical points is important, though this knowledge was linguistically unarticulated knowledge or "know-how". For example, once metal is melted it is important how fast it is allowed to solidify, whether it is left to air-cool slowly (annealing) or whether this processes is accelerated by plunging it into cold water (quenching). In one case you end up with a regular crystalline structure and in the other a more irregular glass like material. Similarly, the blacksmith knew that a piece of metal can be made to change its behaviour, from hard and ductile to strong and brittle, by hammering it while cold. The opposite transmutation, from hard to ductile could be achieved by heating the metal and then allowing it to cool slowly. Both these properties may be desirable in different tools and even in the same tool, for instance, the sword and knife requires the body to be ductile while the cutting edge must be hard. The properties of hardness or toughness, in Deleuze's terms *traits of expression*, and in turn their usefulness in the tool (its capacity to affect or be affected), are emergent properties that result from operations "astride" thresholds and a material containing vague essences or "implicit forms". We can now understand matter as a dynamic material capable of spontaneously generating different structures according to specific singularities which are brought out as the artisan moves the material across specific critical points by manipulating its intensity.

The concept of a dynamic and heterogeneous matter carrying implicit forms can be found in wood as well, for example where the carpenter negotiates the grain of the wood when making a piece of furniture. The carpenter "follows" the traits of expression of the material by working in partnership with its inherent properties, for example by sanding the wood with the grain. This design technique does not correspond to an axiomatic or transcendent law (there is no law that you *must* sand with the grain) but instead corresponds to a problematic or "designerly" way of knowing. We can now understand Deleuze when he argues that,

> Simondon exposes the technological insufficiency of the matter-form model, in that it assumes a fixed form and a matter deemed homogenous. It is the idea of the law that assures the model's coherence, since laws are what submit matter to this or that form, and conversely, realize in matter a given property deduced from that form. But Simondon demonstrates that the *hylomorphic* model leaves many things, active and affective, by the wayside… to the formed and formable matter we must add an entire energetic materiality in movement, carrying *singularities* or *haecceties* that are already like implicit forms that are topological, rather than geometrical, and that combine with processes of deformation: for example, the variable undulations and torsions of the fibres guiding the operation of splitting wood… At any rate it is a question of surrendering to the wood, then following where it leads by connecting operations to a materiality, instead of imposing a form upon matter. (Deleuze & Guattari, 1980/1987, p. 408, emphasis in the original)

In minor science, the artisan must therefore "surrender" to matter, that is, follow its singularities by devising operations that bring forth those potentials to actualise the desired properties. The royal scientist is blind to such traits of a complex heterogeneous matter, and despises surrendering to matter; he only sees and commands. This distinction between *surrender* and *command* implies that the hylomorphic model "derives less from technology or life than from a society divided into governors and governed" (Deleuze, 1980/1987, p. 369). As Simondon (quoted in Protevi, 2001) explains, "the hylomorphic schema corresponds to the knowledge of someone who stays outside the workshop and only considers what goes in and what comes out of it" (p. 8) it is the notion of the master commanding slave labour,

> What the hylomorphic schema reflects in the first place is a socialised representation of work… The technical operation which imposes a form upon a passive and indeterminate matter is… essentially the operation commanded by the free man and executed by the slave. (Simondon, quoted in Protevi, 2001, p. 8)

Hylomorphic representation therefore resonates with fascist desire: the leader comes from on high to rescue the chaos of the people by his imposition of order.

5. THE MINOR SCIENCE OF SUSTAINABLE DESIGN

Deleuze's concept of the relationship between matter and form, as it has been presented in this paper, can be expanded from the familiar non-organic domain to being seen as encompassing the organic and cultural domains as well. In terms of this expanded concept of "matter", the irreducible complexity of the problems encountered by sustainable design, whose aspects form assemblages of non-organic, organic and cultural elements can be seen to require the problematic approach of minor science. The hylomorphic model of royal science presupposes matter (or stakeholders) as a homogenous mass that is obedient to laws and an inert vessel for forms imposed from the outside. The artisanal model of minor science, on the other hand, suggests an epistemology which can negotiate the non-linear, intensive and complex conditions of messy or wicked problems. Problematics presents a design process through which designers and architects can negotiate the irreducible complexity of the contemporary environment without falling victim to the transcendent illusions of essentialist and universal absolutes.

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