ABSTRACT

The aim of this paper is to describe and discuss a proposed framework that enables and encourages a robust communication context for the design process. Sustainability can be seen as a wicked problem, therefore creating, maintaining and managing a consensus during the design process is a necessary requirement. Consequently dialogue is central to this. Dialogue, when successful, triggers the co-evolution of these high level meanings towards a shared consensus, a given for a successful co-design process.

The framework proposes the use of four different layers of abstraction of information in order to facilitate the creation of shared meaning through dialogue. The four levels selected for this model are: the meaning level, the semantic level, the syntactic level and the artifact level. Communication modalities and the types of concepts are different at each level.

Given that “the whole is larger than the sum of its parts”, deconstruction into layers of abstraction can lead to the fragmentation of information and the loss of its richness. In order to avoid loss of meaning, or grounding, the mechanisms of reframing and emergence have been adopted when switching layers.

The necessity for this framework stems from the wide range of emerging approaches to design and their myriad connections to the notion of sustainability. The proposed framework fosters the creation of a platform that allows exchange, evolution and synthesis. That enables designers to access a wider range of understandings and design in a more holistic way utilizing the different possibilities present and widening their solution spaces.

Keywords: Communication, meaning, design dialogue, emergence, reflection

1 INTRODUCTION

Design for sustainability calls for a paradigm shift away from today’s unsustainable models of production and consumption. In the context of this transition design is also evolving in many different directions. We argue that fragmentation is part of ‘the malaise of modernity’ and that Design needs to reconstitute the Holon and approach the many different emerging approaches as a whole. To achieve this dialogue in the context of design needs to be fostered. The framework’s proposed aims are to enable this dialogue amongst all different stakeholders of a design project through different layers of abstraction. At the same time, in order to make sure that no variety will be lost when switching layers, the mechanisms of emergence and reframing have been adopted as the means of switching layers.
2 DESIGN FOR SUSTAINABILITY AND WICKED PROBLEMS

Design for sustainability is a field in which wicked problem thinking has been adopted as an essential part. This adoption of systemic thinking over systematic thinking is deeply rooted in the ill-defined nature of sustainability. "If sustainability is the most challenging wicked problem of the current era then participation in design, as a means to effect deep, transformative, socio-political change, seems essential" (Fuad Luke 2002). The notion of wicked problems was originally put forward by policy makers but since design has been identified as a political process (Bonspiere 1992, Fry 2011) and as such it is part of policy making. At the same time the fields of service design and social innovation are proving grounds for design approaches aiming to support the transition towards sustainability.

Sustainability is classified as a wicked problem and, additionally, it is "an emergent property of the current social system" (Ehrenfeld 2009) that has been approached as a process, a transition (Yee 2014), a paradigm shift (Wood, 2008), a significant structural change (Thackara, 2005), a social revolution (Edwards, 2005), radical social & technical change (Ryan, 2008). The main challenge when dealing with emerging phenomena is that they can only be partially described, as the emergent variety (Bofylatos et al. 2012) does not exist and we can only speculate about the characteristics it might have when emergence takes place. For example, modernity (as an emergent property of the social system) would have been impossible to describe for a person living in the middle ages. A framework to deconstruct and frame the cognitive space associated with sustainability has been proposed in Bofylatos et al 2012. This framework was based around the notion of "structural principles of sustainability", the six principles selected after a long bibliographical review attempted to frame the cognitive space in which sustainability will emerge. Those are: holistic, local, safe, cyclic, socially acceptable, and rational in the use of energy and materials (Bofylatos 2013) through this process we were able to visualise sustainability as the point of intersection of a Venn diagram with six objects (the principles identified). This frames the problem space in which we speculate sustainability will emerge.

![Sustainability as a Venn diagram of the six structural principles](image-url)
The deconstruction process yielded interesting insights into the top-down synthesis of high level concepts. The model proposed in this paper is based on those insights. ‘Holistic’ is perhaps the most important principle as it implies that this is a process of “holistic (de)construction”, a concept supported by the framework described by this paper and will be expanded latter on.

A wicked problem is a social or cultural problem that is difficult or impossible to solve for four reasons: the knowledge on the matter is incomplete or contradictory, too many people with different opinions are part of the problem, the economic burden is high and the problem is highly interconnected with other problems. Horst Rittel, one of the first to formalize a theory of wicked problems, cites ten characteristics of these complicated social issues:

- Wicked problems have no definitive formulation; defining a wicked problem is in itself a wicked problem.
- It is impossible to quantify success when trying to solve a wicked problem.
- There is no template to follow when tackling a wicked problem; designers approaching wicked problems must literally make things up as they go along.
- There is always more than one formulation of a wicked problem, depending greatly on the individual perspective of the designer.
- Every wicked problem is a symptom of another problem.
- No mitigation strategy for a wicked problem exists.
- Offering a “solution” to a wicked problem frequently is a “one-shot”, minimizing the ability for trial and error.
- Every wicked problem is unique.

(Rittel 1978)

Dealing with wicked problems has taken root as a quintessential element of design. Richard Buchanan argues that designers utilize quasi-subject matter, a combination of generalized rules based on deductive thinking synthesized with empirical conclusions that stem from inductive reasoning. This subject matter is not an undetermined subject waiting to be made determinate. It is an indeterminate subject waiting to be made specific and concrete. As Buchanan (1992) states, “design is fundamentally concerned with the particular, and there is no science of the particular” (Buchanan 1992). In this way designers create special tools and methodology needed for transcending the problem space posed by a wicked problem. Wicked problems have been central in the debate of the nature of design and its relation with science (Farrell and Hooker 2013; Galle and Kroes 2013)

3 THE NEED FOR DIALOGUE IN DESIGN

Design is a multi-stakeholder process that demands a constant dialogue and negotiation between all the participants. Dialogue is defined as “a process of negotiating meaning aiming to lead to a shared consensus on the meaning discussed”. Creating and sharing a common vision is a stepping stone towards the creation of successful and inclusive solutions. Especially when designing for complex or wicked problems that are inexhaustible in their scope, there is no
“view from everywhere” but many different perspectives can create a mosaic of different micro-narratives (Lyotard 1984) that tend to paint a richer picture. Taking the user into account from the first stages is important as: “problem definition is itself subjective as it originates from a point of view, therefore all stakeholders’ points of view are equally knowledgeable whether they are experts, designers or other actors.” (Rith, 2007).

Increasing participation has been a trend in the last 50 years starting from the designer as an expert to today’s open and distributed cooperative models that act as a platform for designers, users and other stakeholders. The customer of the 50s turned from the user to the participant and co-creator, and today we are designing in the context of creative communities, “groups of citizens who are collaborating to create solutions to their own problems” (Manzini 2005). This shift is based on the understanding that design will be successful only by maximizing the variety of the problem space by including all perspectives on the matter, additionally this approach increases inclusion and empathy. In addition this shift can be seen from a political standpoint. Technologies such as desktop manufacturing and open source design (Rifkin 2007; Abel 2011) have accelerated the transformation of ideologies into movements by channelling social protest into productive activism (Greer 2008) and have been viewed as viral phenomena regarding the way they spread on communities through the World Wide Web. The microproduction models (Mafei & Bianchino 2014) emerging through these new technologies can be seen as part of the transition towards sustainability as they: challenge the current material culture by making the consumer a maker, foster local craft production, support an alternative economic model. Of course this change in the scope of the design process has brought forward a very interesting debate “it seems clear that design professionals are going to be transformed by the possibilities of open design and local manufacture, equally the research presented here problematizes a world without specialist designers” (Cruickshank & Atkinson 2013). This debate goes beyond the role of designers and also includes thoughts on how blame is distributed in a crowdsourced design process and in the mapping of the intersections between Co-design and OpenDesign.

Communicating the principles and ideas behind sustainability creates an unprecedented need for dialogue and shared understanding. Transition design describes design-led, systems-level societal change toward a more sustainable future. Transition design is based on the notion that fragmentation brought forth through modernity has broken down the Holon in all domains of everyday life (Kossof 2011). In this sense the goal of design is to reconstitute holism in everyday life, a process that inherently demands a better means of communication in order to collectively create the shared meaning associated with sustainability. The quadruple bottom line (Walker 2012) is a tool that aids us in understanding different types of meaning associated with sustainability, these are practical meaning, social meaning and personal meaning. This acts not as a way to fragment meaning, but as a path from a basis for values to a tool for ethical sustainable design decision making. It is the synthesis of those meanings that will lead to a new high level meaning and thus the reframing of the problem space associated with the wicked problem.
The four layers of abstraction proposed enable robust communication and dialogue in the context of wicked problems without loss of variety and generality. The challenge is to address each issue holistically, otherwise it can lead to loss of generality or the creation of ungrounded meaning. The Chinese room thought experiment (Searle 1992) is an exquisite example of how model creation without access to high level meaning can lead to misinterpretation. Searle imagines himself alone in a room following a computer program for responding to Chinese characters slipped under the door. Searle understands nothing of Chinese, and yet, by following the program for manipulating symbols and numerals just as a computer does, he produces appropriate strings of Chinese characters that fool those outside into thinking there is a Chinese speaker in the room. The main point of this thought experiment is that a computational thinking can produce symbols without having access to the higher level functions associated with sensemaking, just by using syntactic rules. Taking the increasing need for communication in design and its constant entanglement with wicked problems as a given, a need to further increase the

![Diagram](http://stuartwalker.org.uk/designs-2/10-quadruple-bottom-line-of-sustainability)

Figure 2 - The Quadruple bottom line (Walker 2012) Source: http://stuartwalker.org.uk/designs-2/10-quadruple-bottom-line-of-sustainability

robust exchange of information and dialogue becomes evident.

The four levels proposed are
4.1 MEANING LAYER

High-level concepts make up this layer of abstraction, due to their wicked nature it is impossible to describe these ideas comprehensively and instead rigorous framing is the goal (Ashby 1958). By meaning we refer to the high complexity mental representation existing in the mind of a person. Meaning is an essential part of autonomous systems such as humans, as Collier suggests that there is no function without autonomy, no intentionality without function, and no meaning without intentionality. The interdependence is completed by considering meaning as a prerequisite for the maintenance of a system’s autonomy during its purposeful interaction with the environment (Collier 1999).

Due to the inability to define those complex concepts, the means of communication is deconstruction of the model and the communication of parts of it. We use representations that exist on a lower layer of abstraction aiming to support the emergence from the receiver’s side. This process is based on dialectics and, for this to be successful communication, it must start from the layer where all stakeholders share a common symbol grounding.

4.2 SEMANTIC LAYER

In order to communicate meaning it has to be deconstructed into lower layer representations. A scientific paradigm is “a universally recognized scientific achievements that, for a time, provide model problems and solutions for a community of practitioners,” (Kuhn 1999). From a cybernetic point of view this works as a regulator of the problem space aiming to reduce entropy. In this sense, the scientific paradigm, tied with its supportive theory and methodologies, acts as a common basis on which new meaning can be built.

Theory is a structured and comprehensive body of theoretical knowledge about a specific cognitive area or discipline. Methodology is the systematic study of methods that are, can be, or have been applied within a discipline and can be regarded as a way to create new knowledge about a specific theoretical framework or paradigm. This new knowledge can spark evolution of the field or even transcend it. At the same time, the newly acquired knowledge creates new meaning. On this layer the stakeholders communicate through the use, the reflection, evaluation and evolution of methodologies and theory. The evolution of the methodology can reach a point where we must transcend theory and reframe it. This evolution can trigger emergence of new meaning on the layer above and, at the same time, through reflection, it can reshape different tools or techniques used to achieve certain goals on the level below.

In the context of design however, as we have already seen, theory is not a finite body of knowledge and it is highly dependent on the application. It is quasi-subject matter. Due to this the content of the semantic layer is dependent on the context in which the design takes place. The semantic layer is an evolving organizational structure that changes on a personal level. With this in mind it is important to keep the lines of dialogue in the context of a multidisciplinary design team.

4.3 SYNTACTIC LAYER

Information on this level is associated with the tools and techniques used in the context of designing. By the term tools we refer to a structured approach to solve a specific problem. In the context of designing, tools are algorithmic in nature. This means that they are made up of a series of steps that, if executed
A four layer of abstraction communication framework supporting design dialogue

correctly, one will reach the expected outcome. In this sense, they can be viewed as deterministic in the sense that no matter who applies those tools or techniques will yield the same results as long as the parameters are the same. However, this is rarely the case as the designer (we are referring to the designer in the scope of Herbert Simon’s work, not the design practitioner but any system that designs) (Simon 1973) is a complex system and as such he adds his personal variety to the problem and solution spaces and as such trumps any ideas of determinism in the context of designing. These theoretical constructs stem from knowledge residing on the two previous layers but, due to their applied nature, can be perceived as lacking the grounding to higher level representations. They are practical interpretations aiming to achieve a specific goal and as such grounding them to theory is not a prerequisite. Being aware of the theoretical constructs residing on a higher layer are not necessary to successfully achieve the goals on a lower layer. These tools and techniques are based on the knowledge that makes up the body of theory on the semantic and meaning layer; explicit knowledge of those is not required to use the tools. However, through the use of these tools, the evaluation, interpretation and reflection on both the process of application and the end result mental representations on the upper levels can be affected and thus new meaning can emerge. Simply using the tool without reflection on the underlying theory makes it impossible to create innovation since the design of complicated systems does not lead to the emergence of new variety.

The main difference between the notions making up the syntactic and the semantic layer is that the latter can be defined. For example, going back to the ‘structural principles of sustainability’ locality can be defined by selecting an appropriate radius whereas ‘socially acceptable’ is based on consensus and can never become an objective part of reality in its entirety. Generally we could say that complex notions can be found on the two upper levels whereas on this level we find complicated notions.

4.4 Artifact Layer

Information on this layer is located within the physical world, whereas all the previous levels reside in the symbolic world. Creating sociotechnical artifacts (Kroes 2011) is the goal of design and engineering. Services and design in a digital world are considered Intangible, Heterogeneous, Inseparable and Perishable (Meroni & Sangiorgi 2011). However, the service evidence - “the tangible manifestation of service that appears above the "line of visibility" in a service blueprint” (Lo 2011) - always exist, even in the digital world. Data for example have a physical manifestation, albeit a miniscule one. The designed artifact bears more than functional meaning, it carries the physical meaning entwined with the ideas and values it embodies and can act as the basis for dialogue about those ideas. This "demonstrative rhetoric" (Buchanan 2001) stems from the material world but can be used to suggest possibilities for the future.

This level is the basis of communication as all communication takes place through sensory stimuli that exist on the physical and not the symbolic level. However, not all parts of the physical world exist in this level. Intentionality is an important part of this level. Artifacts that are used to enable the transfer of meaning can take many different forms. Sketches and prototypes are tools of study but also means to communicate the ideas behind them. Many times the ways that the designed artifact bears the high level meaning is through tacit knowledge (Polanyi 1966) also known as "sticky" knowledge (Szulanski 2002). This non explicit meaning is both open to interpretation and perceived as
ungrounded. Due to its nature, a process of dialogue and reflection can lead to the emergence of meaning associated with a higher layer of abstraction.

A special category of artifacts that explicitly exist to trigger this mechanism of reflection exist. The first type is propositional artifacts (Walker 2008) these artifacts aim to act as tool for contemplation of values and possible futures whilst "embodying issues of concern and reflecting on their implications." (Walker 2013). These artifacts are mainly a tool for introspection, acting as a point of focus for a designer that tries to frame a wicked problem in an intuitive way, in tandem with the conventional analytical evidence-based way of creating new meaning. Another kind of such an artifact-based dialogue in design are 'cultural probes', "a rich and varied set of materials that ... let us ground [our designs] in the detailed textures of the local cultures." (Gaver et al. 1999). These artifacts are a tool to better understand the user and engage the user and the designer in a dialogue that leads to a shared meaning.

This of course is not a finite list of artifacts used by designers to engage in dialogue and the emergence of new meaning, but an example of how meaning is tied to the physical world and how the artifact can complement the spoken word as a carrier of tacit knowledge.

Figure 3 - The proposed framework visualised
5 PRESERVING THE HOLON

Deconstruction alone is not holistic. The term holon refers to the “whole that is more than the sum of its parts”, a complex system that cannot be divided in subsystems and then put together again. In order to preserve the Holon new meaning has to be grounded to mental representations on lower layers. Additionally understanding physical artifacts, techniques, tools and methodologies by tying them down to high complexity meanings. This shared meaning is created through the evolution of personal meaning in the context of a co-design process.

When switching layers, the mechanisms of emergence and reflection are adopted. The aim of these mechanisms is to ensure that variety and generality are not lost. It is very important that all stakeholders of the design process are able to understand the ephemeral nature of the problem and solution space.

5.1 EMERGENCE

In order to make sure that no variety or generality will be lost when changing layers and increasing complexity, the mechanism of emergence has been adopted. From a cybernetic point of view this can be seen as the emergence of new variety on a lower layer triggering the emergence of a new organizational structures and new meaning on a higher layer. This is a solution to the problem of preserving the holon due to upwards causation. Upwards causation creates a causal link between the new high level concept that has emerged and the new variety that triggered its emergence. This of course means that emergence leads to a higher complexity.

5.2 REFRAMING

The process of framing the problem space in order to reframe it and move towards a new, more desired problem state is first and foremost a learning process, albeit one with a variety of solutions. To support the innovative character a double loop learning process is employed (Argyris & Schon 1978). double-loop learning in which after having attempted to achieve a goal on different occasions, it is possible to modify the goal in the light of experience or possibly even reject the goal whereas in single-loop learning is when attempt to solve a problem is repeated, with no variation of method and without ever questioning the goal.

Reflection is central to this process. Schon defines reflection as “the capacity to reflect on action so as to engage in a process of continuous learning” (Schon 1959). This reflection in action is a creator of new variety and is based on the application of theoretical knowledge and the negotiation between the anticipation based on the mental model and the interaction with the real world. Both emergence and reflection are considered adductive ways of reasoning due to the fact that they lead to the addition of new variety in the problem space.

In this context the mechanism of reframing is employed as the way to find practical application of high layer concepts in lower layers. It refers to the way that our understanding of the world changes the way we act in it. In this way it has to do with application and reducing complexity. This is a synthetic process,
which is fundamentally a way to apply adductive logic within the confines of a design problem central to design (Coyne 1988).

6 FURTHER RESEARCH AND CONCLUSIONS

The discipline of design, and society in general, is in the process of a transition. New ways of designing are needed in the context of this transition. This paradigm shift becomes apparent in the new economic models, some even taking the informal or misfit economy, new ways of making and owning physical goods, such as desktop manufacturing or the maker movement. Additionally service design is emerging as a diverse and robust way of designing that aims to minimize the ecological footprint of physical artifacts while leading to the adoption of different modes of sharing and supporting creative communities in the context of social innovation. However "reconstituting the holon" has been identified as a central goal of the transition towards sustainability. As such we have to avoid fragmentation and understand all of the different emerging approaches in a holistic way and approach them as such.

In order to achieve this we need new tools to support such a novel way of designing. This model is a step in this direction. At the same time the wicked and emergent nature of this situation reduces the common variety and as such the support of dialogue that will lead to shared meaning.

The next steps in this process include the application of the model presented in specific intersections of emerging approaches to designing. This process will be supported by understanding and analysing different paths taken in a co-design process.

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