Sustainability as a " super wicked " problem; opportunities and limits for engineering methodology

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Abstract: Characterising sustainability as a “super-wicked” problem alerts us to issues beyond where current thinking about problem structuring enable engineers to deal with the merely wicked. Time is running out, no-one authority is in control, we are the cause of the problem anyway, and we inherently discount the future in our every day decision-making. When these are added to the usual definitions of wicked and messy problems, which only now are we addressing in engineering education, what are the potential limits and opportunities for the methodology of engineering in sustainability? Some modest extrapolations are discussed, based on the results from a recent research project in addressing energy planning in a city development zone.

Key words: super-wicked problems, messy problems, problem structuring methods (PSMs), engineering education, sustainability

1 Introduction

When confronted by the challenge of delivering an EU FP7 Smart-Cities project to address the problem of *comprehensive* energy planning in a city district how might an engineer respond? What *methodologies* from engineering might be appropriate? In the specific context of the STEEP project (Systems Thinking for comprehensive city Efficient Energy Planning), which is a two year project that started in October 2013 and focussed on energy planning in three city development zones in Bristol (Temple Quarter Enterprise Zone), San Sebastián (Urumea Riverside), and Florence (Cascine Park), I attempt to answer these questions based on the ideas of wicked and messy problems and the use of Problem Structuring Methods (PSMs). Whilst these ideas are well known to the Management Science and Soft Operational Research communities’ engineers rarely know anything about them. There is a certain irony here in that one of the key researchers who developed perhaps the pre-eminent PSM, Soft Systems Methodology (SSM), was himself originally an engineer (Checkland, 1981, 2000; Checkland & Jenkins, 1974). Another consideration is pedagogy; how does research like this impact the training of future engineers? Therefore, another purpose of this paper is to present a guide through a literature that is likely to be unfamiliar in the hope of promoting the wider uptake of PSMs by engineers, especially in this domain, and stimulating further methodological development in response to the challenge of super-wicked problems.

2 Method

In this paper I present critical self-reflection on the use of problem structuring methodology applied in the context of the STEEP project in which I have been involved. In this section I construct the overall method for this self reflection from i) definition of wicked/messy and super-wicked problems, ii) appropriateness of Problem Structuring Methods (PSMs) as a valid response to the need to intervene in these problem contexts, iii) methods for evaluating the use of such methods, iv) the role of the ‘expert’ modeller and modelling, and v) extra concerns presented by super-wicked problems. Presentation of my research in this rhetorical style is due to influence by Ormerod (2013) who has constructed a well-reasoned argument for “*more informative case studies of ‘technical’ projects*” to aid future researchers in the difficult endeavour of facilitating interventions in these messy problem contexts. The framework is presented in a similar order to the way in which these topics have been introduced to postgraduate engineers on the EngD in Systems Programme at the University of Bristol since 2009. This also matches the way in which the problem structuring methodology has been 'taught' to the project partners in the STEEP project[1]. The entire training course (as videos and slides) was made open and is available from the project website at http://smartsteep.eu/resources. If anything is not clear in this section of the paper then I refer the reader to this site for clarification. In sections §2.1 to §2.4 I set out the essential elements of the framework and in §2.5 introduce the specific issues of super-wicked problems as described by Bernstein, Cashore, Levin, and Auld (2007).

2.1 Wicked and Messy Problems

Research Engineers[2] (REs) are introduced to the notion of wicked and messy problems early in the EngD in Systems Programme (Yearworth, Edwards, Davis, Burger, & Terry, 2013). The purpose is to get REs used to the idea that engineers in general are increasingly involved in projects where the notion of a *unique* or *optimal solution* is misguided. I would suggest that most projects in sustainability fall into this category. I use Rittel and Webber (1973) as my starting point in this journey. They provide the original characterisation of a wicked problem. My interpretation of their definitions is as follows:

1. No definitive formulation
2. No stopping rule
3. Solutions are not right or wrong, there is no immediate or ultimate test of a solution, but can only be viewed as good or bad
4. Solutions are 'one-shot', there can be no trial-and-error (experiments); every intervention counts significantly, they are essentially unique
5. No enumerable, exhaustively describable, set of solutions
6. Can be considered as symptoms of other problems
7. Can be contested at the level of explanation, there is likely to be conflicting evidence/data
8. Aim is intervention, not knowledge gathering for its own sake

There are other similar characterisations of such problem contexts as messes (Ackoff, 1981), and swamps (Rosenhead, 1992). These definitions are all mirrored in more recent work from Mingers (2011), who provides a similar rendering of the problem space as:

1. Problem situations involving many interested parties with different perspectives (worldviews)
2. Problem situation not well defined
3. Difficulty agreeing objectives
4. Success requires creating agreement amongst parties involved
5. Many uncertainties and lack of reliable (or any) data
6. Working across the boundary between human activity systems and engineering artefacts

The intention is to paint a picture of problem contexts that need to be recognised for what they are, and a trigger for a different[3] response to taking action. Pedagogically, it is sometimes useful to present examples of project failures from other domains and pose the question of whether an adequate approach was taken with the clarity of hindsight into what was clearly a wicked problem context. The learning objective is to engender a sense for these problem contexts and an awareness that an appropriate response is to use a Problem Structuring Method (PSM) with stakeholders.

2.2 Problem Structuring Methods (PSMs)

PSMs are presented as valid response to intervention in wicked/messy problem contexts. There is extensive literature on this justification, see for example (Ackermann, 2012; Eden & Ackermann, 2006; Keys, 2006; Mingers, 2011; Mingers & Rosenhead, 2004, 2011; Rosenhead, 1996, 2006; White, 2009), and on the splitting off of Soft OR from Hard OR to Churchman (1967) citing Rittel. For teaching purposes I summarise the key features for PSMs as

[1] Immediate reflections on this training event can be found in this video case study http://www.bris.ac.uk/cabot/research/casestudies/2014/56.html

[2] We use this term to describe students to reflect their status as equivalent to employees in the companies in which they are carrying out their research.

[3] In the sense of different from what might be considered as 'normal' engineering practice.

follows based on a subset of this literature (Mingers, 2011; Mingers & Rosenhead, 2004; Rosenhead, 1996). PSMs are:

1. Methods, not mathematical, but structured and rigorous and based on qualitative, diagrammatic modelling
2. Allow for a range of distinctive views to be expressed/explored/accommodated and allow for multiple and conflicting objectives
3. Encourage active participation of stakeholders in the modelling process, through facilitated workshops and cognitive accessibility
4. Can facilitate negotiating a joint agenda and ownership of implications of action
5. Significant uncertainty is expected and tolerated
6. Operate iteratively
7. Aim is for exploration, learning, and commitment from stakeholders

It has also been possible to categorise PSMs based on answering the practical question "what is it we are actually doing when we use a PSM?" (Yearworth & White, 2014). This has led to the formulation of a generic constitutive definition (GCD) of a PSM with 9 Aspects as shown in Table 1.

Table 1. The 9 Aspects of the generic constitutive definition (GCD) of PSMs adapted from Yearworth and White (2014).

#	Aspect	Definition
1	Improvement Activity	A structured approach to systemic intervention, *designed* to lead to improvements in a problematic real-world situation
2	Systemic Approach	The problem structuring approach used systems ideas supported by appropriate systems modelling (amongst other requirements)
3	Adaptation/ Creativity	Creativity must have gone into how the problem structuring approach was adapted or elements combined for the particular problem situation
4	Methodological Lessons	Use of the approach led to methodological lessons
5	Worldviews	Recognition that problems are construct of an individual's mind, they do not exist independently of human thought and are defined by an individual's "worldview"
6	Messiness	The problem context in which the problem structuring approach was used was recognised as messy following definitions such as contained in this paper
7	Interactive/ Iterative/ Therapeutic	The intervention has come about through sharing of "*perceptions, persuasion and debate"* in a participative group setting using an interactive and iterative approach. The facilitator adopted a stance that was "*interactive/therapeutic, not expert*"
8	Subjectivity	In the approach taken it has been recognised that the stakeholders of the problem situation are not *"divorced from the problem*"
9	Limits	The approach dealt with conceptual limitations of modelling language used

Part of the original motivation for this work was to provide an axiomatic formulation for PSMs that would appeal to an engineering audience more used to working with pragmatic principles rather than strict, social science, methodology (Yearworth & Edwards, 2014).

2.3 Evaluation Methods

The development of the generic constitutive definition (GCD) required an approach to evaluation that could focus on the PSM to the exclusion of the uniqueness of the specific problem context in which they are used, and the equally unique set of actions arising in consequence (Pawson & Tilley, 1997). Whilst this was sufficient to develop the GCD more specialised techniques are required to fully evaluate a PSM in action such as provided by (Midgley et al., 2013; White, 2006) as well as (Ormerod, 2013), as already mentioned. An example of the use of these techniques can be found in the evaluation of the STEEP project methodology (Yearworth, 2014).

2.4 Effectiveness of Expert Modelling

Whilst PSMs make use of systems modelling as a crucial component (Yearworth & White, 2014) it is also important to briefly touch on the role that 'expert' system modelling can take to support intervention in the sustainability context. In this respect having an adequate theoretical framework for assessing *how* models are used and *when* in the project lifecycle by experts is also crucial (Yearworth & Cornell, 2014). It is mentioned here to provide contrast between the expert mode of modelling, which is perhaps the prevalent way in which engineers work, and the participative and facilitative mode that is the subject of this paper. Integration of such 'hard' modelling into PSMs use is not overly difficult (Kotiadis & Mingers, 2006; Pollack, 2009).

2.5 Super Wicked Problems

Whilst (Ackoff, 1981; Mingers, 2011; Rittel & Webber, 1973) provide a useful starting point for thinking about wicked/messy/swampy problem contexts, (Bernstein et al., 2007) take the original Rittel and Webber idea forward to a new level of urgency for sustainability by introducing four new concerns i) time is running out, ii) no-one authority is in control, iii) we are the cause of the problem anyway, and iv) we inherently discount the future in our every day decision-making. Whilst explicitly focussed on implications for policy, I attempt to interpret their approach into my existing work on the application of PSMs to wicked/messy problems in sustainability. This is the "modest extrapolation" to existing methodology and the subject of the discussion that follows.

Discussion

The STEEP project has demonstrated some of the practical limitations of applying PSMs to the problem of energy planning in the three cities of Bristol, San Sebastián and Florence. A full articulation of these limitations can be found in the project evaluation document (Yearworth, 2014). Personal reflection has pointed me towards the following as the key issues:

1. Ownership and definition of the transformation implied by Aspect 1 of the GCD is co-dependent with the membership of the stakeholder group; the two co-create each other. The '*who*' and '*what*' of a transformational goal must be defined simultaneously at the outset of a project, before any thought about the '*how*', '*when*' and '*why*' can be discussed
2. There is nothing in the STEEP methodology, which is based on the GCD view of PSMs described in this paper, that specifically deals with power and this has been recognised as a weakness (Freeman & Yearworth, 201x). The methodology assumes a plural problem context and that there is sufficient commitment amongst the stakeholders for them to want to work collectively to arrive at a shared understanding and agreement on actions. Without the power to enforce a specific transformational goal, e.g. through the legal or regulatory environment or financial incentives on the part of governments, then it is inevitable that such a goal will be weakened in the process of encountering the interests of the stakeholders.
3. Planning should be thought of as a transformational process constantly reviewing and negotiating the goal(s) of transformation and modifying and updating plans from time to time. We might even think of planning as the process that tries to reduce the gap between imagined, planned futures and what actually happens on the ground. The notion of iterative gap closing expressed as a problem suppression loop is explored in (Ring, 1998; Yearworth et al., 2015).

Limitations 1 and 2 mirror the characterisation of super-wicked problems that "no one authority is in control". In the case of PSMs this is usually considered a weakness in terms of dealing with power, but for (Bernstein et al., 2007) the problem is the absence of power. The idea of interdependent development of transformational goals and formation of stakeholder groups seems a reasonable ambition up to the scale of projects such as STEEP, but difficult to conceive in any larger context. If anything, there is likely to be a constant erosion of goals, a well-known archetype observed by the system dynamics community (Braun, 2007). Freeman and Yearworth (201x) speculate on ways out of this conundrum. Limitation 3 echoes the aspect of super-wicked problems that "time is running out". The constant re-evaluation of transformational goals in the light of our imagined, planned future and current state would highlight the urgency and is the intention of Aspect 7 of the GCD. Bernstein et al. (2007) pose the question "*how might small changes now create enduring path dependent effects in the longer term…*". The idea of path dependency is absent from the GCD and its underpinning literature is a serious deficiency. The idea that "we are the cause of the problem anyway" is certainly touched on in Aspect 8 of the GCD, although not in such a strong form. Rather than cause, the GCD just suggests the impossibility of objectivity on the matter. In this respect the GCD should perhaps be strengthened. However, given the existence of a challenging messy problem and the desire to take "action to improve" it is unlikely that the stakeholders would have no part to play in causes. The inherent discount of the future in our every day decision-making or "hyperbolic discounting" (Ainslie, 1991) is not covered in the GCD. Whilst Aspect 7 introduces the time element through iteration and may highlight urgency, it does not deal with this specific economic issue. Aspect 9 of the GCD acts as a sort of catch-all for owners of the PSM to avoid conceptual limitations in their work this was conceived more as guidance to avoid using a systems modelling approach that does not afford the necessary insight into the problem situation. The problem of hyperbolic discounting suggests the need for specific (systemic financial modelling) tools that may not yet exist. However, as noted in §2.4, integration of such tools into a PSM is not an issue.

4 Conclusions

The STEEP project has provided an opportunity to test the performance of a PSM in a realistic messy problem context. Formal evaluation has revealed a number of shortcomings in the methodology despite the original confidence that PSMs were suitable for this type of problem context based on (Coelho, Antunes, & Martins, 2010; Gezelius & Refsgaard, 2007; Neves, Martins, Antunes, & Dias, 2004; Sheffield, 2004). When these shortcomings are also analysed against the concerns of super-wicked problems it is possible to see where improvements to methodology can be made. This leads to the following focus points for the development of PSMs for use by engineers in sustainability projects:

1. Setting transformational goals, owning stakeholder engagement, and dealing with goal erosion are interdependent problems, which when combined with multi-agency working suggests that conventional workshop-style facilitator-led settings are no longer appropriate.
2. Dealing with worldviews, subjectivity and the fact that we are contributing to the problem in which we are trying to intervene suggests that we need to extend existing methods to deal with more inclusive and widespread participation.
3. The fact that time is running out suggests that we need to move to methods that are quick and inexpensive to deploy, iterate quickly, and persist over time.

These three suggestions when combined point towards the development of PSMs that can be implemented and deployed in an online setting. The STEEP project has already moved in this direction by the implementation of the collaborative stakeholder engagement platform, which can be accessed from the STEEP project website. Further developments along these lines are indicated by the work of (Franco, 2007; Morton, Ackermann, & Belton, 2007; Shaw, Westcombe, Hodgkin, & Montibeller, 2004).

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