How to organise a *sustaining* technological world, one that we can continue to live in?

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Abstract: *In this paper I discuss how to answer the key question for us, globally - how to organise a sustaining technological world, one that we can continue to live in? A key element of answering this question is an epistemological one – how we know the world. Is it a Newtonian one with separate entities interacting/impacting on each other or is it one with the properties of heterogeneity, highly connected and emergence – a turbulent environment? Further if this is even partially the nature of our predicament, that we live in a turbulent world, how do we organise sustaining technological products and outcomes? This is an ontological question. I propose that we see ourselves as co-producing the future, not only through the systems that we as engineers and engineering educators are part of but also through adapting the environment within which these systems operate. If we as engineers see ourselves this way, as creating what can be, then this has implications for engineering education and, engineering practice more broadly, which I begin to articulate.*

Introduction

I believe that engineering is the best discipline to grapple with the question above, because, unlike other disciplines, engineering is not just, about *understanding* the world. It is active; it seeks to create as well as to understand. As William Wulff, the President of the US National Academy of Engineering declares in his paper *The Urgency of Engineering Reform* "… (e)ngineering is synthetic – it strives to create what can be." (Wulff, 1998) Further, as we well know, engineers directly engage with technology, and the technical, in their work. We know technology is not going to go away. Unlike others we do not believe that it is possible to 'go back' to a 'natural' world without technology. But also I believe we need to use technology with purpose. For me one of the greatest purposes of engineering is in working with others to confront the question above.

Some thoughts on the nature of the (engineering) world

This conference calls for us to take part in "connecting teaching, research and industry in engineering education." And that is what I aim in part to do but not in the way that is implied by the linear Newtonian metaphors in the following sentence extracted from the Call for Papers. *"There are huge opportunities to bridge the divides between teaching and research and teaching and industry to create graduates who are ready to step into a fast-moving, globalised engineering workplace surrounded by uncertainty."*

I am sure that many engineering educators would agree that this is a description of their world of engineering education; that is, teaching and research are separate (divided), as are research and industry, occasionally these are 'bridged' when their research is brought into the teaching space, or they get the chance to engage with some industry problem. Engineers will then metaphorically travel over the rivers or ravines via these bridges to connect these separate 'countries'. Also in this portrayal, engineering educators are creating graduates who are ready to 'step' out of the 'education world' into another completely separate world, that of the 'fast-moving, globalised engineering workplace' as engineers, this separate territory of the workplace is 'surrounded' by uncertainty. In this portrayal all the parts are separate and they connect by the slimmest of threads, when necessary. And somehow uncertainty doesn't appear until engineers are out in the workplace.

This is not the dynamic, complex, composite, heterogeneous world of networks/systems/ensembles of people – industry, governments, engineering educators; instruments of power (e.g. authority, regulations, laws, curriculum), protocols, research experiments, teaching experiences, machines, colleagues, allies, and other stakeholders that I live in. This is sociotechnical thinking, we spoke further of this way of thinking in an earlier paper at the International Conference on Innovation, Good Practice and Research in Engineering Education (Young, Goricanec, & Hadgraft, 2004). Key aspects of putting this type of thinking into practice are that there are high levels of ambiguity, we only ever really make partial connections with humans and non-humans and that any connections that you do have may be come unravelled at any point.

The world that I live in is more like a game where the rules change and nobody tells you that they have changed. Just say, for example, that you were part of a game of rugby where only passing back was allowed, and then a minute later you were only allowed to pass forward; not only did the rules change but no one tells you, you have to abstract it from the play and the referee. I would extend this metaphor to argue that the shape of the field may also change – the goal posts might now be much closer than you expected and seconds later the individual posts might be closer together and collectively further away, your depth perception is challenged – what seemed far away a microsecond ago may be right up close and personal now and the players may shape-shift too; they may become new sorts of animals – lions and tigers and bears – oh my! New 'players' may enter the play without warning like the 'dementors' in the Harry Potter stories and also you may end up in a totally different environment – by a tombstone dealing with 'he who cannot be named'. But also, in the past the rules may have stayed constant just long enough for you to think that they are fixed and now you are faced with the prospect that everything is potentially changing. And there is no escaping – you are in it, and of it.

Turbulence

This is the world with the property of 'turbulence' (F. Emery & E. L. Trist, 1965) or in the words of John Law 'generative flux' (Law, 2004) – where not only time but also space can shift, as can the 'rules', individually and/or collectively. Who would have thought early last year that climate change would become such a big issue, given the environmentalists and businesses had been 'at it' for decades. Now, not only is the Federal Opposition trying to 'buy in', as has the President of the USA, our Prime Minister is now a climate change 'realist'. New 'players' are emerging – Australian Business Partnership on Climate Change, the Energy Futures Forum, the Asia Pacific Partnership on Clean Development and Climate and even the Global Nuclear Energy Partnership which is 38 nations trying to create a 'closed circle of nuclear-fuel production' globally. At the time of writing this paper the Australia Government, despite signing up, has declared that Australia won't share stewardship of nuclear waste with the rest of the world (Murphy, 2007). Local governments are moving on energy efficiency, State Governments attempt regulation, Victoria has renewed the licence to extract coal for our dirtiest power station. 'New' solutions are being touted – clean coal, renewable energy systems are proliferating particularly in Europe, Kyoto targets continue to be pursued, including 'beyond' Kyoto, the IPCC have said climate change is happening faster than expected, the Stern Report has said it is more economic to mitigate earlier rather than later. Al Gore is travelling the world 'teaching' people about the situation and recently has pointed to large areas of Artic ice disintegrating with its the potential impacts on the thermohaline ocean circulation, weather and sea-levels.

At the same time, who and what was prepared physically, economically and socially in Australia for the prolonged drought, the lack of water for agricultural, industrial, public and residential uses. The lack of easy solutions has been confounded by various proposals - new dams, 'fixing' the irrigation system in the Goulbourn has been connected to a North-South pipeline to supply water to Melbourne; recycled water for power stations releasing water for Melbourne; desalination – proposed, decried, agreed, popping up in a number of states, connections to power sources and concomitant increases in greenhouse gases; recycling – not for drinking here, but at the same time already in place for irrigators in Werribee and at the Eastern Treatment Plant for golf courses and gardens. Increased variability of flow and recognition of crisis has driven the call for a National response in the Murray Darling Basin, the Victorian Government has blocked, environmental flows are on again, off again. All this 'action' could go 'cold' if we get lots of rain over the next few years.

How do we organise a sustaining technological world, one that sustains ecosystems, within this turbulent environment?

I believe that we could achieve a breakthrough if we, and I use this word broadly, employ both our rationality and our values to define future(s) for Australia that are both desirable and feasible, within this turbulent world. We proposed in *Bringing the Outside, Inside* that we use the Search Conference (participative planning and policy making) methodology of Fred Emery and Eric Trist (M. Emery, 1982), to develop desirable and feasible futures, because this approach formally weaves together the 'system' and its dynamic environment. (The Search methodology is also described in Participative Design for Participative Democracy (F. Emery, 1993), as is the more general notion of *searching* as a mode that educates "our perceptual systems to better *search* out the invariant characteristics and distinguishing features of our personal, social and physical environments" rather than an education in how to someday *research* an accumulated pile of so-called social knowledge.)

Search Conferences begin by considering which trends in the broader environment are critical to our adaptation. When asked this question, participants in two search conferences in education settings (one for an alternative tertiary education provider which is described in two papers (Goricanec & Young, 2001; Young & Goricanec, 2003), the second as an early activity in RMIT's Master of Sustainable Practice, sharing views of the trends in the world – more information on this program can be found in several papers (Goricanec, 2006; Goricanec & Hadgraft, 2007; Goricanec, Hadgraft, & Dorian, 2006)) have described many trends – a small but diverse sample is provided:

- increasing frequency of natural disasters (some questions here) but increase in intensity and impact of natural disasters;
- increasing poverty and affluence;
- decreasing biodiversity; increase in waste;
- increase in shift to alternative energy sources on an individual basis;
- increase in AIDS and other pandemics;
- decrease in Western populations;
- increasingly overwhelmed by the problem 'what can I do?';
- massive increase in efficiency and productivity of industrial production (with some questions here re decrease in farming productivity re transport losses);
- more complex chemicals in food, food production and pharmaceuticals;
- increasing concern about economic security (driving a whole lot of things);
- increasing economic development of the third world;
- decrease in civil society; decreased esteem for the intellectual;
- increased complexity – people withdraw into a small, safe place;
- increased use of technology in our lives.

This is not the complete record but it does provide some insight into the type of world that people are adapting within their day-to-day lives. What outcome will the interaction of all these trends with our (engineering) actions produce? This is the *relevant uncertainty* that we need to work with.

The second phase of the search conference process is to develop a view of the Likely Future if we do not intervene – this takes people to a deep, dark place. The next phase is to develop the most desirable and feasible future that can be envisaged. The latter phase plans actions, collectively and individually to actively adapt with this environment. This latter phase can be separated out as a design conference with a sub-set of participants, as the design process requires that participants have deeper understanding of the 'system', its relationship to its operating environment and the macro environment.

Co-producing our future

It should be noted that the unit of analysis (or the unit of ***intention***) in the search conference process, is the system-in-its-environment and, thereby, **adaptation is defined as a dynamic relationship, not a state of affairs**. Further, the 'inputs' and 'outputs' ***co-produce*** the future and this, in turn, means that: "Not only can the system choose responses likely to adapt to the environment, it can also ***seek to reconfigure the causal texture of the environment*** in a manner likely to be conducive to system-

environment adaptation over the longer term." (Gloster, 1999) Refer to *From Resignation to Active Adaptation* (Goricanec & Young, 2001) for more on this.

David Suzuki has developed an approach, with Canadians, that is, at least in part, similar to what I am proposing, what he calls *Sustainability in a Generation: A New Vision for Canada* (Boyd, 2005). This vision includes goals to generate genuine wealth; improve efficiency; shift to clean energy; reduce waste and pollution; protect and conserve water; produce healthy food; conserve, protect and restore Canadian nature; build sustainable cities; and promote global sustainability. Suzuki in his response to questions at the National Press Club said that as a result of having this vision that he now has quite different conversations with business and governments. Now he can have conversations about how they can work towards the goals described rather than arguing about whether the problem is real – this is a real breakthrough in response.

The distinction that I would make between Suzuki's approach and the 'Search Conference' that I propose is the lack of acknowledgement of the complex, dynamic environment. This is an important thing for participants in that they get to 'see' that their view is incomplete and that others can provide perspectives on other 'parts' of the picture, they get to value the views of others through seeing the public record being generated (this record is available to the participants). And participants also get to 'see' that their understanding of the environment is shared, that they are not on their own. There is also something that happens as a result of these types of Search Conferences and that is that people get a 'sense' of a range of possible futures and what they could do, individually and collectively to produce the most desirable but still feasible one. This provides a strong sense of purpose – hope is generated. The environment in this process is not enacted as an active or passive 'constraint', something that cannot be changed but as part of the whole 'system-in-it's-environment' and that its' causal texture can be reconfigured to better enable innovation to be sustained.

Also to be noted is that engineers are not the only key players, it is necessary to develop 'a matrix of systems, a set of mutually supportive relationships between all the key players in the design, development and delivery of the *engineered* solution.' Here I am using 'engineered solution' in the sense that we proposed in *Bringing the Outside, Inside* at the 2003 AAEE Conference (Goricanec & Young, 2003) as an outcome that comes from an active adaptive engineering practice and further that this practice needs to evolve with the dynamic, shifting environment.

In our paper we also discuss the third phase - '**design** the project based on multi-functional project teams employing the Participative Design Workshop' to undertake the actions proposed.

Once we have described desirable and feasible future(s) for Australia, within this turbulent world, these descriptions of the future can be used to inform your role as engineers and of engineering education – the connections between teaching, researching and industry will become clearer. Indeed engineering could undertake its own version of this approach, with the desirable and feasible future as part of the 'environment' that we need to adapt with.

Sustaining or being able to be sustained?

You will also have noted that I use the term sustaining rather than the normal sustainability or sustainable. The root of the verb sustain is to hold or to keep and I use this rather than the adjective sustainable which is 'to be able to be sustained', as ability doesn't make it happen, we are all able to do things that we don't do in the regular course of our lives. Sustain is a verb, an active word rather than a passive one. In McDonough Braungart Design Chemistry's website (MBDC, 2004) a new design paradigm is described as "an emerging movement of production and commerce (that) eliminates the concept of waste, uses energy from renewable sources, and celebrates cultural and biological diversity…a system of production that fulfils desires for economic and ecological abundance and social equity in both the short and long terms – becoming *sustaining* (not just sustainable) for all generations." This is another breakthrough in thinking – what we are seeking is *sustaining*, desirable and feasible futures, rather than 'eco-efficiency' which seeks to make the current destructive system of waste, pollution and natural resource depletion more efficient, and therefore more sustainable in the medium term.

By thinking in these ways (actively sustaining life, co-producing our future, searching) we can then start to reconfigure the causal texture of our environment to support these sustaining, desirable and feasible futures.

What is the role of engineers (and engineering educators) in co-producing our future?

If engineering students are educated to believe that their role is one of bridging the divides between separate entities over the slimmest of bridges and that uncertainty surrounds us but isn't a part of us, then we are doing them a disservice in their education, for this certainly is not the way that the world presents. We need to be preparing them for the reality of 'creating what can be' in a world with a turbulent causal texture.

We need to be educating (potential) engineers' perceptual systems to better *search* out the invariant characteristics and distinguishing features of their personal, social and physical environments. A higher level of learning is called for, than just knowing *about* the world and the sorts of solutions, tools and techniques that have worked, or doing better within this existing set of alternatives. We require engineers that can 'learn to learn' or who can, in Bateson's words, make '… corrective change(s) in the set of alternatives from which choice is made, or make changes in how the sequence of experience is punctuated'. (Bateson, 1972) Some examples of these changes of practice are:

- seeing the 'system-in-its-environment' as the unit of intention, where adaptation is defined as a dynamic relationship that includes reconfiguring the causal texture of the environment,
- working in or developing a matrix of systems – a set of mutually supportive relationships between all the key players in the design, development and delivery of the *engineered* solution,
- being active participants in **designing** projects in multi-functional project teams employing the Participative Design Workshop.

In order to change the practice of engineers we need to build the capability of engineering educators, the engineering education system and our engineering institutions, to support this change, but we should also be actively participating in and promoting processes that help Australians to articulate sustaining, desirable and feasible futures that can frame our practice.

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