Reprising "wicked problems": social learning, climate change adaptation and the sustainable management of water

Abstract

An inquiry into the practices of neologising, reifying (and categorizing and typologising) was conducted through the use of a question: what is it that we do when we do what we do? as an heuristic device. The systemic inquiry was motivated by an awareness that the terms "wicked" and "tame" problems, coined forty year sago have been poorly taken u despite growing evidence that situations with the named features of "wicked problems" abound and are of increasing concern to humans (e.g. the global water crisis and human-induced climate change). It was concluded that the processes of transforming understandings and practices by taking up the concept of "wicked problems" can be hampered by (i) the way in which language acts as a social technology and (ii) arrangements that preclude novel configurations in the flow of emotioning, crucial to epistemic and identity shift. Practices associated with the coining, acceptance and reification of new concepts can also produce unintended consequences. These findings have implications fro research design in a "projectified world".

Keywords

"Wicked problems"; systemic inquiry; climate change adaptation; social learning.

1. THE PROBLEMATIQUE

Thompson and Warburton (1985) once sensibly set out to find out what was wrong with the Himalayas acknowledging that the problem was to know what the problem was. Climate change adaptation and the "global water crisis" are the new Himalayas! There is now growing agreement globally that these ***are*** problems yet their nature and scope and the means of engagement with, and "solutions" to, them are highly contested. These "problems" have many of the features attributed to complex and uncertain social planning situations that systems scholars experienced in the 1960s and 70s. Intriguingly these scholars coined particular neologisms as a means of describing, and thus classifying, the situations that they experienced. In this paper I explore what it is that we do when we neologise and reify and raise the question of how these practices might constrain systemic practice and the formulation of policies and other institutional arrangements that can facilitate social learning. I raise these issues as part of a broader systemic inquiry into how changes in practices and understandings might give rise to human institutions and behaviours based on a co-evolutionary ethic. My inquiry is a precursor to grounding these understandings in a research design for situations associated with water catchment managing, conceptualised as a sub-system of a climate change adaptation system.

Reprising "wicked problems"

After living and working in the UK for over a decade it was a pleasant surprise on returning to Australia to discover that the Australian Public Service Commission (APSC 2007) had undertaken a thoughtful review of "wicked problems". They described "wicked problems" as problems that "*go beyond the capacity of any one organisation to understand and respond to, and* [where] *there is often disagreement about the causes of the problems and the best way to tackle them. …..Usually, part of the solution to wicked problems involves changing the behaviour of groups of citizens or all citizens. Other key ingredients in solving or at least managing complex policy problems include successfully working across both internal and external organisational boundaries and engaging citizens and stakeholders in policy making and implementation*." They go on to say that "*wicked problems require innovative, comprehensive solutions that can be modified in the light of experience and on-the-ground feedback*" and that "*all of the above can pose challenges to traditional approaches to policy making and programme implementation*". In my experience this last claim is both valid and profound. In a foreward to this paper, the Commissioner of the APS makes the very powerful point that: "*It is important, as a first step, that wicked problems be recognised as such. Successfully tackling wicked problems requires a broad recognition and understanding, including from governments and Ministers, that there are no quick fixes and simple solutions"*. This is a strong statement that does not mince words; from my perspective this observation challenges the very ways our democracies and associated bureaucracies function and can be seen as a call to action in the light of climate change and other "wicked" situations.

Despite this encouraging development there is limited evidence that understandings about "wicked problems" have been incorporated into public discourse and it is questionable as to whether there is widespread capability to engage with, yet alone improve, wicked-problem situations. Rittel and Webber's paper in which they first presented their distinction between "wicked and tame problems" was published in Policy Sciences 4 (1973),

155-169, but was originally presented to the Panel on Policy Sciences, American Association for the Advancement of Science, in Boston in December 1969. Both authors were urban planners at the University of Berkley in California who had observed that there was a whole realm of social planning problems that could not be successfully treated with traditional linear, analytical approaches. In this inquiry I want to look at what Rittel and Webber did when they named "wicked" and "tame" problems forty years ago to see if this might reveal insights into why these terms have been so poorly taken up.

What do we do when we do what we do?

I want to draw attention to two practices that are poorly understood yet important to the question: what is it that we do when we do what we do? The first is the practice of neologising, using or coining new words or expressions. Someone who does this is a neologist and the result of their particular practice is a neologism. The second practice is the act of reifying something. Etienne Wenger (1998 p. 58) draws attention to the implications of reification in his work on communities of practice (CoPs). He describes reification as the practice of "making into a thing" which is something we do all the time although the implications of this practice are not well understood. It has particular implications when we make or treat an abstraction, such as justice, as a concrete material thing (Wenger offers the example of the common statues of a blindfolded woman who ***is*** justice). Wenger (ibid) says: "*we project our meanings into the world* [through living in language] *and then we perceive them as existing in the world, as having a reality of their own*" (p. 58). Wenger goes on to use the abstract concept of reification to refer to "*the process of giving form to our experience by producing objects that congeal this experience into "thingness*"" and he points out that he is introducing reification "*into the discourse because he wants to create a new distinction to serve as a point of focus around which to organise* [his] *discussion*" (p.58). In other words Wenger in his coining of "reification" is creating a neologism. To examine these practices I focus on Rittel and Webber's (1973) work though my inquiry could equally extend to Ackoff's (1974ab) coining of "mess" and "difficulty" or Shön's (1995) distinction between the "swamp of real life issues" and the "high ground of technical rationality".

In trying to answer the question what is it that Rittel and Webber did when they did what they did I find it insightful to ask: what experiences did they have that led them to coin these neologisms? This is a different question to asking: What are the characteristics of wicked problems? Drawing on their paper Rittel & Webber's (1973) main concerns were:

(i) "*There seems to be a growing realization that a weak strut in the professional's support system lies at the juncture where goal-formulation, problem-definition and equity issues meet. Goal-finding (central to planning) is turning out to be an extraordinarily obstinate task*."

(ii) "*We are now sensitized to the waves of repercussions generated by a problem-solving action directed to any one node in the network, and we are no longer surprised to find it inducing problems of greater severity at some other node. And so we have been forced to expand the boundaries of the systems we deal with, trying to internalize those externalities*."

(iii) "*we are calling them "wicked" not because these properties are themselves ethically deplorable. We use the term "wicked" in a meaning akin to that of "malignant" (in contrast to "benign") or "vicious" (like a circle) or "tricky" (like a leprechaun) or "aggressive" (like a lion, in contrast to the docility of a lamb). We do not mean to personify these properties of social systems by implying malicious intent. But then, you may agree that it becomes morally objectionable for the planner to treat a wicked problem as though it were a tame one, or to tame a wicked problem prematurely, or to refuse to recognize the inherent wickedness of social problems.*"

(iv) "*The difficulties attached to rationality are tenacious, and we have so far been unable to get untangled from their web. This is partly because the classical paradigm of science and engineering--the paradigm that has underlain modern professionalism--is not applicable to the problems of open societal systems*."

(v) "*The systems-approach "of the first generation" is inadequate for dealing with wicked-problems. Approaches of the "second generation" should be based on a model of planning as an argumentative process in the course of which an image of the problem and of the solution emerges gradually among the participants, as a product of incessant judgment, subjected to critical argument.*"

I gain the following insights from my inquiry into Rittel and Webber's paper:

(i) They are explicitly concerned with the process of problem formulation – by naming "equity" they are aware, it seems, of who participates in formulating "problems" and how and by whom goals are articulated (notice they say goal finding, not goal setting);

(ii) In what might be regarded as an early appreciation of the nature of networks they recognise that action at one node may induce unintended consequences at another node. They are implicitly referring to positive and

negative feedback processes, the idea of unintended consequences that arise through interconnectedness or its breakdown, and that many boundary judgments fail to account for relevant externalities;

(iii) They use the term wicked in a playful way, exploring different metaphors, whilst at the same time recognising the seriousness of such situations;

(iv) They raise only two implications for practice (a) avoiding treating "wicked problems" as tame "or to tame a wicked problem prematurely, or to refuse to recognize the inherent wickedness of social problems" and (b) the need to develop a second generation systems approach that operates deliberatively in language (as an argumentative process) amongst stakeholders to form an image of the problem as "a product of incessant judgement, subjected to critical argument";

(v) They recognise a very difficult context for the "adoption" of their understandings, claiming rational approaches to be tenacious, unhelpful and supported by "the classical paradigm of science and engineering--the paradigm that has underlain modern professionalism" [which] "is not applicable to the problems of open societal systems".

Like many academic papers Rittel and Webber's is written at quite a high level of abstraction – they do not, for example, ground any of their claims in personal experience though one is left in no doubt that they have had these experiences. They also say relatively little about practice that may lie beyond the labelling of situations as wicked or tame. Perhaps they felt that the naming, or representation, of these "type" of situations as "wicked problems", was their most important task? It is tempting to conclude that little has changed since 1969 – the classical paradigm remains pervasive (though human-induced climate change could act as a tipping point) and, as yet, a second generation systems approach has not taken hold in policy and governance circles i.e., systems explanations and hence practices are not valued in this context. Maturana (pers. comm.) makes the point that when we accept a different explanation our world changes but one can only assume that Rittel and Webber's distinctions have done little to change the worlds of policy makers and practitioners. So what is the relationship between a neologism and an explanation and how might the dynamics of change in this situation be better understood?

Innovation through the displacement of understandings?

One might argue that much progress could be made if we recognised climate change as a mess, or a wicked problem, or a practice situation more like the swamp than the high ground. We know from our 30 plus years of teaching Systems at the Open University, UK that the mess/difficulty distinction has great utility for most students – see Chapman (2005). In many ways the practice response seems clear – recognise these situations for what they are! But is this a trap awaiting the unwary? Are there traps that can produce unintended consequences arising from the practices of neologising and reifying, and, associated with these, of categorizing and typologising? The act of categorization is very common – in research practice the development of typologies is also a frequent form of practice. Although sometimes useful, the act of reification and the circulation of the products of reification in academic discourse in particular leads us to lose sight of how these "things" came into existence and, further, the validity or viability in contemporary circumstances, of their on-going use (one only has to reflect on the ways in which some of these concepts are taught, and thus experienced by learners – the experience may be a far cry from the experiences of those who coined the neologism). This in turn can blind us to the choices we can make, and thus the responsibility we have, for how we engage with situations - Shön (1967) notes that "the situations we conceive in a certain way can be conceived in an infinite variety of ways as well" (p.7).

At its simplest we can choose to engage with a situation as if it were a tame or wicked problem, a mess, difficulty, complex adaptive system etc but each choice brings with it different consequences – experience shows that engaging with situations as a "difficulty" when they might be better understood as "messes" has the effect of exacerbating the mess! Yet without the distinction mess/difficulty we may be blind to the dynamics and thus possibilities in the situation. This, however, is a first order dynamic which is probably most obvious if one considers the type of understanding and underlying emotioning that might arise when a student is exposed to the wicked/tame distinction and their features in a typical lecture format, followed by a traditional form of assessment. Of course this dynamic, and the degree to which it is a first, or second-order dynamic will depend on the history of experiences of the student.

Having embarked on this inquiry I find that Donald Shön has, in part, been there before me; I have found his work initially published as The Displacement of Concepts (1963) and then re-issued as Invention and the Evolution of Ideas (1967) illuminating. For example, he makes the point (1967 p. 7) that "when we identify something as an instance of a concept already given we do nothing to modify our conceptual scheme, we simply order experienced things in terms of it.." He goes on to say (p. 8) that "once having resolved a problematic area of experience, once having found a way of looking at (and therefore dealing with) a situation which was at first novel and puzzling, our impulse to stick with it is overwhelmingly powerful. We have "adapted to it, and

through it". Our concept-forming apparatus operates under a categorical imperative of "let well enough alone". So how do these insights illuminate the dynamics of the wicked/tame distinctions, and their entailments, in social and professional discourse and practice over the last forty years?

If I stand back from the specifics of Rittel and Webber's paper some interesting questions emerge such as: How, if at all, have wicked and tame problems become reified? Or put another way: How have they entered our understandings and practices? Unfortunately I have not undertaken or seen a study that sets out to answer these questions in a systematic way. The APSC paper I referred to earlier can be seen as part of a lineage of attempts to reify understandings about "wicked" and "tame" problems in policy and governance discourse. But surely that too has been tried before? Shön's work can help; his primary concern is with innovation – the displacement of old concepts by new. But is the wicked problem issue really a failure of innovation i.e., a failure of displacement, and thus a form of repression or suppression, a failure to be open to, and responsible for, our circumstances? If so then a question might be: why has the concept of wicked problems (or messes) not displaced other problem metaphors, whether called 'tame', 'difficulties' or just plain old 'problems'? Is it that the metaphor does not have the right affordances (i.e., features that invite actions or reactions that are readily apparent to a user)? Perhaps it is these factors which lie behind the growing popularity of the 'complex adaptive system' (CAS) metaphor, although as I have noted elsewhere – see Ison and Schlindwein (2006) – the users of this neologism perpetuate many of the same mistakes made by systems practitioners over the last fifty years, including creating or reifying CASs as things or objects.

2. WHAT DOES THIS INQUIRY REVEAL?

What does this inquiry reveal? It is probably too simplistic to claim that progress could be made if only more people were aware of the understandings that the distinctions mess/difficulty or wicked/tame problem evoke. It is a start but not enough. Somewhat tentatively I would like to claim that the interconnected set of practices associated with neologising, reifying, categorizing, typologising (etc?) have unintended consequences – they remove us from the primary experiences and underlying emotions that provide the motivation for these practices in the first place. As a result these practices appear to inure us to epistemic shifts, emotional transformations, ego release, identity expansion, reflexivity and the abandonment of certainty. A further consequence can be the conservation of practices and institutional arrangements unsuited to changing circumstances. Wenger (1998) in the context of CoPs has come to understand reification of practices as part of a duality, constituting a whole with participation. It is through participation that the historical consequences of reification can be undone. By being aware of what we do when we bring forth a thing, an object (i.e. reify) it might be possible to devise practices to deal with the unintended consequences – such practice might have be characterized by forms of contextual deconstruction, including practices such as metaphor analysis (Ison 2002). Shön (1967), for example, claims that what he calls the displacement of concepts is "simply another word for the process of metaphor" (p. 57).

In my work reported in Ison (2002) I engaged with policy makers responsible for a new 'knowledge transfer strategy' through a process of exploring their metaphors in use. In the language of this essay the policy proposed was designed to treat wicked problems as tame. It was my action of being highly critical of the policy in a public forum that led to my invitation to come and speak to the Ministry officials. This dynamic is important – it is what I call the 'politics of invitation' (see High et al 2008) – as it creates the underlying emotional dynamic that unfolds. I will not recount here all that I did other than to say that my method led, as I had hoped, to a very authentic conversation (see Guba & Lincoln 1985), one that was highly reflexive, and thus unusual among the five or so people involved. This event was not, however, framed by any institutional arrangements that made it ongoing – it was not a project, nor did it become one. From my follow-up evaluation it was evident that my approach had been effective in triggering reflexivity but it did not trigger any on-going relationship or set of activities. Boxelaar et al (2007) make the point that interventions that merely offer a critique that challenges the prevailing narrative settings can increase uncertainty (and one might surmise, cognitive dissonance). They argue for practices that "create an alternative narrative space in which people can place themselves, particularly practices that enable people to perform and enhance their identities within a context of change". It is not clear however, what practices can achieve this, nor do they give consideration to the effects of powerful institutional arrangements such as the 'project' i.e., our manner of living in a projectified world (see Ison et al 2007a).

The onset of the global water crisis, peak oil and anthropogenic climate change at much the same time together with growing population and consumerism bring a new type of attention to our circumstances – the situations in which we find ourselves. If human beings (along with other species on which we impact) wish to continue to co-evolve with the earth then we have little choice but to understand and act differently to that of the past. I am tempted to conclude that human beings are yet to understand the implications of living in language, or put another way, have failed to see how language can act as a social technology that mediates our understandings and practices and thus our relationship with the biophysical world. Or, following Maturana (pers. comm.), we

have failed to realise that we do not use language but that language uses us in ways we are yet to appreciate and master.

So what contribution can my inquiry make to the design of practical action in a situation that could be aptly described as a 'wicked problem' or a mess?

3. TAKING PURPOSEFUL ACTION IN THE GOULBURN-BROKEN CATCHMENT, A SUBSYSTEM OF THE AUSTRALIAN MURRAY-DARLING BASIN

Australia's water environment is in a state of crisis, characterized by complexity, interdependencies, uncertainty, multiple perspectives and controversies. Particularly within rural situations, sustainability and actions for dealing with water scarcity and climate change adaptation have become important policy priorities. Water is the key element that will underpin sustainable human activity and social wellbeing in situations such as the Goulburn Valley catchment in Victoria, sometimes described as Victoria's 'food bowl'.

The Goulburn Valley faces a period of major change, with the potential for many unforeseen impacts: economic, environmental and social. Complexity and uncertainty in the region have been exacerbated by recent plans to pipe water from the Goulburn Valley to relieve Greater Melbourne's water shortage, by the extended recent drought, climate change, water scarcity and the need for adaptation, and industry restructuring. The region will share in major government investments, including $1 billion for new infrastructure through the Food Bowl Modernisation Program, $1 billion for water savings through the Living Murray Program, and a possible $1 billion for on-farm water savings through the National Plan for Water Security. This is also against a background of a transfer of some powers from the States to the Commonwealth and the development of a new catchment management plan for the Murray-Darling basin which is currently in dire circumstances.

Uniwater (an interdisciplinary research hub of Monash and Melbourne Universities) has a Goulburn Valley Research Program which is already developing projects on agricultural futures, ecological futures and shared data. The dilemma is how to ensure that these valuable inquiries contribute to a whole-of-system approach that supports community wellbeing and a viable social future. While particular disciplines or organisations are generally willing to take a leading role in such projects, are the best outcomes necessarily reached by allowing one group's (e.g. agricultural) interests to dominate? Or by permitting market forces to simply unfold? A central challenge for Uniwater is to provide a framework of theory and praxis to bring these fragmented interests together.

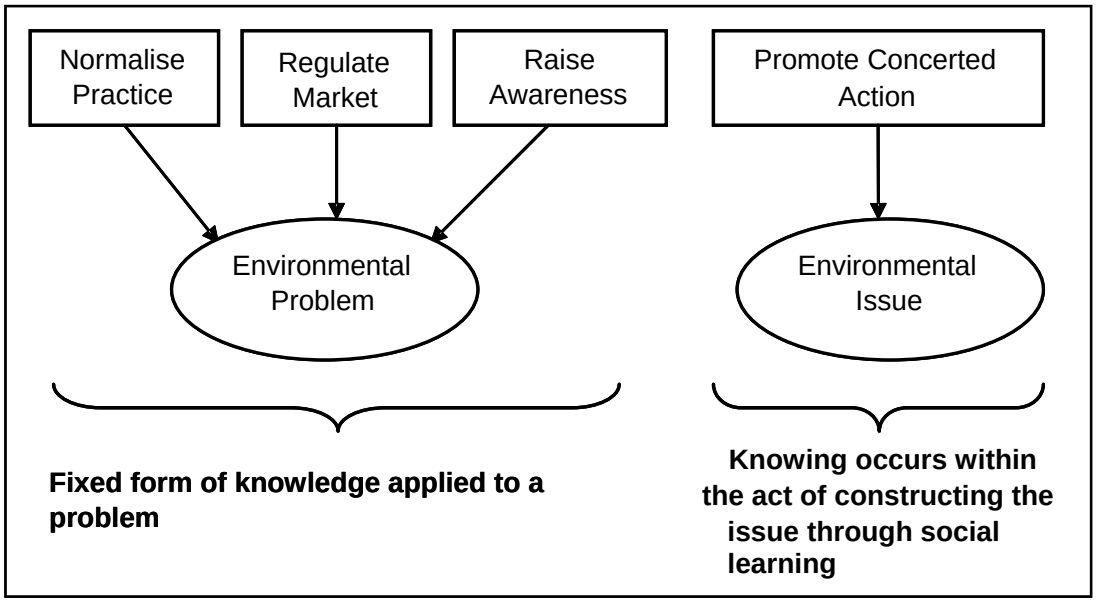

Figure 1. Policy coordination mechanisms compared: Left - within the current paradigm of environmental management comprising hierarchy and the market used to address pre-determined environmental problems based on a fixed form of knowledge and Right - social learning for concerted action based on the process of knowing that occurs through stakeholders constructing what is at issue (Source Ison et al 2007b).

In Rittel and Webber's terms the situation is clearly a 'wicked problem' but labelling it as such does not guarantee that others will agree or that practices in relation to the situation will change. Can systems-based social learning research provide a theoretical and praxis (theory informed practical action) framework capable of

dealing with a challenge of such magnitude? My question is built on the contention that 'wicked problems' require social learning and systemic approaches to effect social and institutional transformations that are viable and sustainable. As outlined by Collins & Ison (2006) "while the 'social' in social learning refers to the collective process that can take place through interactions among multiple interdependent stakeholders who are given proper facilitation, institutional support and a conducive policy environment, our research findings suggest that social learning can be understood as one or all of the following (SLIM 2004):

1. The convergence of goals, criteria and knowledge leading to more accurate mutual expectations and the building of relational capital. If social learning is at work, then convergence and relational capital generate agreement on concerted action for integrated catchment management and the sustainable use of water. Social learning may thus result in sustainable resource use.

2. The process of co-creation of knowledge, which provides insight into the causes of, and the means required to transform, a situation. Social learning is thus an integral part of the make-up of concerted action.

3. The change of behaviours and actions resulting from understanding something through action ('knowing') and leading to concerted action. Social learning is thus an emergent property of the process to transform a situation."

4. The title for a governance mechanism which policy makers can employ (Figure 1).

Based on my inquiry a key question would seem to be: How can the circumstances be created such that an explanation of the situation as a wicked problem is accepted by the most powerful stakeholders and the consequences enacted? Shön and Rein (1994) argue that policy positions rest on underlying structures of belief, perception and appreciation which they call 'frames'. In earlier work (see Russell and Ison 2004) we have drawn on Maturana's concept of conversation as the braiding of emotion and language as a framework-for-action. In that work we follow Maturana's claim that learning and change take place in a relational space, over time, and as a consequence of engagements shaped by the participants' emotions. We describe research practices that illustrates the researcher as chorographer (one practiced in the systematic description of regions – or in the terms of this inquiry, the systematic description of situations) and as choreographer (one practiced in the design of dance arrangements) of the emotions. However, creating the contexts to enact these researcher roles in a purposeful way is not always straightforward – a typical 'project', for example, is not always conducive to co-research. At its most basic all one can do is invite others into conversation and see what emerges.

In the purposeful design of a researching system, or systems, a number of choices seem apparent: (i) a rational, evidence-based approach; (ii) a small 'p' political approach - based say, on relationship building and opening up spaces for invitations; (iii) building a discourse (e.g. Krippendorff, 1995) or, (iv) combinations of all three. We already have empirical evidence for enacting governance arrangements based on social learning as depicted in Figure 1. But this is European evidence not Australian and I have found that this matters. Such empirical evidence, rather than just constituting part of a rational argument can become a mediating object which open's up spaces for learning. In Europe the discourse about social learning, though not yet institutionalised, seems stronger than in Australia. Undoubtedly well designed experiential activity delivers the best conversation and opens up more possibilities for the choreography of the emotions, but as outlined in High (2002) this requires practices which also open up engagement opportunities.

CONCLUSION:

Social learning, like a good concert orchestra, is about creating an effective performance amongst multiple stakeholders in situations of uncertainty and complexity. The key need that social learning addresses is how to orchestrate effective performances amongst multiple stakeholders in 'wicked problem' situations. This involves the transformation of complex situations to improved situations through changes in understanding and practices of those involved but, as this inquiry reveals, the processes of transforming understandings and practices can be hampered by (i) the way in which language acts as a social technology and (ii) arrangements that preclude novel configurations in the flow of emotioning, crucial to epistemic and identity shift. Practices associated with the coining, acceptance and reification of new concepts can produce unintended consequences which in any purposeful activity such as researching may create initial starting conditions that preclude transformations that improve complex situations. Ultimately wicked problems such as water management and climate change are problems of relationship – of human beings with the biosphere – so perhaps other research traditions concerned with the breakdown of relationships, such as systemic family therapy, may offer ways forward.

REFERENCES:

Ackoff, R.L. (1974a) The systems revolution, *Long Range Planning*, 7, 2–5.

Ackoff, R.L. (1974b) *Redesigning the Future*, New York, Wiley.

APSC (Australian Public Service Commission) (2007) Tackling Wicked Problems. A Public Policy Perspective. Canberra, Australian Government/Australian Public Service Commission. 38p.

Boxelaar, L., Paine, M., & Beilin, R. (2007) Change management and complexity: the case for narrative action research, *Journal of Agricultural Education & Extension*, 13, 163-76.

Chapman, J. (2002) *System Failure. Why governments must learn to think differently*, London, Demos, 85p.

Collins, K. & Ison, R.L. (2006) Dare we jump off Arnstein's ladder? Social learning as a new policy paradigm. Proceedings PATH (Participatory Approaches in Science & Technology) Conference, 4th-7th June 2006, Edinburgh.

Guba, E. & Lincoln, Y. (1985) *Naturalistic Inquiry.* California, Sage Publications.

High, Chris (2002) *Opening up spaces for learning: A systems approach to sustainable development*. Unpublished PhD Thesis, UK, The Open University.

High, C., Ison, R., Blackmore, C. & Nemes, G. (2008) Starting off right: Reframing participation though stakeholder analysis and the politics of invitation. Proc. Working Group 13 'The OECD's New Rural Paradigm', XII World Congress of Rural Sociology, Seoul, Korea.

Ison, R.L. (2002) Some reflections on a knowledge transfer strategy: a systemic inquiry. In Farming and Rural Systems Research and Extension, Proceedings Fifth IFSA European Symposium, Florence (April).

Ison, R.L. & Schlindwein, S. (2006) History repeats itself: current traps in complexity practice from a systems perspective. Proc. 12th Australia New Zealand Systems Society (ANZSYS) Conference, "Sustaining our Social and Natural Capital", 3rd – 6th December 2006.

Isoṇ R.L., Röling, N. & Watson, D. (2007b) Challenges to science and society in the sustainable management and use of water: investigating the role of social learning. *Environmental Science & Policy* 10 (6) 499 – 511.

Ison, R.L., Bawden, R.D., Mackenzie, B., Packham, R.G., Sriskandarajah, N. & Armson, R. (2007a) From sustainable to systemic development: an inquiry into transformations in discourse and praxis, Invited Keynote Paper, Australia New Zealand Systems Conference 2007, "Systemic development: local solutions in a global environment" 2 – 5 December 2007, Auckland, New Zealand

Krippendorff, K. (1995) In Paivi Tahkokallio & Susann Vihma, eds 'Design – Pleasure or responsibility? pp. 138-62. Helsinki, University of Art & Design.

Rittel, H.W.J. and Webber, M.M. (1973) Dilemmas in a general theory of planning, *Policy Science*, 4, 155–69.

Russell, D.B. & Ison, R.L. (2004) Maturana's intellectual contribution as a choreography of conversation and action. *Cybernetics & Human Knowing*, 11 (2) 36-48.

Shön, D.A. (1963) *Displacement of Concepts.* London, Tavistock Publications.

Shön, D.A. (1967) *Invention and the Evolution of Ideas*. London, Social Science Paperbacks.

Schön, D.A. (1995) The new scholarship requires a new epistemology, *Change* November/December, pp.27–34.

Schön, D.A. & Rein, M. (1994) *Frame Reflection. Toward the Resolution of Intractable Policy Controversies*, New York, Basic Books.

SLIM (Social Learning for the Integrated and Sustainable Management of Water) (2004) SLIM Framework. (accessible at: http://slim.open.ac.uk)

Thompson, M. & Warburton, M. (1985) Decision making under contradictory certainties: how to save the Himalayas when you can't find out what is wrong with them. *Journal of Applied Systems Analysis*, 12.

Wenger, E., 1998. *Communities of Practice*. Cambridge, Cambridge University Press.

COPYRIGHT

R.L. Ison ©2008. The author/s assign Edith Cowan University a non-exclusive license to use this document for personal use provided that the article is used in full and this copyright statement is reproduced. Such documents may be published on the World Wide Web, CD-ROM, in printed form, and on mirror sites on the World Wide Web. The authors also grant a non-exclusive license to ECU to publish this document in full in the Conference Proceedings. Any other usage is prohibited without the express permission of the authors.