

TITLE: Designing an inquiry-based learning system: innovating in research praxis to transform science-policy-practice relations for sustainable development

SHORT TITLE: Designing an inquiry-based learning system

AUTHORS:

Ison, RL Applied Systems Thinking in Practice (ASTiP) Group, School of Engineering & Innovation, The Open University (UK), Walton Hall, MK7 6AA ray.ison@open.ac.uk +61 404308180

Collins, KB Applied Systems Thinking in Practice (ASTiP) Group, School of Engineering & Innovation, The Open University (UK), Walton Hall, MK7 6AA kevin.collins@open.ac.uk

Iaquinto, BL Department of Geography, The University of Hong Kong, Pokfulam, Hong Kong
iaquinto@hku.hk

Abstract

When designers of activities concerned with the dissemination of research findings pursue their practice all too often the linear model is implicitly or explicitly the default position. This paper uses the lens of praxis (theory-informed practical action) to offer a shift in possibility away from reliance on the linear model of innovation to a second-order modality of research practice more suited to sustainable development goal (SDG) implementation. Whilst second-order modalities of knowledge production, necessary to enact sustainability transitions and transformative praxis, are emerging many lack purposefully designed modes of praxis and are limited in their considerations regarding enactment and performativity. We report on the testing and evaluation of a purpose-driven design of a 'learning system' within the Australian urban-water sector to enact a 'systemic inquiry' capable of generating social learning. Changes in understanding and/or practices by those who participated were achieved, thus satisfying key criteria for initiating but not necessarily sustaining social learning. The praxis innovation described is suited to situations best framed as uncertain, complex and contested. The positive outcomes of the enacted 'learning system' support the case for more investment in action-oriented research to support innovation in the field of second-order systems praxis.

Keywords: Social learning; systemic inquiry; learning system design; linear model; SDGs; sustainability transitions; water sensitive cities

Designing an inquiry-based learning system: innovating in research praxis to transform science-policy-practice relations for sustainable development

1. Research practice for sustainable development - breaking away from old models

How research is, or could be, taken up in practice is a consistent and recurring theme in science and policy studies (Steyaert and Jiggins 2007; Autio et al. 2008; Munõz-Erickson 2014). A persistent line of argument concerns the adequacy, or not, of the linear model of research (Price and Bass 1969; Kline 1985; Russell and Ison 2000a; Balconi et al 2010). The premise of the linear model is that innovation first appears through basic research, is progressed by applied R&D and is concluded by production and diffusion (Godin 2006). This is the common, or mainstream, understanding and commitment that informs most research-related policies and practices. Characterised by Tábara and Chabay (2013) as one of two worldviews, linear model adherents understand “information and knowledge systems as evolving in a closed, ahistorical, social-ecologically disembodied linear space, in ways which can be reduced to a single form of representation.” From a systems-theoretical perspective (Ison 2017) the linear model, when institutionalised, generates practice that is systematic (i.e., linear, step by step) at the expense of the systemic (i.e., recursive, circular, contextual, relational).

The knowledge/action dualism that is conserved by adherence to the linear model precipitates understandings and practices that have been found wanting in many situated areas of research practice because, as Cook and Wagenaar (2012 p. 3) write, “knowledge and context can be explained in terms of—and are evoked within—practice, and not the other way round—and ... this transpires within real worlds each of which has its own unique constraints and affordances, histories and futures.” Thus, attempts to shift away from the linear model are not so much a theoretical question *sensu stricto*, as a question of adequate, situated practice. Or, as we prefer, praxis which we take to mean theoretically informed practical action for innovation and change. Praxis innovation we argue can be understood as a form of systemic design, or more specifically, systemic design research; we follow Schön (1983) who sought to establish “an epistemology of practice implicit in the artistic, intuitive

processes which [design and other] practitioners bring to situations of uncertainty, instability, uniqueness and value conflict". Within this 'second-order' tradition, systems, objects, artifacts, plans and processes cannot be designed deterministically (i.e., as blueprints to be applied across multiple contexts), rather theory-informed contextual design is pursued to create favourable conditions for emergence (Mitchell 2019).

It is with these concerns in mind that we turn to the theme proposed for the 2020 ISSS (International Society for the Systems Sciences) conference.¹ Research reported in this paper is grounded within the issue of sustainable urban water development and governance. In SDG (Sustainable Development Goals) terms the research relates closely to SDG Goals 6, 11, 13 and 17 (Clean Water and Sanitation; Sustainable Cities and Communities; Climate Action and Partnerships to achieve the Goal). But, as various commentators have observed, action based on thinking and practice in a business-as-usual mode is unlikely to succeed over the longer term (Cockburn et al 2018; Liu et al 2018). As Reynolds et al (2017 p. 677) note, pursuit of the SDGs invites the creation of *"an integrated, holistic, multi-stakeholder approach [which] implies the need for systems thinking in practice, a tradition that draws on systems theories, tools and techniques able to facilitate better conversation and cooperation between agencies."*

In Australia, where this study was based, innovation in the urban water sector has been characterised by lock-ins and path dependencies, in addition to limited knowledge amongst urban water practitioners as to how these might be overcome (Brown et al. 2013; Bos et al 2015). In the context of water shortages and weather extremes the concept of 'water sensitive cities' (WSCs) emerged as a way to advance the role of water management in creating more resilient, liveable, productive and sustainable urban environments (Ferguson et al. 2013; Floyd et al. 2014; Brown 2012). The WSC concept arose in the Intergovernmental Agreement on a National Water Initiative (NWI) by the Council of Australian Governments (COAG 2004). Similar constellations of concerns exist in other countries and settings and in relation to progressing the SDGs (Johannessen 2017).

¹ Systemic Change towards Sustainable Development: Innovative and Integrative Approaches.

The research reported here is not about WSCs per se; it is a conceptual, methodological and praxis response to the desire by the Monash-based water governance research program to develop stakeholding (SLIM 2004a) in the WSC concept and to avoid the pitfalls of the linear model of 'knowledge transfer', issues likely to pertain to the totality of SDG implementation (Stafford-Smith et al 2016). Thus, the paper reports and evaluates a second-order modality of praxis innovation pursued through systemic design research that involved (i) experimenting, as this is central to reflection-in-action, (ii) move-testing i.e., something produces what was intended, or not; and (iii) hypothesis-testing (Schön 1987; Visser 2010). The innovation was developed and enacted using purposefully designed and facilitated 'inquiry' sessions and conversations so as to:

- enhance the capacity of water practitioners and their organisations in five state-capital cities in Australia to transition towards a more sustainable WSC
- develop a greater common understanding of what a WSC might look like and the associated barriers and opportunities for achieving this outcome
- test whether the purposeful design of place-based inquiries could trigger changes in understandings and practices of those participating, thus initiating a process of social learning.

The task accepted by the inquiry designers was that it was (i) a 'research task', (ii) conceptualised as systemic design and praxis research in which the primary concern was (iii) the design, implementation and evaluation of 'a situated learning system'. The research offers a set of institutional and praxis innovations that could be applied to action for any SDG goal, thus contributing to progressing SDGs at a meta-level (Reynolds et al 2017; Liu et al 2018).

As we will explain, we choose to understand a 'learning system' as the product of purposeful, situated, design comprising elements that when enacted give rise to learning. Situations, like that of transitioning towards a more sustainable WSC, are usefully framed as uncertain, complex, contested, with many interdependencies including diverse stakes, and thus, multiple perspectives on what is at issue. Such situations demand 'learning systems' designs with particular features. The same is true for situations framed as 'wicked' (Head 2008; Floyd et al 2014; Ison et al 2014). Within these designs new modalities of enactment (praxis) are, we contend, required (Ison et al 2011; Blackmore 2010; Ison 2017).

The concept of a purposeful, designed learning system plus the praxis required to enact a learning system needs to be understood against a background of attempts to move from a purely linear model (as outlined above) towards a process of situated transformation that realises innovation. The next section of this paper situates our research conceptually. We follow this with empirical evidence, firstly by outlining our research materials and methods, including our theory-informed learning-system design. We then provide evaluative evidence of the efficacy of our design in relation to the contexts of use and what we set out to test. The final discussion and conclusions reflect on the adequacy of our theory and practice and summarises our conclusions.

2. Designing learning systems – towards social learning?

This research is underpinned by three conceptual platforms, variously informed by systems theory. These are (i) learning theories and designed learning systems; (ii) systemic inquiry; and (iii) social learning. Our efforts in purposeful design rest upon these three ‘platforms’ which are introduced in turn.

2.1 Understanding learning theoretically and methodologically – designing learning systems

Bateson (1972, p. 298) outlined five different levels of learning, from the most basic type known as ‘zero learning’ to ‘Learning IV’, the most complex. This hierarchy of learning was later taken up by other learning scholars including the distinctions single, double and triple loop learning (Argyris and Schön 1974; 1978; Sterling 2011). Our approach to learning extends these theoretical lineages by drawing heavily on the biology of cognition (Maturana and Varela 1987; Maturana and Poerksen 2004; Mitchell 2020) and a social theory of learning as articulated by Wenger (1998).

Some have described Maturana’s theoretical position as ‘bring forthist’ – i.e., through our doings in the world we bring forth the worlds we understand and live (Tomm 1989; Proulx 2006). As noted by Proulx (2008 p.12) Maturana’s ‘position on knowledge as not being pre-existent or as “taking things in” [but] as being enacted and emerging through the learner’s engagement with his [sic] world is at the core of the complexivist discourse on learning, knowledge and education’. Importantly, this perspective is not a return to earlier cognitivist

theories (see Blackmore 2007; Cuffari et al 2014) as individuals are always socially and culturally situated - we all live our traditions of understanding from which we think and act (Russell and Ison 2000a). Research in the second order tradition is more accurately described as a process or performance, rather than a blueprint or model (Collins et al 2009). It is open to the role played by emotions in shaping the research and the place of conversation (from the Latin *con versare*, to turn together) as a primary basis for human communication (Russell and Ison 2000b; Ison and Russell 2000; 2011).

Schön (1973 p.116) first employed the explicit language of a 'learning system' when he proposed 'that government as a learning system carries with it the idea of public learning, a special way of acquiring new capacity for behaviour in which government learns for the society as a whole'. Our research and praxis seeks to extend Schön's (1973) concept by postulating that a learning system can be employed and applied in any context where purposeful transformational change is sought (Bawden 1994; Ison 1994; Blackmore 2005; 2010).

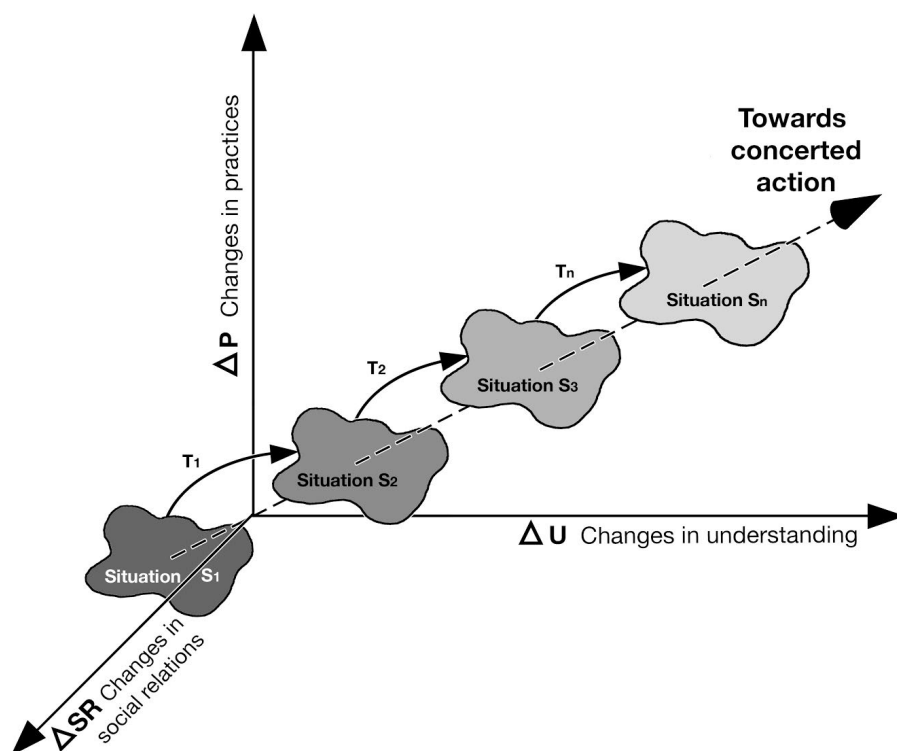


Figure 1. A conceptual framework for transforming complex situations through changes in understandings (ΔU), practices (ΔP) and/or social relations (ΔSR) of those involved: S = situation, moving from S_1 , the history of the 'current' situation to S_n . Source: Adapted from SLIM (2004b).

2.2 Systemic inquiry

Systemic inquiry is a form of praxis which begins by being open to situations and acknowledging uncertainty; thus participants begin in a different emotional space to that which accompanies the emotion of certainty associated with programs and projects. As systemic inquiry progresses it involves the commitment to and enactment of a process of learning amongst those who already have, or through participation build, a stake in an issue of concern (Checkland 2002a; Ison 2002; SLIM 2004b). Systemic inquiries are flexible and open ended; there is not one 'right' way and end only when those involved decide to end them. Systemic inquiry builds on an intellectual lineage associated with Deweyian inquiry that can be found in systems scholarship (Dewey 1933; Churchman 1971; Checkland 2002ab; Blackmore 2009). With appropriate investment systemic inquiry can be seen as a meta-process and institution (in the institutional economics sense) to that of programmes and projects (Ison 2017).

2.3 Social learning

The 'social' in social learning refers to the collective process that can take place through interactions among multiple interdependent stakeholders who experience appropriate and robust facilitation, institutional support and a conducive policy environment (Ison et al 2007; Bos et al 2013). Our research findings suggest that social learning can be understood as one or all of the following (SLIM, 2004b; Collins and Ison 2009; Ison et al 2013):

1. The negotiation of purpose, success criteria and ways of knowing leading to more accurate mutual expectations and the building of relational capital.
2. The process of co-creation of knowledge, which provides insight into the causes of, and the means required to transform, a situation through concerted action (Figure 1).
3. The change of behaviours and actions resulting from understanding something through action ('knowing') and leading to concerted action.

4. The title for a governance mechanism which policy makers can employ particularly in contexts usefully framed as ‘wicked’ and which demands greater initial investment than the linear, systematic, first-order knowledge-adoption model.

Concerted action is understood in ways similar to an orchestra or musical performance: multiple actors engaging in different roles and practices, but with awareness of their interdependencies and the greater whole that is being created. Consistent with this interpretation, the path to concerted action in Figure 1 is not linear nor can it be blueprinted.

[insert Fig 1 here]

3. Research approach

We began this research asking whether it was possible to design and enact (i.e., test) learning systems that could be adapted and operationalised in real time in two-day, city-specific events i.e., could social learning, as we understood it (Figure 1), be generated through a purposefully designed learning system that enacted ‘systemic inquiry’? Our hypothesis was that this could be achieved by paying attention to contextual design, facilitation and methods with evidence (presentations by researchers) able to trigger shifts in understandings and/or practices of those involved. Recognising the need for reflection-in-action on our designs, and that each city was different, we did not set out to test a design blueprint, but to engage also in experimenting and move-testing as outlined by Schön (1987).

3.1. Nested systemic inquiries

Our designed learning system for enacting systemic inquiry operated at two levels (Figure 2); each of five two-day events was designed as a situated systemic inquiry and nested within a meta-level inquiry which encompassed all of the city events. The designs were influenced by the conceptual platforms described in section 2; of particular importance was our desire to trigger changes, amongst those involved, in understandings, practices and social relations, central to our appreciation of social learning (Figure 1). Monitoring, feedback and learning/evaluation processes were conducted at the end of each day and event and at the conclusion of all events, so the whole set of events can also be understood as a meta-level systemic inquiry that purposefully set out to design and improve our praxis as designers and facilitators of learning systems fit for context.

[insert Figure 2 here]

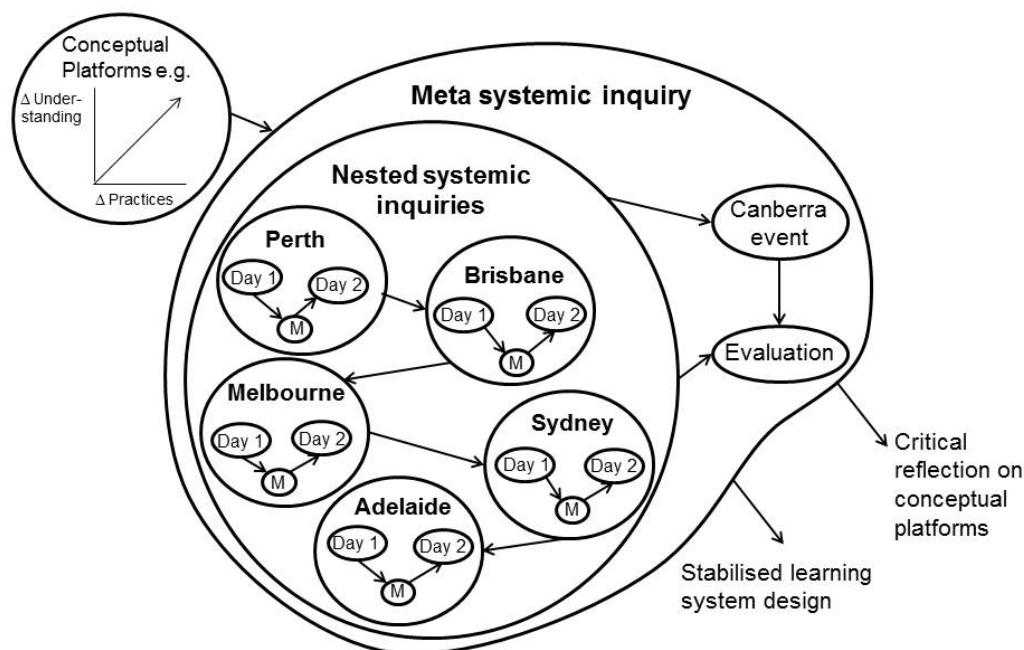


Figure 2. A schematic design of a nested set of systemic inquiries operating at the level of city-based, two-day events within a meta-inquiry concerned with how to (i) create the circumstances for a social learning process to emerge as evidenced by changes in understanding (ΔU) and practices (ΔP) of those involved in a given city and (ii) transition/transform to water sensitive cities in Australia, with the aid of research input including daily monitoring (M) in each city.

All event participants occupied various roles in the Australian urban water sector. Mindful of the need to creatively combine multiple perspectives on what the issues were and how they should be improved (Verweij et al. 2006), an aim of our design was to bring together participants from a diversity of backgrounds, seniority and disciplines and to create an experience of having their understandings and concerns heard and valued. While the majority of participants had engineering or science backgrounds, there were also social scientists, planners, landscape designers, economists, natural resource managers, lawyers and urban horticulturalists. All areas of urban water management were represented but most participants were in policy/strategy or design/technical design/operations;

management seniority and employment in the sector ranged from one to 20 years. For a full analysis of participants across all events see Ison et al (2009).

Two day events were held in February 2009 in Adelaide (72 participants), Melbourne (162 participants), Brisbane (106 participants), Perth (70 participants) and Sydney (119 participants). There was also a follow-up one-day event with 65 participants in May 2009 in Canberra, the national capital, for state and federal policy makers to engage with the results of the other events. Staff of the National Water Commission, a body responsible for oversight of the National Water Initiative (formulated in 2004 but disbanded in 2015) was a supportive presence in all events (see Ison et al 2009).

Feedback received on the first day of the Perth event informed the conduct of day two of the event, which together with feedback from day two informed the design of the following event in Brisbane, where the process was repeated i.e., 'move-testing experiments' (Schön 1987 p. 71). This means that no two events were the same – as designers/organisers we were consistently responding to feedback and adapting the events accordingly. We describe below how the feedback processes were designed and operated for the event-based and meta-inquiries. The final event in Canberra took a very different form as it sought to engage key policy makers with the key findings arising from all the events (This paper does not concern itself with the design and/or outcomes of the Canberra workshop).

3.2. Design approach and elements

The first design stage was to clarify with the sponsors their ambition, scope, non-negotiables and appreciate the resources available, then to explore, clarify and articulate the desired purpose, both overall, and with respect to each event (Figure 3). In systems theory, purpose (the why), is related to the outcomes of a transformation for which a system is seen to exist i.e., what it does. In this work the concept of purpose and the praxis of clarifying purpose operated at multiple levels. It was important to arrive at a design where the sponsor's purpose aligned with our own, which was designing a learning system capable of triggering changes in the understandings and practices of participants by establishing favourable starting conditions for the emergence of social learning (Figure 1).

This was achieved by pre and post-event briefings with the whole research group which included sponsors.

A key informant was recruited from each city to inform organisers of issues specific to their city, in both technical and social/political terms, so as to help in the design of table based-inquiry groups and seating arrangements within each event. Primary aims were to gain gender balance, to maximise the diversity of perspectives each participant was exposed to, and to minimise historical conflict that seemed entrenched (which is not the same as seeking to avoid all conflict). Creating a conversational space was aided by a preliminary process of contracting which took the form of an agreed set of rules, self-monitored, as to how all in the room would behave together e.g., provide others with the experience of being listened to.

The first main activity in all events was a technique called conversation mapping. It was conducted in groups of 6-8 persons per table – see ‘engage in conversation’ or step 2 in the learning system model (Figure 3).

[insert Fig 3 here]

Our design and use of conversation mapping is built on an appreciation of the roots of the word conversation; theoretically and practically we draw on the work of Krippendorff (2009) in relation to authentic conversation in which mutual understanding, self-organisation, equal opportunities to contribute and increasing the number of options for subsequent action are paramount. Conversation mapping began with all participants co-constructing purpose by addressing the very open-ended question: ‘transitioning [Perth, Brisbane, Sydney, Melbourne, Adelaide] to a water sensitive city?’

Systemic inquiry, like other learning processes can be understood as progressing through phases of divergent and convergent thinking/acting (Cropley 2006; Runco 1991). In conversation mapping the elicitation of emergent ‘meta-themes’ is a means to begin a process of converging. A particular theme can then be explored through on-going systemic inquiry or collating the themes in systemic relationship can be attempted. We did both. Participants were asked to identify issues and opportunities arising from their conversation

map. We chose to frame an 'issue' as characterized by uncertainty, conflict, risk, novelty, unusual insight, contested perspectives, power struggles or lack of information.

Activity modelling, central to Soft Systems Methodology (SSM), was used to conceptualise and design the various iterations of our learning system (Figures 2 and 3) and in adapted form was also used by participants to enact the systemic inquiry process (Figure 4). SSM employs verbs as the modelling language and is readily adapted to an action research and/or systemic inquiry process (Checkland and Poulter 2006; 2010; Armson 2011).

The question mark at the end of the central trigger question - 'transitioning X to a water sensitive city?' was important as it both framed the engagement as a co-inquiry and signalled that the researchers did not have a blueprint which they planned to deliver, marking the event as different to practices that employ the first-order linear model. The final version of our learning system design, stabilised after all main-city events, is presented as Figure 3. By stabilised we mean that while our design is not a blueprint that can be applied unchangingly to any context, the design considerations upon which it is based could be applied elsewhere.

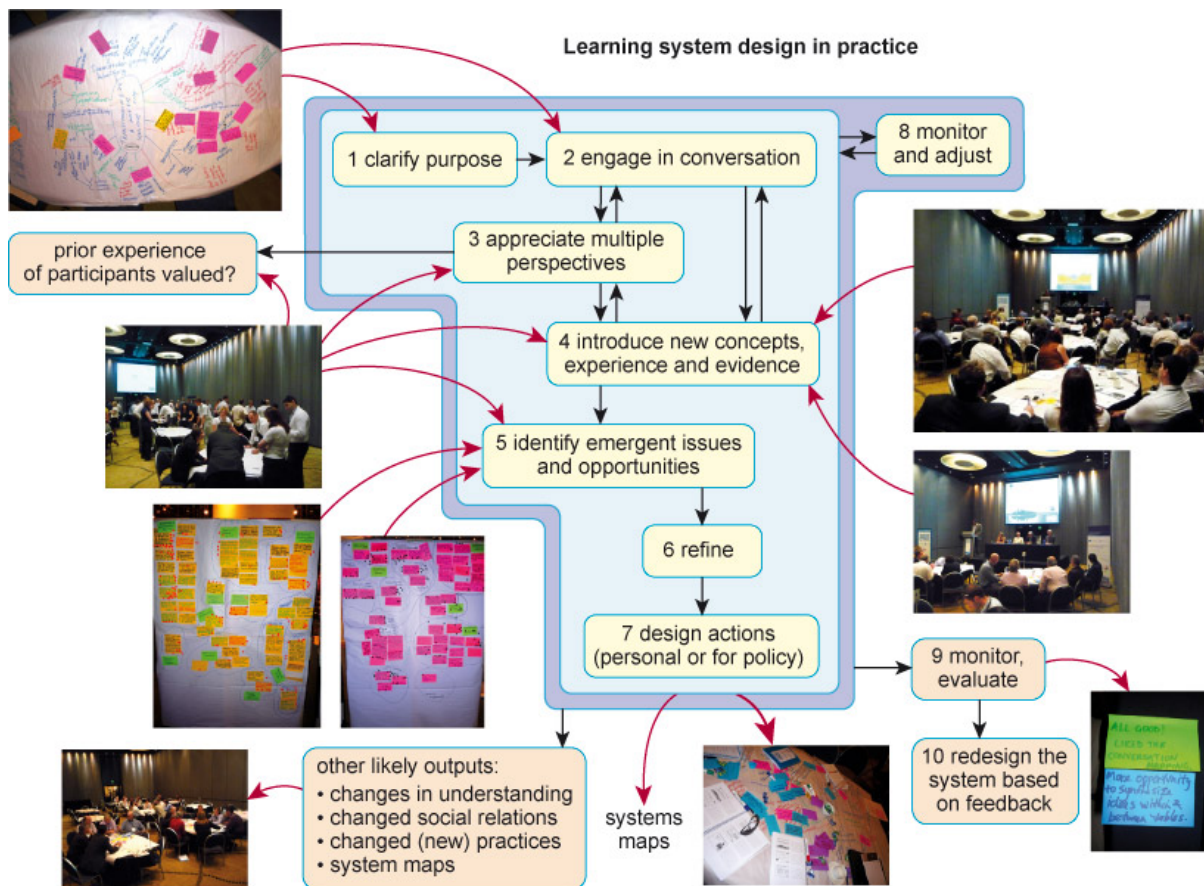


Figure 3. A stabilised learning system design emerging from five events organised as systemic inquiries with images that typified the various activities in practice; only the high order activities are presented – consistent with activity modelling a layered structure can be assumed so that each activity system comprise a sub and sub-sub system.

On day 2 of each event, contracts were re-negotiated, reflections were shared and participants were asked to imagine they had arrived in a water sensitive city. They recorded on different coloured 'post-it' notes characteristics of, actions required, issues to be faced, and opportunities available, to transition their city to a water sensitive city (data not presented – see Ison et al 2009). Processes were devised for participants to move toward systemically desirable actions (in contrast to, say, priority actions that lack systemic relations). The outcome was a set of systemically coherent actions contextualised in the issues and opportunities identified by participants at each table (Figure 4).

The events concluded with a session that required members from each table sharing their own insights into water sensitive cities with members from other tables. The purpose of this

process was to find similarities amongst all the groups and to build coalitions for the purpose of creating a WSC. It was a way of establishing a set of systemically coherent actions that were agreed-upon by water practitioners in each city. These actions could then be used collaboratively to start the process of transitioning. An example from Sydney is provided in Figure 4. It depicts twelve systemically desirable actions (at the level of sub-system) that could be taken to begin transforming Sydney to a water sensitive city.

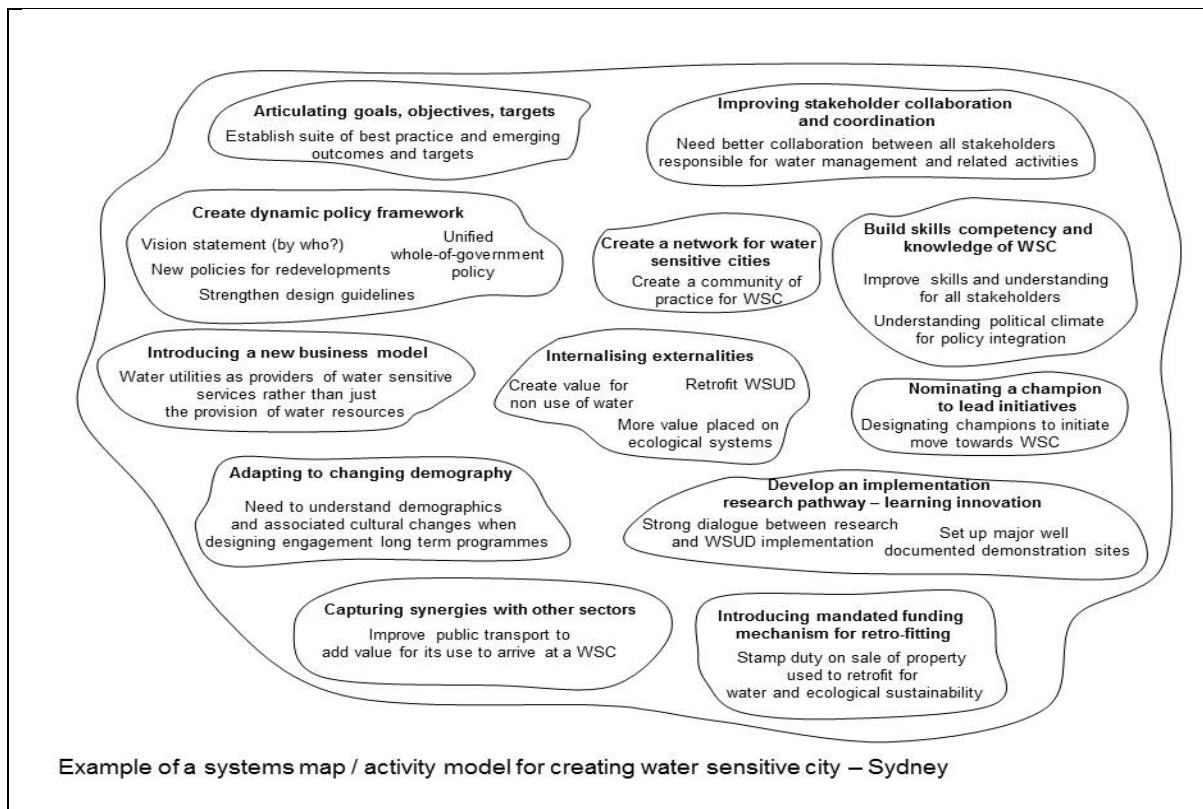


Figure 4. A model of a conceptual system to transform Sydney to a water sensitive city comprising twelve systemically desirable actions (sub-systems) together with some sub-sub-system level activities.

3.3. Emergent, process innovations

The design of our events evolved in response to feedback and learning. A tension for designers and participants in group-based inquiry processes of short duration is whether to maintain or change initial starting groups. As we wanted participants to experience the full two-day inquiry in the same conversation and given the attention we had paid to group selection we decided to maintain the initial group structure throughout an event. However, in response to feedback, we introduced an innovation in Sydney which we called 'scouting

for news of difference'. Building on Gregory Bateson's aphorism of seeking the difference that makes a difference (Bateson 1972, p. 460) we set up two scouting expeditions towards the end of each day that involved members from each table visiting other groups to discern what they did differently. On the whole, based on evaluative feedback (see below), scouting proved to be an appropriate innovation for enabling learning, as insights were shared earlier and more widely.

3.4. Monitoring and evaluation

Monitoring and evaluation was carried out at the end of days one and two (not presented here) and later via a follow up survey sent to all participants. Importance was placed upon valuing the knowledge and experience of both the presenters and the participants. As the events generated a large amount of data (Figure 5), the empirical focus in this paper is upon how we monitored and evaluated our overall learning system designed to enact a systemic inquiry. All raw data was posted on the IWC website and made accessible to the event participants prior to the final evaluation survey according to their original registration (Figure 5). Not all the data can be reported here – see Ison et al 2009 for further details of our results - our focus here is the follow-up survey.

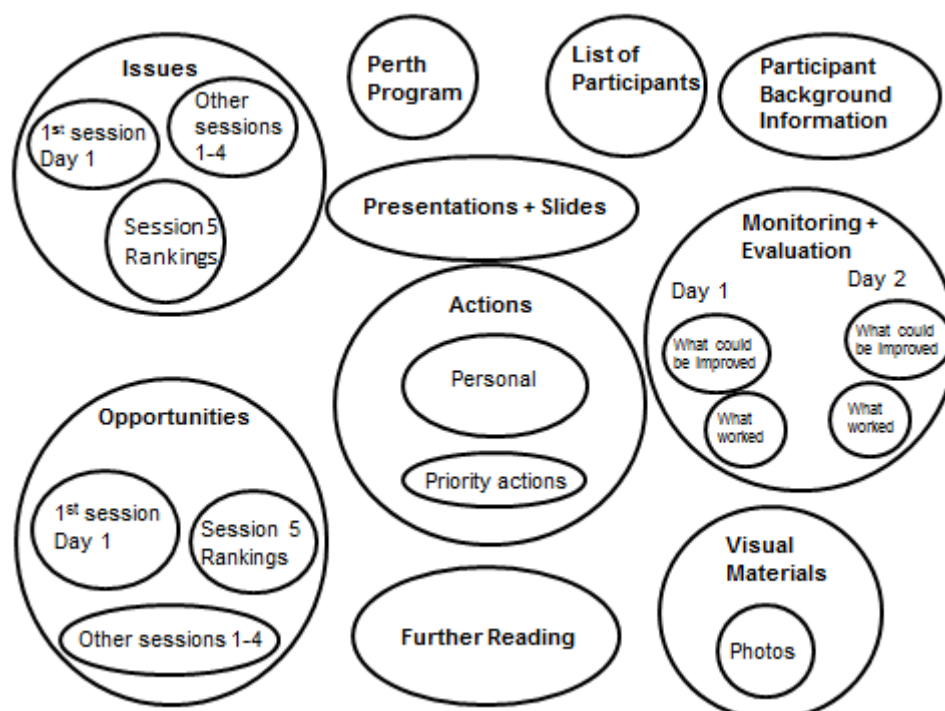


Figure 5. A copy of the on-line entry portal for Perth designed as a systems map for participants to access all data from the event – a similar portal was developed for Brisbane, Melbourne, Sydney, Adelaide and Canberra ²

The evaluation survey was designed to elicit evidence of changes in understandings and/or practices of those involved, as well as feedback on the overall experience, the adequacy of the event design as well as the utility of the various elements, including tools and techniques. A total of 178 responses were received, representing a healthy 33.6% response rate. On a city/state basis the response rates were: Perth (38.6%), Brisbane (23.6%), Melbourne (34.6%), Sydney (40.3%) and Adelaide (20.8%). Survey respondents were generally representative of the total population of participants. The main variations were that in the evaluation Brisbane was proportionally slightly under represented and Adelaide slightly over represented; sewage and water supply professionals were slightly over represented and Natural Resource Management under represented compared to other professions. The disciplinary spread was very similar e.g. engineering 36% (survey) and 33.3% (event) and science 26% (survey) and 25% (event).

4. Learning system design monitoring and evaluation

The predominant motivations of those attending were personal learning and continuing professional development. Many were driven by a desire to engage in discussion and networking and also promote change. This suggests an appreciation of the importance of the topic and the relevance to the professional lives of participants.

4.1 Overall evaluation - learning system effectiveness

As shown in Table 1 there was strong support for all the major elements of events. The evaluation survey reveals that personal expectations of the WSC event were met (80.8%; n=135); the two-day length was considered appropriate (79.6%; n=133) as was the balance of different elements, including interaction and participation (85%; n=142). The majority of respondents noted the interaction between event presenters and participants was satisfying (86.8%; n=145). Whilst some suggestions for improvements were made by participants, the

² See ORO (Open Research Online): <http://oro.open.ac.uk/75895/> (Accessed 5th May 2021).

design team were pleasantly surprised by the frequency of positive comments along the lines of ‘good to hear a diversity of views, good process to explore multi-dimensional problem’ from a Brisbane participant, and ‘well facilitated, interactive sessions were a great idea, good to hear from experts but also to “do” and be involved’ from a Melbourne participant.

Table 1. Evaluation of the main design features based on responses to the question ‘please give us YOUR opinion on a scale of 1 (totally disagree) to 7 (totally agree) about the following statements (Source: survey).

Statement	Disagrees	Neutral	Agrees
Overall, my personal expectations of the Water Sensitive Cities event were met.	7.2% (12)	12.0% (20)	80.8% (135)
The two-day length of the event was right.	10.8% (18)	9.6% (16)	79.6% (133)
The event had a good balance of different elements, such as information exchange, interaction and participation.	5.4% (9)	9.6% (16)	85% (142)
The interaction between event presenters and participants was satisfying.	4.8% (8)	8.4% (14)	86.8% (145)
The overall interactions between the event participants were satisfying.	4.8% (8)	6.0% (10)	89.2% (149)
The contracting rules e.g., ‘giving others the experience of being listened to’ as set out in the beginning of the event served as useful guidance during our table discussions.	6% (10)	15.0% (25)	79% (132)
The presentations were of good value to the overall event.	6.6% (11)	4.2% (7)	89.2% (149)
The logistical arrangements for the event were satisfying.	3.6% (6)	9.6% (16)	86.8% (145)

When asked which event activity they found most useful, presentations were nominated by 47% and table-based inquiries by 41% of respondents; informal networking and plenaries were nominated by 5% for each (n=168). Of the four main table-based event activities most survey respondents (84.3%) believed conversation mapping was the most effective followed by contracting (59.8%), systems mapping (58.7%) and scouting (58.4%). Importantly, less

than 9% of respondents regarded these elements as ineffective. About 82% of respondents said they would use one, or all of the event activities in the future (n = 164).

4.2 Developing new understandings and practices

Changes in understanding and practice, as a result of involvement in the systemic inquiry, were reported amongst participants across all cities (Table 2). Our evaluation showed that 53% of respondents reported their perceptions of a water sensitive city changed and 74.6% reported an increased understanding of the characteristics of a water sensitive city. Many also reported improved understandings of the contributions other water professionals can make to the process of transitioning to WSCs (75.8%) and the need for more effective interdisciplinary approaches (75.2% - Table 2). It was revealing that more respondents agreed they had an increased understanding of the social issues (72%, n=119) rather than an increased understanding of the technical issues (59%, n=98). The only statement receiving less than 50% agreement was 'I believe that stakeholders in the city are now more connected to each other' (44%, n=72). However, 38% (n= 63) were neutral about this statement, as if reserving judgment. Overall the survey results support the design aspiration to achieve changes in understandings; there is also evidence of effecting improvements in social relations.

In the survey, participants were asked about the extent to which they had taken action as a result of the content and process of the events. The most substantial changes in actions were reported at the individual level where participants said they had started talking about WSCs (61.6%) and subsequently drawn systems maps as used in the events (see Figure 4) to understand their situations (69%).

Table 2. Responses to questions designed to address the extent that social learning had, or had not happened; the survey asked for the participant's opinion on a scale of 1 (totally disagree) to 7 (totally agree) about the following statements answering as a result of the event (Source: survey).

Statement	Disagrees	Neutral	Agrees
I believe that stakeholders in the city are now more connected to each other.	18.1% (30)	38.2% (63)	43.6% (72)

I have recognised the need for more effective inter-disciplinary approaches.	7.3% (12)	17.6% (29)	75.2% (124)
I have come to better appreciate contributions other professionals can make.	8.5% (14)	17.6% (29)	75.8% (105)
I have strengthened and/or made new contacts in the water sector.	9.1% (15)	18.8% (31)	72.2% (119)
I have greater understanding of some facilitation techniques that could make my organisation more effective.	6.7% (11)	26.1% (43)	67.3% (111)

Facilitation is also a key aspect of enacting any learning system design (SLIM 2004c; Bos et al 2013); in this regard facilitation was experienced positively (67%; n=111). In the next section we reflect on the adequacy of our second-order design praxis.

5. Discussion and conclusions

As Andersson (2021) notes *'cities appropriate more and more of Earth's land surface, either for the built cities themselves .. or for the production systems they need for their survival..... 'cities' and 'urban' are somewhat deceptive terms as they may give the impression of homogeneous units with clear boundaries'*. With this understanding an imperative arises in the context of SDG implementation to not treat contexts/situations as homogeneous with the possibility that technology and innovation can be 'rolled out' or 'scaled-up'. This research offers an antidote to the widespread embeddedness of the linear model. However, one must always be aware of the political economy of praxis. Cleaver and Franks (2008) contend that academics are often uncertainty creators when all that policy makers want is uncertainty reduction. On the other hand, all policies are experiments in situations of constantly unfolding uncertainty (Ison and Straw 2020).

We created, conducted and evaluated (i.e., tested) a series of designs for events across Australia conceptualised as learning systems capable of enacting a systemic inquiry and triggering social learning. Our meta-purpose was to develop and enact a second-order modality of praxis relevant to transitioning and transforming the current urban water situation towards a water sensitive city (Figures 1, 3; Ison et al 2011) but to do so in a way

that presented evidence for use and investment in our approach in other contexts. As depicted in Figure 2 we also sought to critically reflect on the adequacy of the conceptual foundations of our designing and enactment praxis, as elaborated in section 2, and to offer evidence of an innovation worthy of institutionalising through future investment. Our findings have insights for ongoing innovation in second-order R&D praxis, institutional, including policy, innovation and ultimately for moving towards systemic governance of social-biophysical systems (see Ison et al 2014; Ison and Straw 2020).

Our learning system was designed to start out systemically. We did not progress in a linear or systematic fashion typical of the linear model. The events were fit for purpose; importantly they were suffused with transformative moments for many individuals and groups – as evidenced by verbal feedback and reflections in the plenary sessions with comments such as ‘the learning approach was great, it’s given me new ideas’ and ‘I enjoyed the entire two days – the learning opportunity was tremendous’. In other words, a legacy of transformative potential was created. However, the ‘learning system’ and our capacity to design it, did not emerge out of a policy and governance vacuum. In this regard the legitimacy to the activity provided by the NWI (which explicitly mentions WSCs) and the participation in our events by staff of the National Water Commission (responsible for NWI oversight), were important. This support probably had a major impact on making the invitations to participate legitimate thus facilitating the large numbers attained.

Our findings confirm that a learning system designed as a systemic inquiry is a useful way to engage with uncertainty and that it can be used to enable various levels of learning, including learning about the learning process itself. This was evidenced by the take-up of techniques such as systems mapping and the common refrain from participants to the effect ‘if only our staff meetings were like this’.

The use of a follow-up survey distributed amongst participants was a systematic way to evaluate the effectiveness of our designs and their enactments. Our experience is that most events that are designed in contexts similar to ours are characterised by a first-order ethos. This applies to one, two and week-long events, including conferences (Blackmore et al 2018). Our research provides evidence of efficacy for an alternative second-order design

and praxis pathway for such activities. The research directly addresses both the praxis and design elements of a second-order, approach and contributes to a contested literature calling for more empirical evidence relevant to 'reflexivity, transdisciplinarity and quality control' (Hessels and van Lente, 2008). Tabára and Chabay (2014) argue the case for innovation and investment informed by a worldview that 'understands information and knowledge systems as operating in an open space composed of multiple and diverse patterns of hybrid social–ecological practices and configurations, inevitably embedded in specific times, spaces and contextual conditions' on the basis that practices arising from this worldview 'are better suited to support sustainability learning and transformation'.

Despite our design aspirations we do not claim that participation in these systemic inquiries has led to social learning *sensu stricto*, in the sense of ongoing and purposeful concerted action (Figure 1). On the other hand, we do claim to provide evidence of having created favourable starting conditions for social learning to emerge during and after the events, including evidence of changes in understanding, practices and social relations of those involved - all key elements of situational transformation (Figure 1). These findings have contributed to subsequent research that provides more evidence for the utility of this approach (Foster et al 2019; Allan et al 2020).

The events enabled water practitioners to establish a stake in the transition to WSCs in Australia, and they understood the transformative possibilities now open to them. But it must be remembered that a two day event as designed is limited in its transformative possibilities in that it necessarily abstracts participants out of their context in which change has to be enacted (Armson 2011). Our findings do however point to ways in which designed learning systems for 'systemic inquiry' can be understood as an institution that could be used more widely. They also support those who argue that participation is not the same as social learning (e.g., Collins and Ison 2009; Reed et al 2010).

Second-order praxis is more than design (Ison et al 2011); importantly it is also about the realisation and adaptation of the design in situated practice, or as Schön (1983) would say, 'reflection-in-action'. It is because praxis needs to be enacted that we have provided detail about our designs and their elements. But in wicked, complex and uncertain situations,

uncertainty reduction is a trap resulting in over-simplification and systemic failure, as wicked situations cannot be ameliorated with tame solutions.

An important part of our design was that the 'learning system' could be contextualised in the unique and complex histories and politics of each city. Since completing our research, the development of efforts to promote WSC progressed with funding of a \$120 million Australian Commonwealth Cooperative Research Centre for WSC (CRCWSC) which began in July 2012 to: *'deliver the socio-technical urban water management solutions, education and training programs, and industry engagement required to make towns and cities water sensitive'*³. Unfortunately what was missing from our design was the embedding of the two day events in an explicit, longer-term systemic inquiry process for urban water governance transformation, though the evolution of the CRCWSC could be understood in these terms. To be effective in the longer term, and to have SDG implementation utility, our approach necessitates the concurrent creation of a conducive, systemic governance meta-system (Ison and Straw 2020).

In the context of our work the alternative could have been a much more traditional model of reporting back research findings in a traditional design that drew on some, or all, of the features of the linear model. Our study was not designed to test one model against another and in line with our theoretical position of valuing both the systemic and systematic we would contend that there are times and places for processes informed by the linear model. Our experience suggests however that more investment and capability in designing and enacting systemic approaches is needed at this historical moment. This is because the effectiveness of systemic designs is heightened if participants feel their ideas are valued i.e., if feedback processes operate (Klein 2005).

Other recent innovations that seemingly fit within the second-order modality of praxis that guided our work include: transition management (Loorbach and Rotmans 2010); post-normal sustainability technologies (Frame 2008; Frame and Brown 2008); adaptive co-management (Armitage et al. 2008); enactive social science (De Jaegher and Di Paolo 2007);

³ Comprising \$30 million from the Australian Government, \$29 million cash and \$60 million in-kind contributions from its 86 participating partners, see <http://watersensitivecities.org.au/about-the-crc/>.

social system design (see Metcalf 2014), the interpretive and relational turns in the analysis and enactment of public policy (Wagenaar, 2011; Bartels et al 2020) and transformation research (O'Brien 2012). However, purposefully designed modes of praxis and related concerns with enactment, or performativity, are often missing; the research reported here addresses this gap because within a reflexive, second-order, mode it is possible to ask: what do *we* do in *our* research practice when *we* do what *we* do? (Ison 2017), or put another way: how might *our* practice initiate or contribute to a transformational performance in the context(s) of concern? As recommended by Avelino and Grin (2017) epistemological awareness and flexibility are central to our concerns; though arising from different theoretical traditions our approach could be understood as a praxeology for enacting what they call 'reconstructive' transitions.

If SDG implementation is not to suffer the same fate as the poorly conceived Millennium Ecosystem Assessment then the imperative advanced by Roux et al (2006) that 'scientists cannot afford to remain detached experts who deliver knowledge to managers but must assume the roles of collaborative learners..' will have to be effected. Our research contributes to enabling this shift.

Acknowledgments

We thank all participants, the IWC (International Water Centre) for funding, administrative and logistical support and Annette Bos and Rebekah Brown of the then National Urban Water Governance Program, SGES, Faculty of Arts, Monash University, Clayton, Victoria.

Patrick Steyaert has kindly allowed us to use his adaptation of earlier joint work for Figure 1.

References

- Allan C, Ison R, Mumaw L, Colliver R, Mackay M, Perez-Mujica L, Wallis P. 2020. Jumping off the treadmill: transforming NRM to systemic governing with systemic co-inquiry. *Policy Studies* **41**: 350-371.
- Andersson E, 2021, Knowledge for a different urban future: a reflection, Guest editorial, *Bothalia* 51(1), a1. <http://dx.doi.org/10.38201/btha.abc.v51.i1> .
- Argyris C, Schön DA. 1974. *Theory in Practice: Increasing Professional Effectiveness*. San Francisco, CA: Jossey-Bass.

- Argyris C, Schön D., 1978. *Organizational Learning: A Theory of Action Perspective*. Reading, MA: Addison-Wesley.
- Armitage D, Marschke M, Plummer R., 2008. Adaptive co-management and the paradox of learning. *Global Environmental Change* **18**(1): 86-98.
- Armson R. 2011. *Growing Wings On The Way: Systems Thinking For Messy Situations*. Triarchy Press, Axminster.
- Autio E, Kanninen S, Gustafsson R. 2008. First- and second-order additionality and learning outcomes in collaborative R&D programs. *Research Policy* **37**(1): 59-76.
- Avelino F, Grin J. 2017. Beyond deconstruction. A reconstructive perspective on sustainability transition governance, *Environmental Innovation & Societal Transitions* **22**: 15-25.
- Balconi M, Brusoni S, Orsenigo L. 2010. In defence of the linear model: an essay. *Research Policy* **39**: 1-13.
- Bartels KPR, Wagenaar H, Li Y. 2020. Introduction: towards deliberative policy analysis 2.0. *Policy Studies* pp. 295-306.
- Bateson G. 1972. *Steps to an Ecology of Mind*. University of Chicago Press, London.
- Bawden R. 1994. Creating learning systems: a metaphor for institutional reform in development. In: Scoones, I., Thompson, J. (Eds.), *Beyond Farmer First – Rural People's Knowledge, Agricultural Research and Extension Practice*, Intermediate Technology Press, London, pp. 258-263.
- Blackmore CP. 2005. Learning to appreciate learning systems for environmental decision making: a 'work-in-progress' perspective. *Systems Research and Behavioral Science* **22**(4): 329-341.
- Blackmore CP. 2007. What kinds of knowledge, knowing and learning are required for addressing resource dilemmas?: a theoretical overview. *Environmental Science and Policy* **10**(6): 512-525.
- Blackmore CP. 2009. *Learning systems and communities of practice for environmental decision making*, Unpublished PhD Thesis, The Open University, UK.
- Blackmore CP. 2010. Introduction. In: Blackmore, C. (Ed.), *Social Learning Systems and Communities of Practice*, Springer, London, pp. xi-xv
- Blackmore CP, Sriskandarajah N, Ison RL. 2018. Developing learning systems for addressing uncertainty in farming, food and environment: what has changed in recent times? *Int. J. Agr. Ext.* 03-15
<http://escijournals.net/index.php/IJAE/article/view/2675/1312>
- Bos JJ, Brown RR, Farrelly MA, 2013. A design framework for creating social learning situations, *Global Environmental Change* **23**(2), 398-412.
- Bos JJ, Brown RR, Farrelly MA. 2015. Building networks and coalitions to promote transformational change: Insights from an Australian urban water planning case study, *Environmental Innovation & Societal Transitions*. **15**: 11-25.
- Brown RR. 2012. Transitioning to the Water Sensitive City: the socio-technical challenge, in: C. Howe, C. Mitchell (Eds.), *Water Sensitive Cities*. IWA, London, UK, pp. 29-42.

- Brown RR, Farrelly MA, Loorbach DA. 2013. Actors working the institutions in sustainability transitions: The case of Melbourne's stormwater management. *Global Environmental Change* **23**(4): 701-718.
- Checkland PB. 2002a. The role of the practitioner in a soft-systems study. Quarterly Newsletter, Open University Systems Society (OUSys), Open University, Milton Keynes, 27 pp. S5-S11.
- Checkland PB. 2002b. Thirty years in the systems movement: disappointments I have known, and a way forward. *Systemist* **24**(2): 99-112.
- Checkland PB, Poulter J. 2006. Learning for Action, John Wiley & Sons, Chichester.
- Checkland PB, Poulter J. 2010. Soft Systems Methodology, In: Reynolds, M.B., Holwell, S., (Eds.), *Systems Approaches to Managing Change: A Practical Guide*, Springer with The Open University, London, pp. 191-242.
- Churchman CW. 1971. *The Design of Inquiring Systems: basic concepts of systems and organization*. New York: Basic Books.
- Cleaver F, Franks T. 2008. Distilling or diluting? Negotiating the water-research-policy interface. *Water Alternatives* **1**: 157-76.
- Cockburn J, Palmer CG, Biggs, H, Rosenberg E. 2018. Navigating multiple tensions for engaged praxis in a complex social-ecological system, *Land* **7**: 129 doi:10.3390/land7040129
- Collins KB, Colvin J, Ison RL. 2009. Building 'learning catchments' for integrated catchment managing: designing learning systems and networks based on experiences in the UK, South Africa and Australia. *Water Science & Technology* **59** (4): 687-693.
- Collins KB, Ison RL. 2009. Jumping off Arnstein's ladder: social learning as a new policy paradigm for climate change adaptation. *Environmental Policy & Governance* **19**(6): 358-373.
- Cook SDN, Wagenaar H. 2012. Navigating the eternally unfolding present. Toward an epistemology of practice, *The American Review of Public Administration* **42**(1): 3-38.
- Council of Australian Governments (COAG) 2004. Intergovernmental Agreement on a National Water Initiative, Commonwealth of Australia and the Governments of New South Wales, Victoria, Queensland, South Australia, the Australian Capital Territory and the Northern Territory, signed 25 June 2004, Available at: http://www.coag.gov.au/coag_meeting_outcomes/2004-06-25/docs/iga_national_water_initiative.pdf. Accessed 3 September 2010.
- Cropley A. 2006. In praise of convergent thinking. *Creativity Research Journal* **18**(3): 391-404.
- Cuffari EC, Di Paolo E, De Jaegher A. 2014. From participatory sense making to language: there and back again. *Phenomenology and the Cognitive Sciences* DOI 10.1007/s11097-014-9404-9
- De Jaegher H, Di Paolo E. 2007. Participatory sense-making. An enactive approach to social cognition, *Phenomenology and the Cognitive Sciences*, **6**: 485-507.

- Dewey J. 1933. *How We Think. A Restatement of the Relation of Reflective Thinking to the Educative Process* (revised edn), Boston, D.C. Heath.
- Ferguson BC, Frantzeskaki N, Brown RR. 2013b. A strategic program for transitioning to a Water Sensitive City, *Landscape and Urban Planning* **117**: 32-45.
- Floyd J, Iaquinto BL, Ison RL, Collins K. 2014. Managing complexity in Australian urban water governance: Transitioning Sydney to a water sensitive city. *Futures* **61**: 1-12.
- Foster N, Ison RL, Blackmore CP, Collins KB. 2019. Revisiting deliberative policy analysis through systemic co-inquiry: some experiences from the implementation of the Water Framework Directive in England, *Policy Studies* **40**, 510-533.
- Frame B. 2008. 'Wicked', 'messy', and 'clumsy': long-term frameworks for sustainability. *Environment and Planning C* **26**: 1113-1128.
- Frame B, Brown J. 2008. Developing post normal technologies for sustainability. *Ecological Economics* **65**(2): 225-241.
- Godin B. 2006. The linear model of innovation: The historical construction of an analytical framework. *Science, Technology and Human Values* **31**(6): 639-667.
- Head B. 2008. Wicked problems in public policy. *Public Policy* **3**(2): 101-118.
- Hessels L, van Lente H. 2008. Re-thinking new knowledge production: a literature review and a research agenda, *Research Policy* **37**: 740-760.
- Ison RL. 1994. Designing learning systems: How can systems approaches be applied in the training of research workers and development actors? Proceedings International Symposium on Systems-oriented Research in Agriculture and Rural Development Vol. 2. Lectures and Debates. pp. 369-394. CIRAD-SAR, Montpellier.
- Ison R. 2002. Some reflections on a knowledge transfer strategy: A systemic inquiry, In: Farming and Rural Systems Research and Extension, Proceedings of the Fifth IFSA European Symposium, pp. 647-656.
- Ison RL. 2017. *Systems Practice: How to Act. In situations of uncertainty and complexity in a climate-change world.* 2nd Edition Springer, London and The Open University
- Ison RL, Russell DB. 2000. Exploring some distinctions for the design of learning systems. *Cybernetics and Human Knowing* **7**(4): 43-56.
- Ison RL, Straw, E. 2020. *The Hidden Power of Systems Thinking – Governance in a Climate Emergency.* Routledge, Abingdon.
- Ison RL, Röling N, Watson D. 2007. Challenges to science and society in the sustainable management and use of water: investigating the role of social learning. *Environmental Science and Policy* **10**, 499-511.
- Ison RL, Collins KB, Bos JJ, Iaquinto B. 2009. Transitioning to Water Sensitive Cities in Australia: A summary of the key findings, issues and actions arising from five national capacity building and leadership workshops. NUWGP/IWC, Monash University, Clayton (see <http://oro.open.ac.uk/75895>)
- Ison RL, Russell DB. 2011. The worlds we create: designing learning systems for the underworld of extension practice. In: Jennings, J., Packham, R.P., Woodside, D.

- (Eds.), *Shaping Change: Natural Resource Management, Agriculture and the Role of Extension*, Australasia-Pacific Extension Network (APEN), Australia, pp. 66-76.
- Ison RL, Collins KB, Colvin JC, Jiggins J, Roggero PP, Seddaiu G, Steyaert P, Toderi M, Zanolla C. 2011. Sustainable catchment managing in a climate changing world: new integrative modalities for connecting policy makers, scientists and other stakeholders, *Water Resources Management* 25 (15), 3977-3992.
- Ison RL, Blackmore CP, Iaquinto B. 2013. Towards systemic and adaptive governance: exploring the revealing and concealing aspects of contemporary social-learning metaphors, *Ecological Economics* 87, 34-42
- Ison RL, Collins KB, Wallis P. 2014. Institutionalising social learning: Towards systemic and adaptive governance, *Environmental Science & Policy* 53 (B), 105-117.
- Johannessen Å, 2017. Bridging the floods. The role of social learning for resilience building in urban water services, Doctoral Dissertation, Lund University, Sweden.
- Klein L. 2005. Systemic inquiry – exploring organisations. *Kybernetes* 34(3/4), 439-447.
- Kline SJ. 1985. Innovation is not a linear process, *Research Management*, 28, 36-45.
- Krippendorff K. 2009. Conversation. Possibilities for its repair and descent into dis-course and computation, *Constructivist Foundations*, 4(3), 138-150.
- Liu J, Hull V, Godfray HCJ, Tilman D, Gleick P, et al 2018. Nexus approaches to global sustainable development, *Nature Sustainability* 1, 466-476.
- Loorbach D, Rotman, J. 2010. The practice of transition management: examples and lessons from four distinct cases. *Futures* 42(3), 237-246.
- Maturana H, Varela, FJ. 1987. *The Tree of Knowledge* (Shambala, London).
- Maturana H, Poerksen B. 2004. *From Being to Doing: The Origins of the Biology of Cognition* (Carl-Auer, Heidelberg)
- Mitchell AS. 2020. Rethinking theories of change in the light of enactive cognitive science: Contributions to community-scale local sustainability initiatives, *Systems Research & Behavioral Science* 1-11.
- Munöz-Erickson TA. 2014. Co-production of knowledge-action systems in urban sustainable governance: The KASA approach, *Environmental Science & Policy* 37, 182-191.
- O'Brien K. 2012. Global environmental change II: from adaptation to deliberate transformation, *Progress in Human Geography* 36 (5), 667-676.
- Price WJ, Bass LW. 1969. Scientific research and the innovative process: the dialogue between science and technology plays an important but usually non-linear role in innovation, *Science*, 164, 802-806.
- Proulx J. 2006. Constructivism: A re-equilibration and clarification of the concepts, and some potential implications for teaching and pedagogy. *Radical Pedagogy*, 8(1).
<http://radicalpedagogy.icaap.org>
- Proulx J. 2008. Some differences between Maturana and Varela's theory of cognition and constructivism, *Complicity. An International Journal of Complexity & Education* 5, 11-26.

- Reed MS, Evely AC, Cundill G, Fazey I, Glass J, Laing A, Newig J, Parrish B, Prell C, Raymond C, Stringer LC. 2010. What is Social Learning? *Ecology and Society* <http://www.ecologyandsociety.org/volXX/issYY/artZZ/>
- Reynolds M, Blackmore C, Ison R, Shah R, Wedlock E. 2017. The role of systems thinking in the practice of implementing sustainable development goals, In: W. Leal Filho (ed.), *Handbook of Sustainability Science and Research*, World Sustainability Series, https://doi.org/10.1007/978-3-319-63007-6_42 pp. 677-698. Springer, London.
- Roux DJ, Rogers KH, Biggs HC, Ashton PJ, Sergeant A. 2006. Bridging the science management divide: Moving from unidirectional knowledge transfer to knowledge interfacing and sharing. *Ecology and Society*, 11, 4.
- Runco MA. 1991. *Divergent Thinking*. Ablex, Norwood.
- Russell DB, Ison RL. 2000a. The research-development relationship in rural communities: an opportunity for contextual science. In: Ison, R.L., Russell, D.B. (Eds.), *Agricultural Extension and Rural Development: Breaking out of Traditions*. Cambridge University Press, Cambridge, pp. 10-31.
- Russell DB, Ison RL. 2000b. Enthusiasm: developing critical action for second-order R&D. In: Ison, R.L., Russell, D.B. (Eds.), *Agricultural Extension and Rural Development: Breaking out of Traditions*. Cambridge University Press, Cambridge, pp. 136-160.
- Schön DA. 1973. *Beyond the Stable State. Public and Private Learning in a Changing Society*. The Norton Library, New York.
- Schön D. 1983. *The Reflective Practitioner: How Professionals Think in Action*. Basic Books, New York
- Schön DA. 1987. *Educating the Reflective Practitioner. Toward a New Design for Learning and Teaching in the Professions*, Jossey-Bass Publishers, San Francisco.
- SLIM. 2004a. Stakeholders and stakeholding in integrated Catchment Management and Sustainable use of water, SLIM Policy Brief No. 2, SLIM (available at <http://slim.open.ac.uk>) 4p.
- SLIM. 2004b. SLIM Framework: Social Learning as a Policy Approach for Sustainable Use of Water, (available at <http://slim.open.ac.uk>). p 41.
- SLIM. 2004c. Facilitation in policy processes: Developing new professional skills, SLIM Policy Brief No. 4, SLIM (available at <http://slim.open.ac.uk>) 4p.
- Stafford-Smith M, Griggs D, Gaffney O, Ullah F, Reyers B, Kanie N, et al. 2016. Integration: The key to implementing the sustainable development goals. *Sustainability Science*. doi:10.1007/s11625-016-0383-3
- Sterling S. 2011. Transformative learning and sustainability: sketching the conceptual ground. *Learning and Teaching in Higher Education* 5: 17-33.
- Steyaert P, Jiggins J. 2007. Governance of complex environmental situations through social learning: a synthesis of SLIM's lessons for research, policy and practice, *Environmental Science & Policy*, 10 (6): 575-586.

- Tábara JD, Chabay I. 2013. Coupling Human Information and Knowledge Systems with social–ecological systems change: Reframing research, education, and policy for sustainability, *Environmental Science & Policy* 28, 71-81.
- Tomm K. 1989. The view of cognition of H. Maturana. An occasional paper and communication given at the University of Alberta (Edmonton, Canada). January 20th, 1989 (Cited in Proulx 2008).
- Verweij M, Douglas M, Ellis R, Engel C, Hendriks F, Lohmann S, Ney S, Rayner S, Thompson M. 2006. Clumsy solutions for a complex world: The case of climate change. *Public Administration* 84(4): 817-843.
- Visser W, 2010. Schön: Design as a reflective practice. Collection, Parsons Paris School of art and design, *Art + Design & Psychology*, pp.21-25.
- Wagenaar H. 2011. *Meaning in Action: Interpretation and Dialogue in Policy Analysis*, Routledge, London.
- Wenger E. 1998. *Communities of Practice: learning, meaning and identity*. Cambridge University Press: Cambridge.