CHAPTER 10

Working Interactively with Causal Loop Diagrams: Intervention Choices and Paradoxes in Practical Applications

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INTRODUCTION

Causal loop diagrams are the most striking exponents of systems thinking (see box 1) and have been made popular by Senge and colleagues about learning organisations (Senge, 1990; Senge *et al*., 1994, 1999). The systems dynamics community has emphasised the advantages of systems thinking, especially its usefulness in coping with complex issues. Complex issues have 'objectionable' characteristics such as multidimensionality, feedback loops and delay effects. As a consequence people come up against cognitive limitations when they try to get a grip on these problems. They are often taken by surprise by typical systemic phenomena. For example, the most obvious solutions often aggravate the issue, or the organisation 'pushes back' when you come up with feasible solutions. This is confounded by the fact that more feasible solutions are often counter-intuitive because they are located in unexpected places (removed in time and space), which stands to reason, because if it were not so, it would not have been a complex issue to begin with. Causal loop diagrams are an effective instrument for identifying feedback mechanisms, examining them critically and arriving at feasible interventions. In short: an instrument well worth using for complex issues. It is not one that is really necessary for simple problems.

Causal loop diagrams can help in tackling complex issues effectively. Until the 1970s this type of diagram was the main technique to be described. It has since become clear that for the diagrams to be effective, it is better for people to participate in creating and applying them. Working interactively with causal loop diagrams has increasingly gained attention. You don't learn as much from reading a causal loop diagram as you do from making one. Applying acquired insights or accelerating decision-making also requires

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working interactively with diagrams. This means that change agents should not only be able to make diagrams, they should also be able to design and facilitate the participation of the parties concerned. There are various ways of doing this and this chapter introduces some frameworks, illustrated with case histories, to assist change agents in shaping the intervention process. The aim is to further the practical use of causal loop diagrams so that this becomes a craft in organizations rather than just a popular idea.

Box 1. Characteristics of systems thinking and causal loop diagrams

Systems thinking is a container concept for a broad spectrum of concepts and instruments that have grown since the 1940s into differentiated schools of thought. What they have in common is that they examine the whole to understand systems, not just the parts, and especially they examine interdependencies between the parts (factors, forces and suchlike). To that end systems thinkers tend to look at reality from a helicopter view. There are, however, many differences as well. Early schools of thought are cybernetics (e.g. Beer, 1985), system dynamics (e.g. Forrester, 1961) and open systems theory (e.g. Von Bertalanffy, 1968). More recent additions include Soft Systems Methodology (Checkland & Scholes, 1990) and chaos theory (e.g. Prigogine, 1985).

Causal loop diagrams came out of the system dynamics school. Hardcore system dynamicists often use them in combination with stock-and-flow diagrams and behaviour-over-time graphs. However, I will leave these aside here: causal loop diagrams on their own are already quite useful. Thinking in feedback mechanisms (both positive and negative) is a typical characteristic: it helps explain why some complex problems persist while others are unstable. These mechanisms can be invisible at first glance, because causes may be far removed from the consequences and because causes can be subtle or have delayed effects. Causal loop diagrams bring such mechanisms to light. Existing diagrams are frequently used for training (‘flight simulators’) or for reflection (system archetypes). But the most powerful application seems to be the (interactive) crafting and use of such diagrams customised to a specific situation. Moreover, customised work rightly emphasises that causal loop diagrams are never true in general, but correspond to specific situations and that the diagrams are not predeterministic: they can change over time and between contexts.

Causal loop diagrams can be recognised by:

- *Lots of arrows between factors* These arrows do not stand for ‘first this, then that’, but for causal relationships. They illustrate the emphasis on interdependencies: seeing connections in a web of cause and effect.
- *Occurrence of circles* These are the feedback mechanisms that best explain the dynamics in the system. Circles become possible because causes can also be effects, and vice versa. Because there is more than one cause and one effect, it is easy for intermeshing circles to emerge to help explain complex patterns.
- *Elegance in visualisation* Usually, intelligent simplification is pursued in order to identify the most important dynamics amidst the multitude of information and relationships. The aim is to sketch just that and no more. Where language is always linear, the sketch can display non-linearity succinctly. As a cognitive map it facilitates group discussions and reflections of dynamics that constrain them.

Curiously enough, the popularity of publications about systems thinking and learning organisations has not resulted in a broad application of causal loop diagrams in practice among students, managers and consultants. Investigations into instruments used for strategy formation by management, for example, show they hardly appear (Rigby, 2002; Warren, 2004; Zock & Rautenberg, 2004). This is in sharp contrast with instruments such as the business balanced scorecard, value chains or strategic analysis.

One explanation could be that until the 1970s, diagrams were made by experts only: other parties/clients were scarcely involved (Rouwette & Vennix, 2006). There are many reasons why this is undesirable. Different actors may have information and perspectives that make up part of the puzzle. Ideally, all these pieces should be lying on the table, to allow the diagram (and thus understanding) to be made more complete and robust. Additionally, even (or especially) a perfect diagram does not suffice to bring about change. It can easily disappear in a drawer, because of, for instance, political or cognitive defence mechanisms (Argyris, 1990). For such diagrams to have any real impact on how an organisation functions it is often instrumental for people to learn from them. At other times it is instrumental for people to buy into the change, that people's ideas grow closer, or that those involved are willing to accept greater complexity. Not all of these conditions need to be met, at least not in most cases or at the same time. However, participation is required to allow for any of these conditions, albeit in different ways. This requirement is amplified when issues are not only complex as regards content, but are also socially complex. For example, many people in different roles contribute to an issue's persistence and those people have diverse opinions about what the issue really is and also have different ideas about whether solutions are necessary, what they might be, who should be involved and who is in charge. Issues with these characteristics have been described as 'wicked' (Rittel & Webber, 1973; Bella, King & Kailin, 2003). Basically, one does not make causal loop diagrams only about social systems, but also *within* social systems and *for* social systems (Vriens & Achterbergh, 2005). Since the 1970s systems dynamicists have been arguing for the need to work more interactively with causal loop diagrams in order to reap greater benefits from them and all kinds of approaches have been suggested (e.g. Lane, 1992; Andersen & Richardson, 1997; Vennix, 1999).

A second explanation for the frugal practical application of causal loop diagrams is that the community of systems dynamicists does not commonly overlap with the communities of organisational developers, strategic analysts or policy scientists in whose work domains causal loop diagrams could prove an added value. For convenience sake, I give all those other professionals the overarching label 'change agents', as they occupy themselves explicitly with influencing social systems. There seems to be a case of cold feet among these change agents when it comes to causal loop diagrams. Change agents with a 'humanities view' associate the jargon of system dynamics with an engineering approach: a rational empirical approach to organisational change in which you quickly end up in the role of expert (Zock & Rautenberg, 2004). This means they rightly acknowledge that making diagrams is a craft in its own right, but they mistakenly conclude that they either have to leave it to the boffins, or at least should forgo participative construction of causal loop diagrams. Change agents with a 'science view' have other pitfalls: their analytical familiarity with linear sequential models (as in ICT, logistics or project management) means they often find it difficult to think in causalities (instead of sequences) and circles (instead of phases or steps). They feel that clarity about uni-linear causes and effects escapes them in these web-like diagrams. That is understandable, for in feedback mechanisms effects also become causes, and vice versa. That makes it less straightforward what action

perspectives should be deduced from such a causal web. The ensuing uncertainty makes them even less inclined to work interactively with these diagrams, not wanting to sacrifice precision and control even more. In short: whereas the humanities-inclined have less trouble with the principles of systems thinking, but are wary because of its technical aura, the science-minded are wary for exactly the opposite reasons.

The aim of this chapter is to describe how interested change agents can work *interactively* with causal loop diagrams. How does one use such a powerful analytical instrument without the 'nuts and bolts' taking over? What kinds of change objectives are best addressed with causal loop diagrams? What are the consequences of that choice of objective for the design of participation and interactions? Does an interactive process fit the specific situation and issue? How does one set up the process during different phases of diagram construction and application? What has to be taken into account in doing that?

I draw on literature from both systems dynamics and change management, because working interactively with causal loop diagrams relies on both domains. I will illustrate three frameworks with my own case histories (made anonymous) as an illustration of the diverse ways in which one can work interactively with them. I have deliberately excluded the actual diagrams in the case descriptions. That is because in this chapter I am *not* examining the technique or look of causal loop diagrams. I don't want to imply that this is not necessary. Just as you will achieve little change impact in organisations with a purely technical approach, so a pure process approach will come up short if you work with muddled diagrams (Warren, 2004). Working interactively with causal loop diagrams requires that the facilitator is willing to read up on how you make and apply robust diagrams. Fortunately, there are many publications available for this (e.g. Vennix, 1996; O'Connor & McDermott, 1997; Shibley, 2001; Vermaak, 2003). To help form an image, some characteristics of causal loop diagrams have been typified in Box 1.

CONTRASTING CHANGE STRATEGIES AND UNDERLYING MECHANISMS

Actually, 'working with causal loop diagrams' is not *one* intervention. It is more like an umbrella term covering widely contrasting processes: sometimes it corresponds to a learning environment, sometimes to political negotiations, sometimes to expert consultancy. The toolkit (the diagrams) might be the same, but the goals for which they are put to use, the way the processes are shaped and the underlying mechanisms that make them work differ widely. In these respects, using causal loop diagrams for team learning generally shows a greater similarity with the use of inter-vision or dialogue in teams (where no diagrams are produced) than with other projects that do utilise diagrams. Similarly, in political decision-making you can replace the instrument of causal loop diagrams more easily with that of mediation than you can switch to a totally different style of facilitation (e.g. teaching or provoking). Why is this?

As soon as we do not focus exclusively on the technique of causal loop diagrams, but pay attention to the effectiveness of the change processes, we have to look more deeply: on the level of underlying mechanisms instead of on the level of instruments (see e.g. Argyris & Schön, 1978). On that level, there is a variety of contrasting explanations and strategies for change, each based on *different assumptions*. In the change management literature this variety is represented in several ways (e.g. Van der Zee, 1995; Huy, 2001;

Caldwell, 2005). In my own work I often use a distinction in five contrasting paradigms, each distinguished by a different colour (De Caluwé & Vermaak, 2003, 2004). The systems dynamics literature too increasingly distinguishes between the types of goals and strategies for which causal loop diagrams can be used (e.g. Morecroft, 1992; Vennix, 1999; Vriens & Achterberg, 2005). For convenience sake I will cluster these strategies into three main approaches that can be recognised in both areas of literature:

1. *The rationality-oriented approach* The emphasis here is on making a solid causal loop diagram in terms of its content. The purpose is to gather and make available all required knowledge, but especially that of experts inside and outside the system, to ensure that 'the reality' will be represented as accurately as possible in the diagram. One tries to alleviate worries about the incompleteness of diagnostic information. The main objective is to decipher how the problem fits together and is sustained. The diagram needs to be as precise, objective and valid as possible. This is a rational-empirical approach. It focuses on the contents of the analysis. Experienced model-builders are the ones constructing the diagram: only then can one be assured that the most important feedback mechanisms are uncovered and represented in the diagram. The result is made available to the parties concerned only once the analysis is ready. Diagram construction can be followed by tests and analyses to further check and enhance its validity. Any action planning preferably takes the form of research as well, for instance by making and testing scenarios. Systems dynamics publications on methods and techniques are in keeping with this approach (e.g. Forrester, 1961; Wolstenholme, 1992; Burns & Musa, 2001).
2. *The commitment-oriented approach* The emphasis lies in getting people on board to make a change happen. Causal loop diagrams are used to pull diverging opinions closer together. The main thing is not that the analysis is correct, but that it is recognised and supported. Only when it resonates can it form an effective basis for decision-making about what needs to happen next. What is considered valuable in this approach is orchestrated action; power factions, resistances, contrasting motivations and suchlike are deemed worrisome. It is assumed that the parties concerned can only accept the views of others if their own views are taken into account: they should be recognisable in the diagram. This applies especially to people who are firmly established within the organisation. Forming diagrams is a process of negotiation about meanings aimed at commonality. Without that commonality, one does not trust that any implementation will actually take place. This process of negotiation can sometimes have a political character and target key figures, but often it will also broaden and attempt to realise a support base through the whole organisation. The double meaning of the concept of 'support' (leaders or shop floor) is illustrative as far as that goes. In the systems dynamics literature this is represented by the strategic forum (Richmond, 1997), models in the policy process (Greenberger, Crenson & Crissey, 1976) and system dynamics for business strategy (Lyneis, 1999).
3. *The development-oriented approach* The emphasis here is on learning and exploring. Making causal loop diagrams is a means to exchange observations, points of view and mental models. Here one strives to makes these explicit and discussable. Change agents pay attention to the quality of listening and reflecting, and aim to unblock any learning obstacles such as groupthink or cognitive dissonance. The main thing is neither that the analysis is correct, nor that people reach a consensus. Diversity is usually not seen as problematic. Rather, it is seen as food for dialogue and consciousness-raising. The

idea is that this provides support for learning in and between groups, which should translate continuously and incrementally into exploration and experimentation. New insights lead to new behaviour, and vice versa. Thinking and doing are separated as little as possible. Causal loop diagrams support the renewal on both fronts: you make diagrams to increase insight and to direct further actions. New insights and new behaviour both inevitably influence the dynamics in the organisation. This makes causal loop diagrams feasible representations for a limited time only: the dynamic that is studied develops along with the parties concerned. In the system dynamics literature it concerns modelling as learning (Lane, 1992), the 'fifth discipline' of the learning organisation (Senge, 1990) and group model-building (Vennix, 1996).

It can be confusing that words are sometimes borrowed from one approach for use in another: thus Senge talks about striving towards 'consensus' in team learning, a term that belongs more to a political arena than to a reflective environment. He does distinguish two types: a focusing-down version that strives towards commonality (comparable with a commitment orientation) and an opening-up version that embraces multiple viewpoints (comparable with a development orientation), but this second one is quite an unusual interpretation of the notion of consensus.

It is important to be clear about the type of change strategy to be employed so as to better guide the design of how to work interactively with causal loop diagrams. It is easy enough to cause effects opposite to the intended ones if one uses the diagrams without understanding the underlying mechanisms it should support. This makes it relevant to ask which strategy is viable given the circumstances. What criterion is most important given the specific situation: are you most attached to diagnostic precision, to enlisting support or to enhance learning? The answer implies which change strategy you put your faith in. Furthermore, it implies how best to shape the interaction process, including how to work interactively with the diagrams.

It is not possible to *mix* the three approaches at random: if, for example, you toss a political negotiation process through a learning process, not much learning will take place. It is appropriate in a learning process to present yourself as vulnerable, to share your own questions and doubts, to ask others for help. In contrast, in a political negotiation process people keep their cards close to their chest so they do not weaken their position. They do not pull their punches either as they don't mind undermining other people's position. These opposite reflexes do not go together well. This does not mean that, when a choice has been made for a leading strategy, other interventions cannot be *supportive*. The more complex a task, the more important it sometimes is to add contrasting interventions, but tactically and to a limited extent. For example, one could firmly anchor a development-oriented approach by making a political deal with the most important stakeholders. This kind of anchoring seeks to enhance commitment, purely as a supportive condition so that, above all, a lot of learning can take place later. Dealing productively with the tensions between contrasting change strategies is a complex topic that I will only touch on here and in the section on intervention paradoxes, without theorising too much about it (see Caluwé & Vermaak, 2006; Vermaak, 2006, 2008).

Case Study 1. Example of a rationality-oriented approach

I contracted a consultancy project with a university to map out in precise sequential steps how one of its colleges lost its market position despite a great many change

attempts and analyses. We sifted though piles of data and held many interviews both in and outside the college. It ultimately resulted in scenarios (based on a causal loop diagram) that were assessed on feasibility and were presented in a final report with recommendations. For a long time there had been internal disagreement about causes of and solutions to the loss of market position. The report was to serve as a 'judgement of Solomon'. To build confidence in that judgement among the various parties, people had agreed that it should be based on know-how and expert analysis. This was reinforced by the fact that it was a college in the field of the sciences where such an empirical approach was part-and-parcel of everyday work. There was little interest in a participatory approach: it was felt that time was running out for the college. It now seemed more important for a reasoned decision to be made soon about its future than for its employees to learn how they could accept or integrate each other's perspectives. They would always be able to do that later. The most important supporting interventions were probably interventions to ensure commitment between each phase, which helped ensure that all the parties involved backed up the intermediate results before we proceeded further: a kind of 'decision funnel' where all are manoeuvred step by step into a consensus. These phase transitions were also the tensest moments, because critics would start searching for errors in the analysis with which they might undermine any conclusions counter to their own standpoints. In the end the report laid the basis for collective decisions and actions.

Case Study 2. Example of a commitment-oriented approach

A consultancy team provided support to the top 75 of a large service provider to analyse *and* decide where service quality could take a leap forward. This was done separately in four groups (three service divisions + the support division), each in two two-day sessions. In the sessions first collective ambition images were created for each of the eleven types of service that the company provided. Then groupware was used to map out what enhanced or undermined service quality in the eyes of the people involved. Their statements and ideas were structured with the software, displayed on a big screen, discussed and, where applicable, adjusted. It became a kind of pressure cooker to come to agreement in two sessions on what drives quality. It was not the judgement of an expert that counted here, but rather a consensus among the top 75. The assumption was that these parties would have the most important facts and viewpoints to figure it out. To that end the group's composition was adjusted to enhance diversity (opinion leaders participated alongside management). This clearly was not a rationality-oriented approach. The 'pressure cooker' prevented extensive questioning of assumptions, exploring each other's viewpoints, etc. Thus it was not a real learning approach, although inviting different ideas and looking for connections between them did mean that the major supporting interventions were development-oriented. The findings from all the sessions were bundled together and discussed thoroughly with the top 15 people in the entire organisation. The aim was to come to final decisions about a resulting plan of approach for the whole business. This sounds more like a blueprint than it really was, because all the comprising parts of this plan were basically thought up by the parties in the previous (parallel) sessions, and the implementation would also be done by the same group of people as well.

Case Study 3. Example of a development-oriented approach

'Windows and mirrors' are classic interventions in a development-oriented approach. By opening new windows people become aware of new perspectives; by looking in the mirror they become conscious of the impact their actions have on others. Both are instrumental for learning. In training sessions or work conferences I regularly use small causal loop diagrams to this end and encourage others to do so as well. The diagrams help to capture visually patterns of interaction in a group, to explain the underlying (and sometimes compelling) dynamic and reflect on them with the parties present. This makes those involved more conscious of enabling or constricting group dynamic processes. See it as a necessary step to steer those processes in a constructive direction. At a conference with representatives from an industry with a dismal environmental track record, the diagram that emerged was similar to that of the 'tragedy of the commons', a classic system archetype (Hardin, 1968; Senge, 1994). Discussions showed that a quarter of the group was against environmental measures, while the rest found it difficult to make their products 'cleaner' because they feared they would not be able to recover the extra costs if the biggest polluters (the quarter) continued business as usual. Continuing this collective dynamic would predictably result in displacement either as a result of government legislation or as a result of other types of industries coming up with alternative, eco-friendly, products. Somehow, however, that penny did not seem to drop. During a conference morning I sketched the dysfunctional interaction pattern, checked it with a colleague and reflected it back at the group. Reactions varied from shock, laughter, to denial (the latter mostly among the 'polluters'), but the vicious cycle at least and at last became part of the discussion. We proposed to do a simulation that same day, based on the tragedy of the commons. The typical dynamics emerged again, life-size, despite everyone's intentions not to do so. At the end of the day this contributed to a willingness to explore other avenues that might break the destructive pattern. The next day an alternative and collective approach was set up that would be followed, with trial and error, by a conference six months later: then a final decision would be taken to stick to that new route or not.

In cases where you encourage others to learn how to give this kind of diagram feedback, the learning effect is more substantial: in addition to providing more insight into patterns, you are also spreading the skill to reflect with diagrams. Whether you do it yourself or have others do it, the completeness, proof or precision of the diagrams plays a subordinate role: it is *not* a rationality-oriented approach. In the case of the polluting industry, the most important supporting intervention that followed the learning interventions were commitment oriented: to pull together as an industry sector behind an environmental programme. The examples above are about 'small' learning interventions, in duration and size. In such cases the diagrams themselves are also small and concise. But this need not be so (see the last case study in this chapter).

RECURRING PHASES IN MODEL FORMATION AND APPLICATION

Even though you can use diagrams within contrasting change strategies, the content-related activities that you go through are similar in model formation and application. Their

characterisation in a number of phases is not disputed, though their segmentation and labels may differ somewhat (Luna-Reyes & Andersen, 2003; Rouwette & Vennix, 2006).

The *conceptualisation* of a diagram generally starts with three phases. A diagram cannot be better than the information on which it is based. That means that a diagnosis process must precede modelling, regardless of how large or small you make it. The information becomes more meaningful the more keenly you search and inquire. Formulating purpose statements of research questions can help to this end, as can any other useful delineations. This helps avoid getting lost in an endless diagnosis that is doomed to superficiality due to a lack of focus. Three phases help ensure good conceptualisation:

1a. *Delineation and pre-diagnosis* Define the issue or problem that has to be mapped out. What is the system boundary within which this occurs and is being investigated? It has to be large enough to contain the dynamics of the issue. Organisational culture, for example, is difficult to diagnose within strict departmental boundaries, because departments rarely function culturally as an island within the rest of the organisation. On the other hand, a system boundary that is too wide stimulates the collection of an abundance of information without this adding to more insight. Also, define who and how this diagram is supposed to help. There are no real problems without problem-owners. And if they are to benefit from the diagram it had better also take their role in the dynamic into account (e.g. their actions, credibility, ambition or ability) as an important factor for success or failure. It also helps identify who one could involve in understanding or fixing the problem. Delineating the problem you are investigating and who the problem-owners are can sometimes be a change project in itself.

1b. *Diagnosing* This is all about looking at the issue from multiple perspectives. This principle helps ensure that no important contributing factors or actors are overlooked, especially when some fall outside the prevailing fields of vision of those involved, including any change agents. Without attention to those factors, relevant feedback mechanisms remain hidden and are excluded from the diagram. The question is also how to challenge one-sidedness consistently as a change agent. Do you do the diagnosing together instead of on your own? Do you use a conceptual map with contrasting models/viewpoints? What kind of diversity of sources is desirable? But there is also the question of saturation: when do you have enough information and when do you stop digging? And how do you analyse and contrast information? And who collects and analyses it all and feeds the findings back to those involved? Diagnosis requires openness to the multiple faces and layers of complex issues, and a deferment of judgement.

1c. *Modelling* This is about making the causal loop diagram itself. Which factors do you select from the abundance of information that the diagnosis provided? Which steps do you take (e.g. using narratives or behaviour-over-time graphs) to put together hypotheses about feedback mechanisms? It is essential to weigh up these hypotheses, sensing how convincingly they explain the issues, testing them against data and intuition, building on them with causal consequences. Thus a diagram grows through reasoning, and along the way all kinds of assumptions and mini-theories must perish on closer scrutiny, including those to which people had grown attached. Interactive questions are also involved: who sketches the diagrams, how do they go about it, how often and how much are they modified, and when and how do you decide that the result resonates and that the diagram is good enough?

These three phases are sufficient for model-building, but working with causal loop diagrams often does not stop there:

2. Model formation can result in *testing and experiencing*. The aim can be to make the model even more solid with the help of computer simulation or evaluations. The idea is to acquire more analytical sharpness and certainty. Another approach is *gaming*: those involved experience in a 'microcosm' (in a simulation) what the dynamics of the problems are 'on the large scale' (e.g. Engeström, 2004). The advantage of *gaming* is that the described dynamics are not so much analysed as *experienced*, and that this is achieved with a fraction of the time and risks (e.g. negative impacts) of real-life situations. This makes it a safe way to broaden and deepen insights in wicked issues where real life experimentation is often messy (Duke & Geurts, 2004).
3. On the basis of these insights you can come to *action planning*, preferably aimed at using leverage effects. This relies on the use of a charming and deep-seated notion in systems thinking: the ability to achieve as much impact as possible with as little effort as possible by focusing on the right factors. During planning you look for those factors in the causal loop diagram. You then gauge which change strategy (see previous section) would be most effective in impacting these factors. Next, you detail the change strategy into an intervention plan. Action planning can be small-scale – for example, one individual who takes charge of his own work environment – and it can look organic: reasoned intentions, for instance. But it can also be about large collective strategies based on tested alternatives: for example, working with scenarios or analysing policy alternatives (De Geus, 1988; Von Reibnitz, 1988).
4. On the basis of action plans, you can also *intervene*. This can vary from experimenting in and during one's own work, to collective plan-based implementation of change.

Thinking in aligned and mutually reinforcing activities in which you make and apply causal loop diagrams is what turns working with causal loop diagrams into deliberate organisational change. This contrasts with a focus on the diagram as a 'thing' that everything revolves around: a useful trick or ultimate product. Moreover, it helps prevent those involved from becoming disappointed in this set of instruments. But there is another reason: the underlying mechanisms of change that I talked about in the previous section are easier to translate into an intervention process when you have phase distinction in mind, for not only the model formation (1c) but also the preceding and following phases can be shaped very differently, depending on the orientation of the chosen change strategy. However, there are two things I would like to put into perspective:

- A predominantly development-oriented approach does not mean that *all phases* need to be shaped in *one specific way* even with the *same orientation*. The same applies to the other two approaches. This fits with the acknowledgement in the previous section that support is sometimes needed from contrasting interventions, particularly when addressing more complex issues. For instance, it can sometimes help to stretch mindsets (development orientation) before you facilitate those involved to come to a consensus (commitment orientation). Being able to play with (small) intervention differences between phases makes it possible to fine-tune your approach to the demands of a given situation.

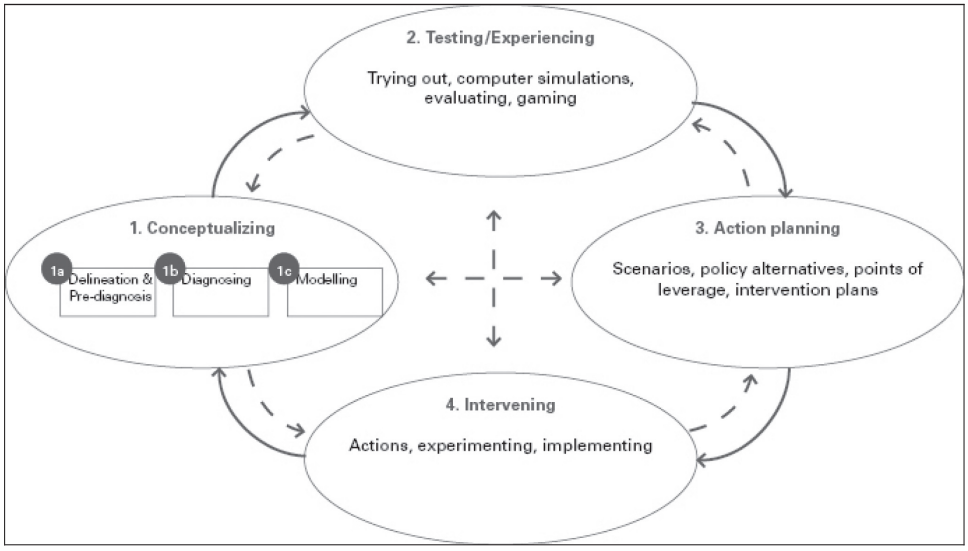

Figure 10.1 Phases in model formation and application

- The connection between conceptualising, testing, action planning and intervening (see Figure 10.1) may look familiar to the well-read. It can be seen as a variation on cycles that occur, for example, in learning processes (Kolb & Kolb, 2005) or quality control (Deming, 1986). Those cycles are about the oscillation between thinking and acting, planning and reflecting, constructing and deconstructing, even though every type of cycle gives this its own twist. The cycles imply that *breaking up* the four main activities into (major) sequential steps is often too simplistic. It may just as well (or better) be processes in which doing, testing, planning and learning are intertwined and follow each other in quick successions (Maani & Maharaj, 2004). You can even go back through the phases: testing can result in a review of diagrams, and through experimentation a desire can arise for model formation or modification. Not all the phases always have to take place either. Sometimes half of the phases can be enough. All this opens the possibility and even desirability of *incremental and iterative (sub-) processes*.

Case Study 4. Example of an iterative sub-process

After a few stormy years one of the main divisions of a telecommunication company had put their house in order again. To this end they had paid more attention to cost-cutting than to innovation and had relied more on top-down management than on internal entrepreneurship. There was a desire to rectify this imbalance, starting with a work conference with the top 60 managers and 'rainmakers'. The intention was to revitalise the division, starting with exploring dormant ambitions and hidden potentials. The internal change agents were convinced that more would be gained by the whole group coming out of the conference with new insights and abilities than by division

management leaving the conference with a polished business plan. That is why the approach was mainly development-oriented. For 1½ days, conceptualisation (1) of the dynamics of the business took centre stage. The other phases received only limited attention later. The delineation (1a) was defined in a plenary discussion. In the diagnosis (1b) we sought out multiple viewpoints by continually looking for and inquiring into deviating and contrasting information, and by giving a voice to people who generally were not heard, but also by examining, as an external party, what the dominant diagnostic models were (predominantly business models, often at the organisational level) and redressing that one-sidedness by introducing contrasting models. All the diagnostic information was put on the wall until the wall was covered and little new information was added. After introducing the technique of causal loop diagrams, ten groups each made their own diagram; some diagrams differed substantially from others. Every diagram showed the implicit theory of those involved about why things were going the way they were in their division, and where the potential for development could be found. Every diagram was discussed, with people commenting on what was convincing about them, but also what would improve the diagram or where there seemed to be gaps. Both the contents and technical sides of the diagrams were part of this collective review. No attempt was made to combine the diagrams together into one mega-diagram. For the time being it seemed more important and more novel for people to be learning how to view things from multiple perspectives, how to think systemically *and* how to apply this to their own working environment and exchange this with colleagues. Pressure to come to collective decisions (commitment orientation) would only hinder this, just like emphasising the analytical accuracy of diagrams (rationality orientation). The intervention process paused for a while: no immediate follow-up or 'implementation' was required. Small iterations did follow to build on the insights gathered. Those involved were encouraged to try out the 'hypotheses' in their diagrams in practice (2) by checking their implications in real-life settings and performing mini-interventions based on them. And they were encouraged to refine their diagrams on that basis with their colleagues (first iteration). Later, a smaller work group collected new insights and diagrams as ammunition for making a new discussion diagram in which the most valued insights and causal loops were kept intact (second iteration). At a later stage this would result in collective action (switchover to a different change strategy).

Case Study 5. An example of a complete, but shifting, project

A museum undergoing a two-year change process went though most of the phases identified here. The museum was alive and well. It seemed that with a lovely collection, highly esteemed exhibitions, a good location and well-motivated people there was little to complain about. But there was a flipside to all this, which revealed itself in exhausting improvisation, neglected internal organisation and internal communication shaped and restricted by status differences. You could characterise the internal coordination by internal lobbying interspersed by autocratic leadership. This created a host of interpersonal tensions. In the change effort we wanted to take a collective step back from this dynamic, take a good look at it and make it explicit. All would have the opportunity

to speak out. The emerging picture would be the basis for a supported plan to break with bad habits and retain what made the place work. Whatever the resulting plan, it should not exacerbate the present overburdening: there had to be leverage effects. The case study demonstrates how change strategies can shift between phases. The start of the project was commitment-oriented: the delineation (1a) was established with the most influential players, while the insights and opinions of all the staff members were gathered in the diagnosis. Even though staff members' insights did lead interviewers to ask further questions, in principle what interviewees contributed was not contested: that would be an expert-based interpretation. This rationality-oriented approach took over in the diagram formation (1c): the change team did not deem it important for everyone in the museum to learn systems thinking. Moreover, there was a risk that embedded interaction patterns would make that modelling process quite difficult. The assumption was that it would be more effective if the diagram were first to show the negative impact of present interaction patterns and to legitimise that something should be done about them, for quite a few people were not yet convinced. The advantage of switching to a more expert approach was that it was easier to have the diagram do justice to contrasting points of view (like pieces of a puzzle), to avoid questions of guilt (for in feedback circles there is never only *one* actor or factor to blame) and to be as accurate as possible in pinpointing where leverage effects could be found. This diagram was presented and discussed with all the employees present. This in turn produced many questions (new insights), 'a-ha' moments (recognition) and relief (no question of guilt). Some, especially the most powerful players, did have to pause for a moment, mainly because their view of the museum lost its prime position. Thinking in terms of leverage was leading in shaping the intervention plan (3). As leverage was deemed greatest for unfamiliar interventions that were not 'more of the same' for the museum, the plan had to be drafted and introduced by outsiders: the experts. But immediately after that it was deliberately made subject of negotiation with different platforms in which all those concerned were present or represented: a way to gain sufficient commitment. Next, there was a switch to development-oriented interventions (4) because the diagram suggested that such a change strategy would have the strongest leverage effect. Besides some organisational clarification, this revolved around learning to cooperate across compartments and disciplines, learning to work in structured projects, strengthening leadership independent of formal position or status, and broadening influencing styles. Here there were relatively few iterations (although some adjusting, trimming and adding did occur on the way) in comparison with case study 4.

INTERVENTION PARADOXES

This chapter deals with how to shape an intervention process when using causal loop diagrams. I started with a relatively simple distinction in three contrasting change strategies (section 1). This was made a bit more complex by suggesting that sometimes you should not refrain from using contrasting interventions to support a leading change strategy as long as you are conscious of how the tension between them can both help and hinder. Next I suggested that intervention phases can be distinguished both before and after the

actual modelling itself (section 2). This too was made more complex by pointing out the possibility of incremental, iterative and partial use of the phases in model formation and application, sometimes even with a shift in change strategy in between these phases. Increasing the complexity and variety in intervention processes is, of course, not an end in itself: if a change can be kept simple, then keep it simple. Unfortunately, when issues or context becomes more complex, a simple intervention process often does not suffice. With this in mind I introduce an additional way to fine-tune this process: working with intervention paradoxes.

The tougher the issues in organisations, the more context shapes behaviour rather than the intentions of individuals (Bella, King & Kailin, 2003). This is interesting, because it fits well with the recurring gut feeling of many involved that issues are too large for them to solve autonomously ('the system' is to blame) and it also fits in with the purport of systems thinking that persistent issues are sustained by vicious circles, not so much by any one guilty actor or factor. In any case, as soon as context becomes the subject of change, intervention paradoxes begin to flourish, because what helps deal with the context is often also deemed inappropriate by that same context. 'The paradox of feasibility may well be that researchers/consultants who are serious about the practical uses of their work, can succeed only if they not only understand but also utilize the dynamics of the existing dominant practice of their client's organisation' (Dutton & Ashford, 1993). Basically this requires *double plays*: sufficiently deviating from the dominant practice to break embedded routines while sufficiently using the dominant practice to be heard. 'More of the same' in viewpoints, participation, contracting, change strategies, etc. is always most easily accepted and understood. However, it also reconfirms the context: their acceptance arises by grace of the fact that they match rather than question dominant expectations and routines. Deviating (second- and third-order) approaches are more effective for transforming contexts, but trigger organisational defences, partly because they are lesser known and less understood (Argyris, 1990). If they do get implemented, it's often in diluted form. This quickly proves that 'those novelties do not work here' and strengthens the notion that there must be good reason for maintaining the status quo. Actually, there is some truth to that. A top-level manager in the public sector once asked me if I had a trick for turning his ministry into a learning organisation, something they had been grappling with for years. The answer, in line with the above, was that I could imagine little to add to the already overflowing change agenda that might compensate effectively what the ministry reconfirms every single day in its routines: namely that employees are not supposed to learn at and during work with their colleagues. (It is not that people do not learn, but they do so on an individual basis only and persistently off the job: by meeting in social settings away from work, by attending standard trainings offered by the personnel department, and by copying the skill from respected colleagues in change encounters.) In other words: if the context is learning-unfriendly, learning interventions are the interventions with the most added value as well as the ones that summon the most resistance. *Extremes do not work* with intervention paradoxes: more of the same works just as little as something totally different, a pure rationality-orientation works just as little as a pure development-orientation, clear successive phases just as little as continuous iterations. There is no single best approach and certainly no definitive solution: those are reserved for simpler tasks (Rittel & Webber, 1973). It is a matter of switching flexibly and creatively between those opposites and in doing so, making contributions that work well here and now, but are likely to lose their effectiveness in other times and places.

Case Study 6. An example of a change process with intervention paradoxes

This case study was a research intervention conducted at the Dutch Ministry of Foreign Affairs in which various intervention paradoxes surfaced and had to be handled. The project was triggered by the council of top managers who had worked to stimulate result-oriented operations, a popular subject in public sector reform. Its spearhead was 'VBTB', a Dutch acronym roughly translated as 'from policy budgeting to policy accountability'. Given the mixed results so far, they wanted to breathe new life into it. This goal was 'rebuilt' by those most involved during the delineation phase (1) into the critical consideration of the current administrative practice, popularly dubbed 'how steering works at the ministry'. A key question became explaining why some *tough issues* persisted no matter what had been tried in the past. What could new action perspectives be? The findings would be the basis for a long and hard discussion with the council in charge to kick-start new thinking. Overall the research intervention was development-oriented. However, sticking to that orientation only wouldn't suffice: this is where intervention paradoxes come in.

The redefinition in the months leading up to the research equals a *first intervention paradox*: do you, as change agents, subscribe to the project questions and delineation of the people involved even when you feel these have been *framed in a way that limits the usefulness* of its outcomes? Or do you take an activist stance as change agent? The latter can raise an ethical dilemma: can you raise issues and get the ball rolling when it's unlikely you will be in a position to finish what you started. As change agents your stay is generally for a limited time only. In this case, two internal and one external party did take an activist stance. That is, we wanted to redefine the project with those involved, not do it for them. A pre-diagnosis was done with all the members of the council. The findings were interpreted by us to show that the one-sided rational empirical approach of many VBTB processes did not do justice to the complexity of the work at the ministry and that you a more differentiated (multiple) view on steering was required: foreign policy is not just about predictable, controllable and measurable processes; nor will it ever be. The discussions that followed with the council legitimised the desired twist in the intervention process.

Next, we would have liked to use a real learning approach for the diagnosis (1b): preferably a participative effort (then they learn more) with all the civil servants concerned, preferably be research-based (to look under the surface for mechanisms that help shed light on it all), and preferably including some outside parties pitching in (to include recessive views). The various plans we thought up, however, were met with resistance: they either cost too much in terms of time and money, were too unusual for this platform, or raised questions of feasibility and necessity. This landed us in a *second intervention paradox*: whether to play according to the normal *interaction rules* that aid decision-making and are readily accepted, or to bend these rules to allow for learning even though this provokes resistance. Research in the ministry is typically delegated or outsourced; findings are fed back in the shape of an executive summary (a few pages only with bulleted highlights) to a hierarchical platform where people have little time to discuss it. It is an approach that is geared to decision-making on issues people understand sufficiently. Tough issues, in contrast, are insufficiently understood and you learn about them by participating in researching them or addressing them (Pacanowsky,

1995). We manoeuvred to set up two interactive platforms, a small platform that was able to go in depth, and a second, wider platform that would allow the participation of the whole council. The small platform included internal and external parties. We gathered contrasting information and interpretations on the issues, hypothesised about systemic patterns and underlying mechanisms, and tried to shoot holes in each of them as way to build theory. Triangulation was key: we collected rich descriptions next to facts and figures and informal stories next to formal reports, we studied interrelationships between factors next to each of the factors themselves, and we selected as many interviewees on their insight as on their formal position. The wider platform was the full council itself: leading to the later discussions about findings, they were already involved in the diagnosis by way of learning conversations with each of them individually, cloaked as interviews for information-gathering. The idea was that their willingness to question present administrative practice and learn different ways of looking at it would neither grow by us just listening, nor by us trying to convince or entice them. What did help was to examine their views with them, comparing them with other views, problematising assumptions. That is what we did in the talks and that raised the council members' interest to go more in depth at a later date: a lengthy discussion with the whole council.

In trying to make sense of the information collected (from 1b to 1c) the small platform got into trouble. We found a great many contrasting and implicit understandings of 'steering' in the ministry: it seemed to cover pretty much all aspects of the organisation. The emerging list of unwanted symptoms seemed endless and there also seemed little agreement in the ministry about solutions. How could we prevent that any definition of steering, any prioritisation of issues or any recommendations we would come up with would not just be *added to the already existing pile*? What would make our findings not be 'more of the same'? Some whispered to us that advice usually only got heard if it is accompanied by verbal power play and hierarchical sponsorship. 'The previous consultants' blood is still dripping from the walls.' Not really what we were looking for given our learning strategy. So we were stuck in a *third intervention paradox*. The council expected to get an analysis on the *level of concrete issues and actions*, while in our view this would not contribute much new. We therefore chose to move from the level of symptoms to that of explanations of the dynamic that creates them, and from the level of actions to that of principles that guides actions. The first shift would help to foster insight into 'why things work the way they do' and perhaps thus legitimate the possibility to see and do something different. The latter shift would prevent the council from plunging straight into lists of water-downed actions (for principles are too abstract to be delegated and implemented just like that), 'proving' in no time that they do not work, only because people do not have the skill to bring those context-transforming principles to life within such impossible conditions. We also introduced a somewhat controversial hypothesis: that we would display similar behaviour if we were in the shoes of those we described sustaining the tough issues. Most employees were quite capable and the organisation was healthy enough. It did not stand to reason that specific actors or factors were exclusively to blame for the ministry's predicaments. Also the issues were persistent despite frequent personnel reshuffles. We assumed context was driving behaviour, rather than intentions (a systemic view, see earlier). This notion put us on the track of using causal loop diagrams (1c).

And yet this choice too brought along new problems. Reading causal loop diagrams, talking about principles, unravelling underlying mechanisms: our findings could easily reach a high level of abstraction and be full of dense jargon from the social sciences. This brought us to the *fourth intervention paradox*: to what extent do we let the *contents and form of our findings match the expectations* of those involved? How much jargon is doable? Which level of abstraction? Which degree of complexity? And to what extent can hidden organisational behaviour be revealed without provoking defensive behaviour? We strove for 'intelligent simplification' to capture as much complexity as possible in a way that was still acceptable to those involved. The complexity was represented schematically in six causal loop diagrams (each not too big) but brought to life at the same time through anecdotes, quotes, examples that were immediately recognisable and preferably slightly provocative. The causal webs might have been new, but not the phenomena described. We devoted most space to explanations of the current practice, because that would tie directly to people's experience. In contrast, we kept our text on action perspectives concise, we only wanted to create sufficient constructive confusion and interest to make people willing to experiment. No amount of explanation or instruction would suffice anyway given lack of experience with these action perspectives in the ministry. The findings were structured in neat chunks and lists: ten intrinsic strengths and ten tough issues, six explanation dynamics and six action perspectives. And lots of one-liners. We strove to squeeze it into 15 pages. It turned out to be 60.

We faced a *fifth intervention paradox* when *organising discussions* about the findings. It seemed incongruent to use the one-way communication of an expert report to convey a message about the need to unravel, learn and work interactively on complex issues. On the other hand, how could we expect prevailing ideas to be questioned if we ourselves didn't introduce contrasting views that would take the discussion to another level? Basically, we wanted both: facilitate two-way discussions and convey a message. We created two interaction platforms, a concise formal moment with the council and an informal inkblot effect within the rest of the organisation. The formal platform was set up as an afternoon and evening meeting in a castle, away from the hustle and bustle. The atmosphere was full of anticipation as there was also an international soccer match between the Netherlands and Germany that night, which generally grips the whole country. We mixed together short conceptual inputs (13 times) with facilitated dialogue (14 times) as a way to handle the paradox. With the inputs we put new key ideas on the table, with the subsequent dialogue we encouraged people to share where they recognised these dynamics in their own working environment. The tone was light, the interaction playful. Our findings were not sent beforehand to prevent the managers from doing the usual: arriving with their opinions and standpoints already formed. It was a lively debate, culminating in a dinner during which the council pulled the ownership of the process back to itself. This led to spontaneous brainstorming about small actions and experiments in each of their own domains (delegation reflexes were repressed for a change). They were both satisfied and slightly uncomfortable: can it be OK if we as council members do not know how to translate action perspectives into concrete steps? What if these steps depend on the circumstances, precluding a 'one size fits all' plan for the ministry? Can we really take a step back and reflect in such a hectic environment with overloaded agendas and political pressure?

The informal platform for discussion was the extensive internal network within the ministry. During our research it became clear how strong this network was, fuelled by the intrinsic skill of foreign diplomats, the often life-time stay within the service, the continuous reshuffling of colleagues over the globe in ever-changing compositions, etc. We had noticed how information spreads faster through this network than though any formal channel, especially when it concerns semi-confidential and somewhat controversial stuff. So we decided to make use of that. We shaped the findings into a report with such characteristics. And we made it independently readable. Next, we encouraged (after making a deal about this with the council) that the report would be 'leaked' via the grapevine to those interested. Within a few months we could trace the numbers rising from ten copies for the council to hundreds throughout the organisation's 150 locations. Eighteen months later it was still spreading. It began to be known as the 'culture report', a term we had never used, and a 'must read'. The report helped stir up discussions on all kinds of platforms and every week spontaneous e-mails were sent to the writers. Small groups started convening to reflect on the report and experiment with it, sometimes in their own departments, sometimes with friends within the network, sometimes with us. Some people were relieved because they recognised their own dilemmas in the report (sometimes for the first time); others were depressed by the lack of quick fixes. Some (managers especially) wanted decisions to be made either to get it off the agenda or to delegate it to others to implement it: they kept each other nicely in balance. For this reason, we had deliberately opted not to give the report any formal status. That, and the conceptual nature of the piece, made it not perfectly unsuitable for managerial decisions to 'introduce' or 'disregard' its findings. At any rate, the most important purpose had been to fuel the search for new insights and perspectives on tough issues in the ministry. And that search was still being fuelled long after the research project was formally ended with its presentation to the council.

CONCLUSIONS

Systems thinking needs two legs to stand firmly: understanding the technique of causal loop diagrams and the ability to facilitate interaction processes around it. This implies a broadening of skills and views for most system dynamicists as well as for most change agents. There are many imaginable variations of working with diagrams. For any given situation only a few will be feasible. Being aware of the spectrum of possibilities and making choices thoughtfully within it are, at any rate, resolute steps towards systems thinking as a craft. This does not imply that working with causal loop diagrams becomes a predictable change process. The good news, however, is that working interactively with causal loop diagrams is also partly a self-correcting process, which makes it easy to become proficient at it while doing it.

REFERENCES

Andersen D. F. & G. P. Richardson. Scripts for group model building. *System Dynamics Review* 13(2) (1997), pp. 107–129.

Andersen D. F., G. P. Richardson & J. A. M. Vennix. Group model building: adding more science to the craft. *System Dynamics Review* 13(2) (1997), pp. 187–203.
Argyris, C. *Overcoming Organisational Defenses: Facilitating Organisational Learning*. Upper Saddle River, NJ: Prentice-Hall, 1990.
Argyris, C. & D. A. Schön. *Organisational Learning: A Theory of Action Perspective.* Reading, MA: Addison-Wesley, 1978.
Beer, S. *Diagnosing the System for Organisations.* Chichester: Wiley, 1985.
Bella, D. A., J. B. King & D. Kailin. The dark side of organisations and a method to reveal it. *Emergence* 5 (2003), pp. 66–82.
Bertalanffy, L. von. *General Systems Theory: Foundations, Development, Applications.* New York: Braziller, 1968.
Burns, J. R. & P. Musa. *Validation o f Causal Loop Diagrams.* System Dynamics Society Conference, Atlanta, GA, 2001.
Caldwell, R. Things fall apart? Discourses on agency and change in organisations, *Human Relations* 58 (2005), pp. 83–114.
Caluwé, L. de & H. Vermaak. *Learning to Change: A Guide for Organisation Change Agents.* London, Thousand Oaks, CA and Delhi: Sage, 2003.
Caluwé, L. de & H. Vermaak. Change paradigms: an overview. *Organisation Development Journal* 22(3) (2004), pp. 9–18.
Caluwé, L. de & H. Vermaak. *Leren veranderen; een handboek voor de veranderkundige.* 2nd edition. Deventer: Kluwer, 2006.
Checkland, P. & J. Scholes. *Soft Systems Methodology in Action.* Chichester: Wiley, 1990.
Deming, W. E. *Out of Crisis.* Cambridge: Cambridge University Press, 1986.
Duke R. D. & J. L. A. Geurts. *Policy Games for Strategic Management: Pathways into the Unknown.* Amsterdam: Dutch University Press, 2004.
Dutton, J. E. & S. J. Ashford. Selling issues to top management. *Academy of Management Review* 18 (1993), pp. 397–428.
Engeström, Y. *Learning by Expanding: An Activity-theoretical Approach to Developmental Research.* http://communication.ucsd.edu/MCA/Paper/Engestrom/expanding/toc.htm, 2004.
Forrester, J. W. *Industrial Dynamics.* Cambridge, MA: MIT Press, 1961.
Geus, A. P. de. Planning as learning. *Harvard Business Review* 2 (1988), pp. 70–74.
Greenberger, M., M. A. Crenson & B. L. Crissey. *Models in the Policy Process: Public Decision Making in the Computer Era.* New York: Russell Sage Foundation, 1976.
Hardin, G. The tragedy of the commons. *Science* 162 (1968), pp. 1243–1248.
Huy, Q. N. Time, temporal capability and planned change. *Academy of Management Review* 26(4) (2001), pp. 601–623.
Kolb, A. Y. & D. A. Kolb. Learning styles and learning spaces: enhancing experiential learning in higher education. *Academy of Management* 4(2) (2005).
Lane, D. C. Modelling as learning: a consultancy methodology for enhancing learning in management teams. *European Journal of Operational Research* 59 (1992), pp. 64–84.
Luna-Reyes L. F. & D. L. Andersen. Collecting and analyzing qualitative data for system dynamics: methods and models. *System Dynamics Review* 19(4) (2003), pp. 271–296.
Lyneis, J. M. System dynamics for business strategy: a phased approach. *System Dynamics Review* 15(1) (1999), pp. 37–70.
Maani, K. E. & V. V. Maharaj. Links between systems thinking and complex decision making. *System Dynamics Review* 20(1) (2004), pp. 21–48.
Morecroft, J. D. W. Executive knowledge, models and learning. *European Journal of Operational Research* 59 (1992), pp. 9–27.
O'Connor, J. & I. McDermott. *The Art of Systems Thinking: Essential Skills for Creativity and Problem Solving.* San Francisco: Thorsons, 1997.
Pacanowsky, M. Team tools for wicked problems. *Organisational Dynamics* (1995), pp. 36–51.
Prigogine, I. *Orde uit chaos.* Amsterdam: Bert Bakker, 1985.
Reibnitz, U. von. *Scenario Techniques.* New York: McGraw-Hill, 1988.
Richmond, B. The strategic forum: aligning objectives, strategy and process. *System Dynamics Review* 13(2) (1997), pp. 131–148.
Rigby, D. K. *Management Tools 2003.* Boston, MA: Bain, 2002.

Rittel, H. W. J. & M. M. Webber Dilemmas in a general theory of planning. *Policy Sciences* 4 (1973), pp. 155–169.

Rouwette, E. A. J. A. & J. A. M. Vennix. System dynamics and organisational interventions. *Systems Research and Behavioral Science* 23(6) (2006).

Senge, P. M. *The Fifth Discipline: The Art and Practice of the Learning Organisation.* New York: Doubleday/Currency, 1990.

Senge, P. M., C. Roberts, R. B. Ross, B. J. Smith & A. Kleiner. *The Fifth Discipline Fieldbook: Strategies and Tools for Building a Learning Organisation.* New York: Doubleday/Currency, 1994.

Senge, P. M., A. Kleiner, C. Roberts, R. Ross, G. Roth & B. Smith. *The Dance of Change: The Challenges to Sustaining Momentum in Learning Organisations.* New York: Doubleday/Currency, 1999.

Shibley, J. J. *Making Loops: A Method for Drawing Causal Loop Diagrams,* 2001. http://www.systemsprimer.com/making_loops_intro.htm Accessed 20 September, 2002.

Vennix, J. A. M. *Group Model Building: Facilitating Team Learning Using Systems Dynamics.* Chichester: Wiley, 1996.

Vennix, J. A. M. Group model-building: Tackling messy problems. *System Dynamics Review* 15(4) (1999), pp. 379–401.

Vermaak, H. Betekenis geven aan een diagnose met een causaal diagram; Een analytisch hulpmiddel voor de meest intuïtieve taak van veranderaars. *Handboek voor Organisatie Instrumenten* (July 2003), pp. 1–28.

Vermaak, H. *OD without Context Management is a Luxury Item.* Academy of Management Conference, Atlanta, GA, 2006.

Vermaak, H. *Vernieuwen rond taaie vraagstukken.* Deventer: Kluwer, forthcoming 2008.

Vriens, D. & J. Achterbergh. *The Social Dimension of System Dynamics-based Modelling.* Paper presented at Second European System Dynamics Conference, Nijmegen, 2005.

Warren K. Why has feedback systems thinking struggled to influence strategy and policy formulation? Suggestive evidence, explanations and solutions. *Systems Research and Behavioral Science* 21 (2004), pp. 351–370.

Wolstenholme, E. F. The definition and application of a stepwise approach to model conceptualisation and analysis. *European Journal of Operational Research* 59 (1992), pp. 123–136.

Zee, H. van der. De vijf denkparadigma's binnen het opleidings- en ontwikkelingsveld. *M&O* 2 (1995), pp. 107–134.

Zock, A. & M. Rautenberg. *A Critical Review of the Use of System Dynamics for Organisational Consultation Projects.* Proceedings of the 22nd International Conference of the System Dynamics Society, Oxford, 2004.