European Journal of Operational Research 205 (2010) 489–500

Contents lists available at ScienceDirect

European Journal of Operational Research

journal homepage: www.elsevier.com/locate/ejor

Invited Review

Facilitated modelling in operational research

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ARTICLE INFO

Article history:
Received 20 November 2008
Accepted 23 September 2009
Available online 27 September 2009

Keywords:
Problem structuring
Decision making
Facilitation
Modelling
OR consultancy
Organisational intervention

ABSTRACT

The traditional way of employing operational research in organisational interventions has been the expert mode. In this mode, the problem situation faced by the client is given to the operational research consultant, who then builds a model of the situation, solves the model to arrive at an optimal (or quasi-optimal) solution, and then provides a recommendation to the client based on the obtained solution. An alternative mode of engagement is to conduct the whole intervention together with the client: from structuring and defining the nature of the problem situation of interest, to supporting the evaluation of priorities and development of plans for subsequent implementation. In this latter mode, the operational researcher works throughout the intervention not only as an analyst, but also as a facilitator to the client. This paper discusses this latter mode of engagement with clients, with particular emphasis on the use of facilitated modelling as the intervention tool. Drawing on research scattered across a range of publications and domains, the review presented here provides a formal definition of facilitated modelling, together with a general framework that allows the conceptualisation of a wide variety of facilitated modelling approaches to organisational intervention. Design issues in facilitated modelling and their practical implication are discussed, and directions for future research identified.

1. Introduction

There is little doubt of the positive role and impact that the discipline of Operational Research (OR) has had in organisations since its appearance over more than half a century ago. This is aptly illustrated by the EURO Medal and the Franz Edelman prizes, two of the most prestigious awards for the practice and proven impact of operational research projects. Indeed accounts of successful organisational interventions that demonstrate the value that OR can provide are regularly published in this journal and other academic and practitioner outlets, such as *Interfaces* and the *Journal of the Operational Research Society*. Modelling and analysis are at the core of these reported interventions, which show how the development and use of OR models can help organisations tackle a wide variety of complex problem situations.

The most common and traditional way of conducting these OR interventions is to adopt what we call the *expert mode*, where the operational researcher uses OR methods and models that permit an 'objective' analysis of the client's problem situation, together with the recommendation of optimal (or quasi-optimal) solutions to alleviate that problem situation. Most OR text books offer excellent advice on how to perform such type of analysis, which has been successfully used to solve a broad range of challenging management problems in areas such as logistics, operations, marketing, and finance.

On the other hand, when dealing with problem situations at a more strategic level, the expert mode of intervention may not always be appropriate. There may be several reasons for its inadequacy in such circumstances including: lack of agreement on the scope and depth of the problem situation to be addressed; the existence of several stakeholders with distinct and, often conflicting, perspectives, objectives, values and interests, which have to be negotiated in order to reach a decision about the problem situation; and the varying levels of participation required in the decision making process, which can have a significant impact on whether the solutions derived from the analysis are not only desirable for the client, but also politically feasible (i.e. implementable and supportable) for the organisation (Eden, 1992; Rosenhead and Mingers, 2001a).

Since the 1980s, an alternative way of conducting OR in organisational interventions has been suggested, where the operational researcher acts not only as an analyst, but also as a facilitator to the client. This approach uses *facilitated modelling* as the intervention tool, which requires the operational researcher to carry out the whole intervention jointly with the client: from helping to structure and define the nature of the problem situation of interest, to supporting the evaluation of priorities and development of plans for subsequent implementation. This mode of engagement is particularly suitable for supporting the analysis of complex problem

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doi:10.1016/j.ejor.2009.09.030

situations, or the evaluation of strategic decisions, given the characteristics we have described above.

Despite being promoted for nearly three decades, and successfully employed in practice, there is not – as far as we are aware – a general framework that allows the conceptualisation of the wide variety of *facilitated* modelling approaches reported in the literature. This review is an attempt to provide such a framework, and to discuss its implications for OR intervention design and practice.

The rest of the paper is structured as follows. We start our review by examining two alternative modes of engagement between clients and OR consultants. We then examine the concept of facilitation, with particular emphasis on group facilitation. Following it, we discuss four key dimensions of facilitated modelling: the characteristics of a facilitated modelling process; the nature of facilitative models; the outcomes of facilitated modelling; and the skills of facilitated modelling. We then classify well-established approaches developed within the operational research, decision sciences, and systems fields; and list the outcomes which have been claimed to be the result of their use. We devote the latter part of the paper to a discussion of some of the design issues of facilitated modelling and their implications for practice. The paper ends with conclusions and suggests some directions for future work in the field of facilitated modelling.

2. Modes of consultancy engagement

In this section, we briefly describe two alternative modes of engagement in OR interventions. Our discussion below draws primarily on the taxonomies developed by Schein (1998) and Eden and Sims (1979), within the organisational development and operational research fields, respectively.

2.1. The expert mode in OR interventions

The expert mode corresponds to the traditional way in which most OR consultants operate. In this mode, the operational researcher is not only an expert in OR, but also an expert in the particular field where the client's problem is located. To illustrate this mode of OR consultancy, let us assume that a particular client organisation needs to identify a strategy for transporting their products from production plants to cities' depots, and asks an OR consultant for advice as an expert in this type of problem. In this case, the OR consultant would frame the situation as a transport network problem and, subsequently, formulate the problem in a way that lends itself to an optimisation model. In the formulation the consultant would define metrics to assess the performance of different potential solutions, which are typically chosen according to the formulation for that type of problem. The consultant would then collect data, from the client organisation, about levels of demands from cities' depots, levels of supply from production plants and costs of transportation. Once the modelling is ready, the optimisation model would be solved to find out the optimal level to be transported along each plant-depot route. The results would subsequently be presented to the client, usually via a detailed report where the optimal solution, which needs to be implemented to minimise costs, is prescribed. Finally, the client pays for the OR analysis, the prescribed solution, and the operational researcher's expertise about the problem. In Table 1 we present these main steps and, in the second column, how an OR consultant typically would intervene following the expert mode.

The expert mode seems like a natural and sensible way of solving a problem such as the one described above. Before we discuss an alternative mode of engagement between clients and OR

Table 1
Expert versus facilitated modes of OR consultancy.

	Expert mode	Facilitated mode
Framing problems	Problems are a real entity, thus the main task of the operational researcher is to represent the real problem that the client organisation is dealing with, avoiding "biases" from different perspectives.	Problems are socially constructed, thus the operational researcher has to help a management team drawn from the client organisation in negotiating a problem definition that can accommodate their different perspectives.
Formulating problems	The real problem has to be formulated as precisely as possible. It is the task of the operational researcher to formulate the problem.	The problem has to be structured by the managent team, whose members are aware about its different aspects and contextual details. The process of problem structuring is supported by the operational researcher, acting as a facilitator, and the development of a model that captures the structure of the problem.
Defining metrics	The expert defines the metrics to assess the performance of options, based mainly on the nature of the problem that the consultant is analysing.	The metrics to assess the performance of options reflect the objectives and priorities of the organisation, as defined by the managent team, and with the support of the operational researcher.
Collecting data	Data collection is always extensive and of a quantitative nature. It is the operational researcher that defines, based on the nature of the problem, what information has to be gathered.	Data collection may be extensive, depending on the problem, but involves not only quantitative but also qualitative data and preference information. The objectives and priorities established by the managent team guide which information will be gathered.
Evaluating options	The model is solved by the operational researcher, and optimal solutions for the problem are found.	The evaluation of options is conducted interactively with the managent team. The consequences of adopting each option are assessed by a model and this informs the team's discussions.
Presenting results	The optimal solutions are then reported back to the client, usually via a detailed report. It is crucial that the report makes explicit all the assumptions made, as the client was not involved in formulating the problem.	Results are shown interactively to the managent team. They are allowed "to play" with the model and see the consequences of implementing potential options. The report has typically a less important role, as it is the support for the decision making process that is the key for the client.
Committing for action	The operational researcher hopes that, given the scientific nature of the analysis, the client will be committed to implement its prescriptions.	The operational researcher hopes that the participatory process of reaching a decision, using a facilitated modelling approach, will increase the team's commitment to the implementation of the chosen options.
Paying the consultant	The client pays for the analysis, the prescription of solutions, and the operational research expertise about the problem.	The client pays for the decision support, the recommendations of actions, and the operational researcher's expertise on facilitating the decision making process.
Aim of the intervention	Provide the optimal solutions to the client.	Help the client in learning more about their problem and in gaining confidence for the way forward.

consultants, let us examine further some of the key assumptions underlying the expert mode of OR consultancy:

- *Assumption 1: problems are real entities*. The expert mode assumes that problem situations exist as external realities and therefore they should not depend on who is describing such reality. Indeed the task of the OR expert is to remove any 'bias' in the description of the problem in order to solve the 'real problem' (Landry, 1995; Roy, 1993). This has an impact on how problems are framed and formulated. In particular, it means that the task of the operational researcher alone is to frame 'correctly' the problem and formulate 'precisely' the model, without the need of client involvement.
- *Assumption 2: the analysis should be 'objective'*. A related assumption is that the analysis should be objective, i.e., subjective opinions and different viewpoints about the problem tend to be avoided (Ackoff, 1979; Rosenhead and Mingers, 2001a; Williams, 2008). This leads OR consultants to define, by themselves, the metrics that they are using for evaluating the solutions, based on the type of problem and how it is typically solved. It also means that they will gather mostly quantitative data for their model and will solve the model in the backroom, as the analysis tends to be technically challenging.
- *Assumption 3: clients want optimal solutions*. The expert mode assumes that clients want expertise to solve decision problems. The way that OR typically offers expertise is by providing a set of optimal (or quasi-optimal) solutions to the client (Ackoff, 1979; Roy, 1993). This is done usually via a detailed report, containing the optimal recommendations, as well as the main assumptions employed in the analysis (Williams, 2008).
- *Assumption 4: implementation of scientifically-based analysis is straightforward*. There is an expectation among operational researchers that the implementation of solutions derived from well-conducted OR analysis will be relatively uncomplicated. As the solutions are clearly optimal, from the metrics employed, there is no reason why they should not be implemented by the client organisation (Eden, 1982; Eden and Sims, 1979).

2.2. The facilitated mode in OR interventions

In this mode, a management team or group, drawn from the client organisation, is typically placed as responsible for scoping, analysing and solving the problem situation of interest; the team is supported by the OR consultant, who acts as a facilitator. Almost every step taken in the intervention – from defining what the problem is, to creating and analysing models, and providing the recommendations – is conducted interactively with the team. This produces noticeable differences in the way the intervention is undertaken, as indicated in the third column of Table 1. This level of client participation within the intervention process requires the development of a 'helping relationship' (Schein, 1998) between OR consultants and their clients.

The four assumptions taken by the expert mode, which were detailed in the previous section, are quite different in the facilitated mode:

- *Assumption 1: problems are socially constructed entities*. The facilitated mode recognises that, while some aspects of problems are tangible, their nature and salience will depend on how managers subjectively construct them. Different managers will perceive a given problem situation in quite diverse ways, due to their distinct interests and foci and, therefore, will describe the situation according to those perceptions. Instead of trying to define the 'real' problem, the OR analyst in this mode will support the management team to come up with a joint problem definition, which encompasses the main features of their individual perceptions about the situation (Eden, 1982; Eden et al., 1981; Landry, 1995).
- *Assumption 2: subjectivity is unavoidable*. The facilitated mode acknowledges that problem situations always involve subjective elements, for example: different perceptions about future directions for the organisation; distinct opinions about the organisational objectives to be pursued; and organisational objectives that have a qualitative nature (Eden and Sims, 1979; Keeney, 1992; Rosenhead and Mingers, 2001a). Instead of disregarding such aspects as 'non-rational' or irrelevant, the OR consultant, in a facilitative role, will help the management team to externalise such subjective issues and represent them in a model.
- *Assumption 3: clients want 'satisficing' solutions*. The facilitated mode assumes that for certain problem situations, clients are usually more concerned about finding good, politically feasible solutions, instead of optimal ones. If the complexity of the problem is very high, any model is necessarily simplistic. Therefore, its results should be seen as a mere indication of what would happen if the solution were implemented. In these cases, clients are usually satisfied in finding a set of good options that can provide clear improvements to the organisational system, and which are deemed implementable at the same time (Eden and Ackermann, 2004; Phillips, 1984).
- *Assumption 4: participation increases commitment for implementation*. The facilitated mode assumes that involvement of key stakeholders in the process of modelling and analysis markedly increases the chance that OR recommendations will actually be implemented (Eden, 1989; Friend and Hickling, 2005; Phillips, 2007; Rosenhead and Mingers, 2001a; Vennix, 1996). The rationale underlying this assumption is that their involvement will make stakeholders more confident in the analysis performed, and more committed to the recommendations derived from it. Such confidence and commitment will be strengthened if: key stakeholders believe that their views, preferences and objectives were taken into account for the analysis; the model represents adequately the problem they want to solve; the assumptions made are organisationally realistic; and the solutions found in the analysis are sound and justifiable.

None of the two modes of engagement described above is necessarily the best. For operational, well-defined problems, the expert mode is usually quite appropriate: there is a clear and unarguable quantitative objective to be optimised; the structure of the problem, despite being technically challenging, is well-known and renders itself to quantitative modelling; and solutions are clear-cut and easily implementable. On the other hand, strategic problems frequently require the facilitated mode, due to their complex social nature and qualitative dimensions, their uniqueness, and the need to engage a management team in the decision making process (Eden and Ackermann, 2004; Eden and Radford, 1990; Rosenhead and Mingers, 2001a; Williams, 2008).

The facilitated mode of OR consultancy uses facilitated modelling as the intervention tool, which requires the OR consultant to deploy both facilitation and modelling skills within the intervention. The next section thus introduces the notion of facilitation as a particular approach to organisational intervention, in preparation for our subsequent treatment of facilitated modelling as an OR intervention tool.

3. Facilitation as an intervention approach

The notion of facilitation has been known for centuries. Hogan (2002) argues that ancient philosophers such as Socrates deployed what can be considered facilitation skills, such as questioning, story telling, metaphors and self-reflection, to engage people in

challenging their mindsets and encouraging new ways of thinking. With roots in cognitive science, social psychology, community development and negotiation, facilitation has been advocated by its proponents as a tool to assist participants to become the architects of their own future (Doyle and Strauss, 1976; Egen, 1973; Kaner, 2007).

Facilitation can be done at two levels: facilitating an individual, or facilitating a group. As the problem situations for which the facilitated mode of OR consultancy is required typically involves a management team drawn from the client organisation (Eden and Sims, 1979), we will focus here on group-level facilitation.

The general purpose of group facilitation is to enable participants to work together much more effectively in resolving the issues of concern that brought them together. An effective facilitator helps a group complete its 'primary task' (Phillips and Phillips, 1993) by trying to capitalise on the benefits derived from group work whilst, at the same time, help to overcome its dysfunctional dynamics such as free-riding, production blocking, evaluation apprehension, information overload, and cognitive inertia – for an extensive treatment of these and other dysfunctional dynamics see Shaw (1981). To achieve this, the facilitator encourages full participation, promotes mutual understanding, fosters inclusive solutions, and cultivates shared responsibility (Kaner, 2007).

To gain a better understanding of the role of facilitation within a group process, we will examine two tasks which are common in facilitated group interventions: problem structuring and evaluating decision options. Both group tasks typically (although not always) take place within a single facilitated intervention, and can be characterised as interactive, involving divergent and convergent thinking processes (Kaner, 2007).

In the case of a *problem structuring* task, the facilitator encourages divergent thinking by helping participants to explicitly articulate and explore their different perspectives of the problem of interest; the facilitator then supports convergent thinking by helping participants form a consolidated perspective of the problem. Similarly, for a *decision option evaluation* task, the facilitator promotes divergent thinking by helping participants to think about the objectives they want to achieve in that decision, as well as to develop creative and feasible solutions to the problem; convergent thinking is then supported by the facilitator through helping participants to consolidate the best ideas into a set of options, which are subsequently evaluated by the objectives the group wants to achieve, until participants arrive at a final recommendation or action plan.

An important theoretical assumption in the group facilitation literature is that effective group decision making requires *both* divergent and convergent thinking to take place. A never-ending increase in ideas is likely to lead to information overload; similarly, consensus that is formed without a thorough exploration of issues can lead to inferior decisions (Russo and Schoemaker, 1989).

Divergent and convergent thinking processes do not follow a linear sequence. Rather, they tend to operate in an iterative fashion, enabling participants to cycle between divergence and convergence thinking. This can cause confusion, anxiety and frustration within the group, an intermediate group process stage known as the 'groan zone' (Kaner, 2005, 2007). Here, the role of the facilitator is to help participants to integrate new and different ways of thinking with their own, so that a shared framework of understanding is achieved. Participants who manage to tolerate the demands of going through the groan zone are more likely to discover common ground and negotiate a way forward within the group.

A summary of the generic roles of the facilitator throughout the different stages of a facilitated group process is shown in Table 2.

A distinctive feature of traditional group facilitation is the absence of any formal modelling. Its roots have led their proponents and practitioners to mainly focus on managing group dynamics and interpersonal issues that are, of course, critical to a successful problem structuring and/or evaluation of decision options. However, as is well known in OR, there are inherent advantages in building models: the possibility of representing a large amount of information; the convenience of organising the elements of the problem situation in a suitable way (e.g. issues, alternatives, goals and criteria, uncertainty and risk); the ability to gain a better understanding of the 'systemicity' of the situation, and to evaluate the consequences of a large number of decision alternatives; and the learning derived from "playing" with the model (changing its assumptions and parameters and analysing the consequences of such changes). This leads to the notion of facilitated modelling, which is described next.

4. Facilitated modelling

Earlier in the paper we discussed the appropriateness of the facilitated mode of OR consultancy for certain type of problem situations. In practice, a facilitated mode requires both carefully managing the client–consultant relationship, and conducting facilitated modelling throughout the intervention. The first aspect has been treated extensively elsewhere (e.g. Eden and Ackermann, 2004; Eden and Sims, 1979; Williams, 2008) so our focus is on the second aspect.

The term 'facilitated modelling' will be used here to describe a process by which formal models are jointly developed with a client group, face-to-face, with or without the assistance of computer support (Eden and Radford, 1990). We consider a model as 'formal' if it represents a problem situation in any of the following ways: (1) activity or process flows; (2) cause and effect relationships; (3) relationships between decision choices and their (deterministic or uncertain) consequences. A formal model is amenable to analysis and manipulation, but not necessarily quantifiable. Models produced in facilitated interventions are used by managers to share and increase their individual understandings of the problem situation of interest, help them articulate their preferences and thus enable them to appreciate the potential impact of different options, and facilitate the negotiation of courses of action that are politically feasible.

Table 2
Facilitator's roles in group problem structuring and decision option evaluation tasks.

Group process stage	Group task	
	Problem structuring	Evaluation of options
Divergent thinking	Facilitator helps participants to explicitly articulate and explore their different perspectives of the problem.	Facilitator helps participants to think about their objectives, as well as to develop creative and feasible solutions to the problem.
Groan zone	Facilitator helps participants to integrate new and different ways of thinking with their own, so that a shared framework of understanding is achieved.	Facilitator helps participants to integrate new and different ways of thinking with their own, so that a shared flamed work of understanding is achieved.
Convergent thinking	Facilitator helps participants to form a consolidated perspective of the problem.	Facilitator helps participants to consolidate the best ideas into a set of options which are subsequently refined, and assessed, until the group arrives at a final recommendation or action plan.

We will organise our discussion in this section around four aspects of facilitated modelling: process, models, outcomes, and facilitation skills.

4.1. The process of facilitated modelling

The primary orientation of facilitated modelling is to assist a client group in agreeing the nature of a problem situation they face, and on a feasible action plan intended to tackle that situation so that progress towards solving the problem can be made. This is because, in complex problem situations, or strategic decisions, there is likely to be a plurality of stakeholders with different interests who will need to engage in a group dialogue, if the problems they face are to be resolved by means other than an overt exercise of power and control (Rosenhead and Mingers, 2001a).

Consequently, when group members participate in a facilitated modelling process, they hold 'designed' conversations (Franco, 2006) to exchange their understandings and views about the situation that is being analysed. The process is therefore a participative one, in the sense that participants are able to jointly define the situation, make sense of it, negotiate a shared problem definition, and develop and evaluate a portfolio of options relevant to the problem so defined. This participatory process is supported by the OR consultant acting both as a modeller and a facilitator (Ackermann, 1996; Phillips and Phillips, 1993).

Because interaction between the participants, and of the participants with the analysis, is needed to jointly build a model of the situation, facilitated modelling is an interactive process. Participants' interaction with the model reshapes the analysis, and the model analysis reshapes the group discussion. Such interactive processes continue until the problem situation is satisfactorily structured and analysed, so that the group feels sufficiently confident in making commitments and implementing options.

Facilitated modelling is typically organised into group work phases, which roughly correspond to: structuring the situation and agreeing a focus; developing a model of organisational objectives or systems; creating, refining and evaluating option actions; and developing action plans. This 'phased-ness' makes it possible for the users of facilitated modelling to end the process without passing through all the phases, and still have a tangible product that can be of use to them. Furthermore, the phases of facilitated modelling do not have to be followed in a linear sequence; rather, it is possible for the participants to cycle between the phases.

A characteristic feature of facilitated modelling is its ability to enable participants, during the modelling process, to distance themselves from initial positions, effectively providing them with a certain degree of detachment regarding their own stakes. As Eden (1992) and Eden and Ackermann (2004) have argued, facilitated modelling allows participants to change their positions in response to what they have learned about the problem situation without 'losing face' or destroying the social order in the group. Changing positions imply individuals 'changing their minds', i.e. changed beliefs, changed values, and changes in the salience of particular issues or values (Eden, 1986). The consequence of this adaptability is that it becomes easier for participants to reconcile the position they eventually take both with principles and with past words and actions during the group discussion.

Thus far we have looked at the characteristics of a facilitated modelling process. As we have seen, facilitated modelling requires a facilitative modeller supporting a group model-building process that must be participatory, interactive, with certain degree of detachment from their stakes, and non-linear. At the same time, the facilitative modeller and the chosen modelling approach must be responsive to the dynamics of group work and the nature of politics and power associated with the particular situation at hand.

In terms of technology, facilitated modelling can be a relatively unsophisticated activity, conducted in a workshop format, and one which does not necessarily require software to support it (Ackermann and Eden, 1994). Non-computer-supported environments typically involve (Hickling, 1990; Huxham, 1990): a room spacious enough for participants to move around freely and with movable chairs laid out in a horse-shoe fashion; large sheets of paper attached around the walls of the room; a simple, non-permanent means of sticking papers to these walls; and a good supply of marker pens with contrasting colours.

Facilitated modelling can also be deployed with computers to support effective storing, retrieving, manipulating, and communicating of data (Ackermann, 1990; Eden, 1992; Phillips, 1989; Phillips and Phillips, 1993). The use of computers loaded with specialised software enables fast model building and real time computing (Ackermann and Eden, 1994; Eden, 1992). Some software, such as *Group Explorer* (www.banxia.com) and *VISA* groupware (http://www.simul8.com/products/visagroup.htm), also allow participants to enter their views relating to a problem situation directly and anonymously into it. The system is then operated by the modeller who manipulates and analyses the data according to the wishes of the group. Once a model of the problem is built and stored in the system, several analyses can be performed 'on-the-hoof'. This type of computer-supported environment still demands an active role for the facilitator and the model to inform and structure the group discussion, as opposed to other mainly 'technology-driven' support systems (Morton et al., 2003) where the facilitator's role and the use of formal models is rather limited.

The preceding discussion makes it clear that model-based facilitation is different from standard group facilitation. Although both forms of facilitation are similar in the way the facilitator provides process support to a group, it is both the handling of the content of the group's communicative exchanges, and the process of working on that content, where the main differences lie. In facilitated modelling, content is managed through the use of formal models, as opposed to other facilitative means. Modelling and model use are the defining characteristics of facilitated modelling, and what gives it its unambiguous OR identity.

4.2. The nature of facilitative models

Models produced in facilitated interventions provide managers with a facilitative learning device, i.e. a 'play tool' that allows them to rehearse ideas and action possibilities about the situation of interest (De Geus, 1988; Eden, 1992; Lane, 1992). The availability of such a tool, it is argued, increases managers' multiple understandings of the situation, and support them in negotiating courses of action that are culturally and political feasible for the client organisation.

Facilitative models represent, among other things, relationships between concepts, activities or stakeholders, relationships of similarity or influence, and relationships between options. The components of any particular model will depend on the chosen focus for the group modelling activity (e.g. evaluating choices of options, designing systems) and on the primary task it aims to support (i.e. problem structuring, evaluation of decision options, or both).

It has been claimed that visual methods are of particular value in representing complexity to lay audiences who might otherwise find quantitative models opaque (Eden and Ackermann, 2004; Rosenhead and Mingers, 2001a). In a facilitative model there is supposed to be nothing hidden, which makes them transparent (i.e. easy to understand) and accessible (i.e. simple to use). Thus facilitative models employ heavily visual displays (e.g. cognitive and causal maps, causal loop diagrams, stocks and flows pictures, decision graphs, value trees), and mostly use participants' own language to represent the problem situation, as well as their own judgmental preferences to evaluate decision options.

A consequence of considering a model as a facilitative learning mechanism is the challenge of assessing what constitutes a valid model and a good model solution. Probably the best answer to this issue is to employ the concept of building a requisite model (Phillips, 1984): one that contains sufficient knowledge and information to help the client group find a way forward.

The preceding discussion has been centred on the characteristics of facilitated modelling and what it means to be both a facilitator and a modeller. Several outcomes have been claimed to be the result of the use of facilitated modelling. These are discussed next.

4.3. Outcomes of facilitated modelling

A number of outcomes have been claimed to be the result of the use of facilitated modelling approaches. Some of them will be tangible outputs of the modelling process itself, whilst others will be less visible but valuable in their own right.

The most visible facilitated modelling outcome is obviously the model built during the group process. The model contains the structure of the problem situation, and allows performing analyses and drawing conclusions from its responses. Furthermore, the model is thought to facilitate the achievement of a number of invisible outcomes. First, it is argued that by allowing the mutual exploration of the problem structure as portrayed by the model, facilitated modelling enables the accommodation of multiple and differing positions among participants (Checkland, 1981). This argument is based on the notion that complex problem situations, or strategic decisions, will commonly require participants to adjust their positions and/or expectations, to take into consideration the possible objectives and strategies of others (Rosenhead and Mingers, 2001a). Accommodations between managers may also require coalition forming (Eden, 1986), which can produce a shift in power relations within members of the client group participating in the modelling process (Eden, 1992).

Second, the analysis and manipulation of the relationships between model variables, together with the evaluation of decision options, is thought to give participants an increased and shared understanding (rather than consensus) of the problem situation, of the impact of potential courses of action, of others' beliefs and values, and of organisational processes and cultures (Rosenhead and Mingers, 2001a). Such gained understanding is taken to be conducive to develop a sense of common purpose that preserves individual differences of opinion (Phillips, 2007; Schilling et al., 2007), as well as learning (Checkland, 1999; Friend and Hickling, 1997; Vennix, 1996).

Finally, it is argued that group members' active participation in the modelling and analysis process produces strong ownership of the problem formulation, and of the actions to be taken; as well as a commitment to the way forward, in the sense of an acceptance of responsibility for the consequences of the actions taken (Eden, 1992; Phillips, 2007; Rosenhead and Mingers, 2001a).

4.4. Skills of the facilitative modeller

Facilitated modelling requires the OR consultant to act as a facilitator during the modelling and analysis process. This means that the OR consultant should be prepared to use general facilitation skills as part of the modelling work. We consider here four fundamental facilitation skills required for effective facilitated modelling: active listening, chart-writing, managing group dynamics and power shifts, and reaching closure. These are described next:

- *Active listening* requires the modeller to be able to clarify, develop, summarise and refine participants' contributions by paraphrasing and/or mirroring what participants say; validating what they say without judging; asking them non-directive questions and refraining from making value judgements; gathering lists of their contributions and summarising them at key stages during the group process; helping them to take turns; keeping track of the various discussion themes that may emerge simultaneously; balancing the discussion to avoid blind spots; and listening for the common ground. The group discussion will be guided by the information and format demands of the particular facilitated modelling approach the OR consultant is employing.
- *Chart-writing* is particularly relevant for those facilitative modellers who tend to rely on manual rather than computer support (e.g. flip charts, white boards, Post-it notes, etc.). This requires competence in a number of aspects, from writing style and speed to the use of appropriate formats (e.g. lists, matrices, flow charts) and symbols (e.g. arrows, bullets, stars). Representing the information will be guided by the coding rules of the particular facilitated modelling approach the OR consultant is using.
- *Managing group dynamics and power shifts* is perhaps one of the most fundamental skills for the facilitative modeller. Through active listening, the modeller must be able to sense when difficult group dynamics crop up during modelling, and treat them as group situations that must be handled supportively. A typical approach is for the modeller to help the group step back from the content of the ongoing discussion and talk about the process instead. This is usually achieved by, for example, encouraging more people to participate, acknowledging and handling out-of-context distractions, educating participants about the groan zone, and helping participants to deal with any unfinished business. In addition, the use of some participative processes (e.g. anonymity, nominal group technique) by the facilitator can sometimes affect the power base within the group (Eden, 1992). Difficult group dynamics and power shifts thus require the facilitative modeller to know whether, how and why to intervene during the modelling process. A useful framework that provides a structured way to diagnose group behaviour and decide whether and how to intervene is the diagnosis-intervention cycle – see Schwartz (2002) for an extensive treatment of this framework.
- *Reaching closure* is a key skill that a facilitative modeller uses to help the group reach agreements about the way forward. This requires the modeller to identify when the group has reached a point, from 'playing' with the model, at which closure on a proposal is needed and a requisite model has been achieved (Eden, 1992; Phillips, 1984). Depending on the particular organisational context within which the facilitative modeller is working, those with the power and authority to make commitments for the implementation of particular courses of action must then decide whether the issue/proposal needs further group discussion, or whether a decision abut the issue/proposal can be made.

A summary of the facilitation skills discussed above is shown in Table 3. A more comprehensive exposition of the skills and competencies required by facilitators can be found in Kaner (2007), Phillips and Phillips (1993), Schuman (2005) and Schwartz (2002),

In Fig. 1, we have attempted to capture the main aspects of facilitated modelling discussed in this section. The figure suggests that the OR consultant interacts simultaneously in two 'spaces': as an analyst in the *modelling* space and as a facilitator in the *group process* space. In the former, the consultant uses a particular OR methodology to inform model building and represents the problem situation as described by the group, using an OR model. Meanwhile, in the *group process* space, the consultant facilitates the group (informed by the facilitation methods used), supports the group's discussion and interacts with the group's members. The group provides information that allows the facilitator to model the problem situation and, conversely, the model generates responses that support the group's discussions about the issues they are dealing with. Two types of outcomes are provided by facilitated

Table 3
Key facilitation skills in facilitated modelling.

Active listening	Paraphrasing and mirroring contributions Gathering lists of contributions and summarising them Asking participants non-directive questions and refraining from making value judgements Helping with turn taking Tracking discussion themes Balancing discussion
Chart-writing	Effective use of flipcharts and whiteboards by: – Clear writing and appropriate flip-chart or white-board pens – Printing in straight, thick-lined, plain block, capital letters – Using appropriate letter size, enough margins, use of indenting and underlying, sufficient space between lines – Using suitable colours, formats and symbols
Managing group dynamics and power shifts	Stepping back from content and talking about process by: – Encouraging more people to participate – Acknowledging and handling out of-context distractions – Educating participants about the groan zone – Helping participants to deal with unfinished business Diagnose group behaviour and decide whether, how and when to intervene
Reaching closure	Identifying when group has reached point when closure on a proposal is needed by: – Stopping group discussion – Polling the group – Checking if the model is already requisite – Check with those with the power and authority to make commitments whether more group discussion is needed or whether a decision can be made

modelling: in the *modelling* space, there are model outcomes (such as priorities for actions, system's responses, etc.); in the *group process* space, there are group outcomes (such as commitment to action, learning, etc.). The two spaces cannot be divorced from each other (Eden, 1990), as there will be cross-impacts from one space to the other (for example, conceptual mistakes in the model may generate meaningless system's responses, which then impact negatively on group outcomes, such as creating low commitment to action).

Before we discuss practical issues related to the design of OR interventions based on facilitated modelling, a brief review of some of the more established facilitated modelling approaches will be offered next.

5. Types of facilitated modelling

We have selected a family of modelling approaches that, in our view, sit comfortably within the definition and characteristics of facilitated modelling articulated above:

- *Facilitated problem structuring*: A set of modelling methods collectively known as 'Soft OR' methods. Their main features are: the assumption of subjectivism (different views about the world); groups as the key organisational resource to share and produce knowledge, and make recommendations; the limited role of quantification in the analysis (mostly qualitative modelling). Rosenhead and Mingers (2001a) discuss a number of well-established problem structuring methods which include Strategic Options Development and Analysis, Soft Systems Methodology, and Strategic Choice Approach. Although the problem structuring methods described in Rosenhead and Mingers (2001b) were originated in the OR community, others have started to appear elsewhere – see, example, the Dialogue Mapping approach developed by Conklin (2006) with roots in the information systems field.
- *Facilitated system dynamics*: Originated in the system dynamics field, it supports the modelling of systems where dynamics

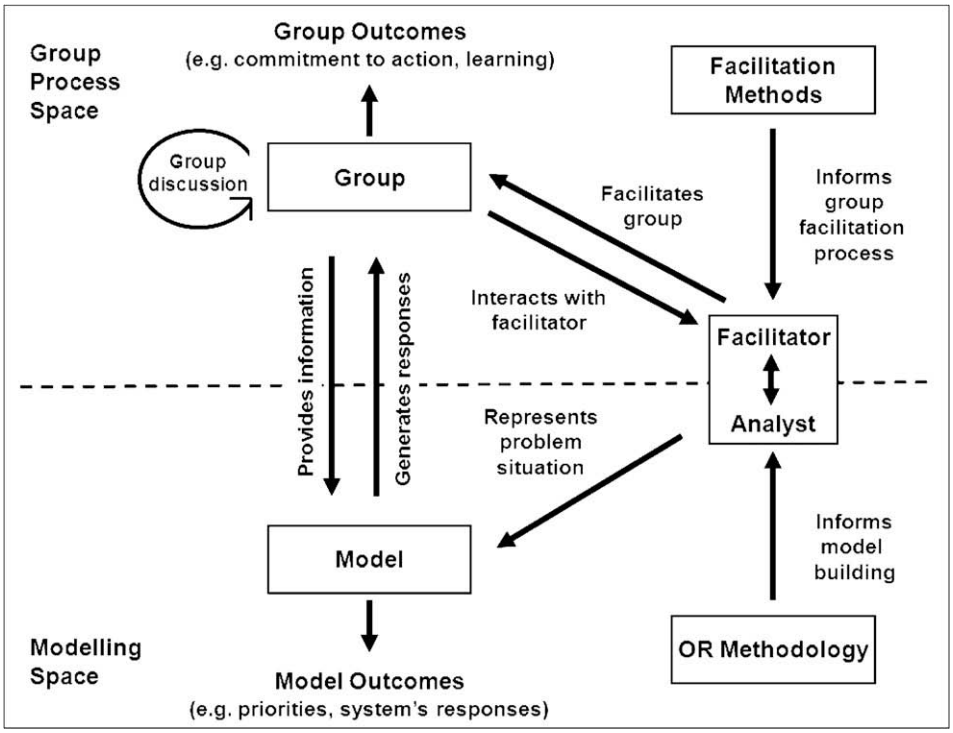

Fig. 1. Facilitated modelling in operational research.

and feedback loops are important in understanding the impact of decision policies/options over time. For details on the use of system dynamics in facilitated mode see Andersen and Richardson (1997), Lane (1992), Richardson and Andersen (1995) and Vennix (1996).

- *Facilitated decision analysis*: A set of methods that help modelling decisions that involve multiple objectives and/or uncertainty of outcomes. For details on modelling multiple objectives in a facilitated mode see Phillips (2007); and Belton and Stewart (2002), and on modelling uncertainty using this mode see Matheson and Matheson (1998).

It is also possible to deploy facilitated approaches that integrate the different modelling methods listed above, aiming to take benefit from their strengths. For example, the reasoning maps method employs problem-structuring methods and multi-criteria analysis (Montibeller et al., 2008). Another example includes the combined use of computer-supported causal mapping using *Group Explorer*, which uses problem-structuring methods with information systems concepts (Ackermann and Eden, 2001a), and system dynamics modelling (Howick et al., 2008).

The major facilitated modelling approaches are listed in Table 4 with accompanying focus, modelling approach and general purpose. Facilitated modelling have been applied in a wide variety of areas including: *health* (Belton et al., 1997; Cavana et al., 1999; Hindle et al., 1995; Lartindrake and Curran, 1996; Royston et al., 1999; Wells, 1995); *transport* (Khisty, 1995; Ulengin and Topcu, 1997); *natural resource management* (Brown and MacLeod, 1996; Fielden and Jacques, 1998; Gough and Ward, 1996; Joubert et al., 2003); *manufacturing* (Ackermann, 1997; Terry Williams et al., 2003); *project management* (Barcus and Montibeller, 2008; Franco et al., 2004; Winter, 2006); *knowledge management* (Montibeller et al., 2006; Shaw et al., 2003); *strategy development* (Howick et al., 2006; Montibeller and Franco, forthcoming; O'Brien and Meadows, 2007; Salo et al., 2003); *information systems* (Ormerod, 1995, 1996, 1998); inter-*organisational collaboration* (Franco, 2008; Huxham, 1996); *community work* (Hodgkin et al., 2005; Walsh and Hostick, 2005; White, 1996; White and Taket, 1997); *portfolio analysis* (Matheson and Matheson, 1998; Montibeller et al., 2009; Phillips and Bana e Costa, 2007); and *project prioritisation* (Bana e Costa et al., 1999).

So far we have reviewed the characteristics of facilitated modelling, and classified a number of well-established facilitated modelling approaches. The next section discusses some conceptual and practical issues related to the design of facilitated modelling interventions.

6. Intervention design issues and implications for practice

In this section we focus on design issues that an OR consultant may consider when conducting interventions based on facilitated modelling. Our emphasis will be on the design of the facilitated modelling process itself, rather than the entire OR intervention. Broader design issues related to facilitated OR interventions, including the management of the consultant-client relationship, have already been treated extensively elsewhere (Ackermann, 1996; Eden and Ackermann, 2004; Eden and Sims, 1979; Phillips and Phillips, 1993; Schein, 1998), and the interested reader is referred to these works.

The focus of our discussion here will be on a single facilitated modelling session delivered in a 1 to 3-day workshop format, which is the typical format adopted by many facilitated modelling approaches. Six dimensions are identified as key when designing such a session, as we detail below.

The first dimension is the *focus of modelling*, as a facilitated modelling session can be designed mainly to support problem structuring or the evaluation of decision/policy options. Problem structuring is typically supported via problem structuring methods such as SODA (Ackermann and Eden, 2001b) or Soft Systems Methodology (Checkland, 1981; Checkland and Poulter, 2006; Checkland and Scholes, 1990), whereas approaches such as Group Model Building (Vennix, 1996) and Decision Conferencing (Phillips, 2007) have been used mostly to support the quantitative evaluation of decision options/policies. Different facilitation skills are required for each phase, for example problem structuring requires a facilitator who copes well with ambiguity, multiple perspectives and a large amount of qualitative data; while the evaluation of options requires someone with synthesizing abilities and able to handle a large amount of quantitative data. Supporting both activities, within a single intervention, is also feasible, but it requires the OR consultant (or consultancy team) to be able to adopt a multi-methodology approach to intervention (Mingers and Brocklesby, 1997; Mingers and Gill, 1997).

The second dimension concerns the way that *data is gathered for structuring the model*. Some methodologies use well-defined categories to elicit data up front, as in the case of, for example, Strategic

Table 4
Sample of facilitated modelling approaches.

Approach	Philosophy	Illustrative examples	Illustrative references
Facilitated problem structuring	A set of methods mainly originated in the OR community. Their main features are: the assumption of subjectivism (different views about the world); groups as the key organisational entity in making decisions; the limited role of quantification in the analysis (mostly qualitative modelling).	Strategic options development and analysis	Ackermann and Eden (2001b)
		Strategic choice approach	Friend and Hickling (2005)
		Soft systems methodology	Checkland and Scholes (1990)
		Dialog mapping	Conklin (2006)
Facilitated system dynamics	Originated in the system dynamics field, it supports the modelling of systems where dynamics and feedback loops are important in understanding the impact of decision policies/options over time.	Group model building	Andersen and Richardson (1997); Lane (1992); Richardson and Andersen (1995); Vennix (1996)
Facilitated decision analysis	A set of methods that help modelling decisions that involve multiple objectives and/or uncertainty of outcomes.	Multi-criteria decision analysis	Belton and Stewart (2002)
		Decision trees and simulation	Matheson and Matheson (1998)
		Multi-criteria portfolio analysis	Phillips and Bana e Costa (2007)

Choice (e.g. decision areas and options, uncertainty areas, comparison areas – see Friend and Hickling, 2005 for details) and Soft Systems Methodology (e.g. CATWOE, P/Q/R, root definitions - see Checkland and Scholes, 1990 for details). Other methodologies involve eliciting all relevant data before pre-defined categories are applied to it. This form of data elicitation is typical of modelling approaches such as, for example, SODA, Group Model Building, and Dialogue Mapping. Different data elicitation approaches pose different demands on how the OR consultant manages the content of the model: the first approach requires a top–down data gathering, by imposing pre-determined categories to classify the data; the second one requires working bottom–up, by grouping the data to form categories. The choice of approach will thus depend on the particular preferences of the facilitator for working either top–down or bottom–up, as well as on the management team's adaptability in providing the data in the elicitation formats required by the method adopted.

A related issue, and the third dimension, is the *type of data requirements* for building the model. Some facilitative models are mainly diagrammatic representations of the problem situation and thus have reduced quantitative data requirements (e.g. a cognitive map or a causal loop diagram), closer to the way participants think and communicate. Others, such as a multi-criteria evaluation model or a systems dynamics model do require data in quantified form (based on qualitative statements about relationships between elements of the problem) in order to build the model. The degree of quantification needed for some facilitated modelling approaches requires the OR consultant to be aware of the cognitive demands that this may impose on the participants. For example, research has shown that quantitative judgmental data can be difficult to elicit (Budescu and Wallsten, 1985) and influenced by cognitive biases (Kahneman et al., 1982; Plous, 1993; Poyhonen et al., 2001). On the other hand, quantitative models tend to produce outputs that are less ambiguous and more amenable to further analysis (though the reduction of ambiguity may impose restrictions on the group's ability to reach agreements). Therefore the OR consultant needs to make a choice between these two conflicting modelling objectives, given the type of problem situation that the client organisation wishes to address and the abilities and competences of those participating in the modelling process.

The amount of data elicited (whether qualitative or quantitative) in facilitated modelling sessions is usually high, which can challenge participants' information processing capabilities (Miller, 1956; Simon, 1957). This raises our fourth dimension, the *degree of technology support* needed for a facilitated modelling session (where the term 'technology' is used here to describe the level of computer support used in the session). Problem structuring methods such as Soft Systems Methodology and Strategic Choice, for example, have traditionally favoured unsophisticated forms of technology support (i.e. manual rather than computer-based). On the other hand, approaches within which models are built to perform numerical calculations and/or quantitative sensitivity analyses, such as Decision Conferencing or Group Model Building, tend to rely almost exclusively on computer support (Phillips, 1989), which can be used in 'single-user' mode (facilitator operates the modelling software) or multiple-user mode (participants are able to use the modelling software themselves guided by the facilitator) (Ackermann and Eden, 2001a). Other modelling approaches such

Table 5
Design issues in facilitated modelling and implications for practice.

Design issue	Description		Range		Implication for practice
1. Focus of modelling	The extent to which the approach provides support to a particular phase of decision making	Emphasis on problem structuring	⟷	Emphasis on the evaluation of options/ policies	Choice influenced by: • Facilitation skills of the analyst • Type of problem the client is dealing with (A team of facilitators may be required if supporting both phases)
2. Type of data gathering for structuring the model	The way in which the data about the problem is gathered and employed to structure the model	Bottom–up (categories are created from data)	⟷	Top–down (data is elicited for pre-defined categories)	Choice influenced by: • The facilitator's preferences for working bottom–up or top–down with data • The adaptability of managers to provide the data required by the model
3. Type of data requirements	The type of data required by the model	Data of qualitative nature	⟷	Data of quantitative nature	Choice influenced by: • Type of problem that the client is dealing with • Balance between ambiguity and precision • Abilities and competences of management team
4. Degree of technology support required	The degree of technology support required by the modelling approach	Manual	⟷	Computer-supported (single-user or multi-user)	Choice influenced by: • Personal preferences as well as skills of the facilitator for using a particular technology • Acceptable levels of risk for modelling 'on-the-hoof' at different speeds • Availability of more than one facilitator
5. Degree of flexibility of modelling rules	How flexible are the modelling rules required by the methodology being employed	Flexible	⟷	Strict	Choices influenced by: • Phase of the decision making being supported • Type of decision problem • Type of analysis required
6. Degree of content facilitation required	How much content facilitation is required by the modelling process	Weak content facilitation by the analyst or self-facilitation by the group	⟷	Strong content facilitation by the analyst	Choice influenced by: • Demands placed on the analyst • Need for keeping momentum and energy levels in the group, and increase ownership of the model • Degree of self-motivation and competency of the group

as SODA tend to use a combination of both computer and non-computer support.

A decision about which level of technology support is appropriate for a facilitated modelling session will depend on several factors. Firstly, the OR consultant's personal preferences for and skills to use a particular technology are obvious influences, as well as the perceived complexity associated with the modelling task. As stated earlier, facilitated modelling requires 'on-the-hoof' modelling and analysis of large amount of data. A non-computer-supported environment will restrict the speed at which the data is elicited and manipulated, making the task relatively easier for both the facilitative modeller and the participants. On the other hand, computer-supported environments may be more effective in terms of collecting data during the workshop (particularly those that allow a multi-user mode of working); but they can pose significant challenges to the modeller's ability to structure the data, as well as to the participants' understanding of what is going on, due to the speed at which data is elicited and structured. Consequently, when the different levels of computer technology are being considered, having more than one facilitator/modeller for the session may be needed (Ackermann, 1990).

The fifth dimension is the *degree of flexibility of the modelling rules* being employed. Some methodologies, such as Decision Analysis and System Dynamics, require stricter specification of variables and the fulfilment of a larger number of structural properties. On the other hand, models that use mainly qualitative modelling are usually more flexible in their modelling rules. Stricter rules usually permit a higher level of inference in the model, particularly important when appraising alternatives and policies. Conversely, the flexibility is beneficial for representing situations where there is high ambiguity of meanings and multiple perspectives, which are common features in problem structuring. Furthermore, some complex decision problems may require different levels of formal analysis and interaction with the group (for instance, from representing the problem with a qualitative model to evaluating options quantitatively). Such features then guide the choice about the degree of flexibility of its modelling rules required and, consequently, the choice of the OR method to be employed in the intervention.

The final dimension we suggest is the *degree of content facilitation* required in a modelling session. Although there is some debate among facilitative modellers as to the need to contribute to content and use of substantive expertise (see, for example, Huxham and Cropper, 1994), we argue here that some facilitated modelling approaches require more content facilitation that others. For example, SODA, Decision Conferencing and Group Model Building, tend to demand stronger content facilitation and in some cases require the use of more than one facilitator (e.g. SODA uses one facilitator for managing model content, the other one for managing group process). On the other hand, approaches such as Strategic Choice can allow a group to become self-facilitated after the coding guidelines of the modelling approach have been internalised by the participants (the same can be said about Soft Systems Methodology). This means that a less central role may be required for the facilitative modeller in such cases, who will only have to ensure that the coding guidelines are being followed throughout the process. In addition, allowing groups to self-facilitate themselves within the modelling session can help to keep up the momentum and energy levels within the group, and increase their ownership of the resulting model. On the other hand, it does require that the group is self-motivated and competent enough to perform the tasks that the facilitator is requiring.

The dimensions we just described are somehow idiosyncratic, as they are drawn from our particular experiences as facilitative modellers, but we hope that they provide useful insights into the design choices open to a facilitative modeller. In Table 5 we present a summary of each dimension, with its description, the range it can vary and some implications for practice.

7. Conclusions and directions for future research

This paper reviewed a particular mode of OR intervention in organisations: facilitated modelling – a process by which OR models are created jointly with clients in a facilitated mode. The paper distinguished such mode of intervention from the more traditional expert mode, usually adopted by OR consultants. It suggested a definition for facilitated modelling, and discussed several of its main aspects such as the process of facilitated modelling, the nature of facilitative models, the outcomes that can be expected from facilitated modelling interventions, and the skills required by the facilitative modeller. It also proposed a classification of facilitated modelling approaches based on the OR methodologies from which they have been developed; and a set of dimensions that may be relevant when designing facilitated modelling interventions.

We have noted that facilitated modelling in OR significantly differs from traditional (i.e. non-model based) facilitation. We have also stated that facilitated modelling demands a particular set of skills on the OR consultant. Previous incursions in this field, from an OR perspective, never made explicit such important distinctions. In this sense, this paper is an attempt at providing a framework that could allow a better understanding of facilitated modelling interventions.

Another aspect that is relevant to highlight is that, in our view, there is not a 'best' mode of organisational intervention; such choice has to be made based on the nature of the problem situation that OR consultants are dealing with, as well as their own preferences (Cropper, 1990). This is in contrast to suggestions that one is better than the other, or that there is one 'right' approach to OR interventions. Nevertheless, we should say that, from our practical experience, the facilitated mode is particularly suitable for supporting the main phases of strategic decision making: the structuring of complex problematic situations and/or the evaluation of strategic decision options.

Several areas for further research can be envisaged, and we suggest some of them below:

- *Better understanding of facilitated modelling processes in practice*: Most of the evidence about the use of facilitated modelling in practice has tended to be purely anecdotal. There have been recent attempts to conducting research on this topic using more systematic observation and analysis (e.g. Afordakos et al., 2008; Shaw et al., 2003; White, 2006), and much could be learnt with more extensive research programmes in this area.
- *Generalisation of best model-based facilitation practices*: Following from the previous item, a better understanding of facilitated modelling practices could (and should) be focused on trying to generalise best model-based facilitation. We feel that just importing the literature of standard facilitation is not always viable, as facilitated modelling is a complex endeavour requiring a variety of skills and behaviours. Although there is some evidence of work in this area (e.g. Ackermann, 1996; Akkermans and Vennix, 1997; Papamichail et al., 2007), there is still significant scope for further work.
- *Systematic assessment of outcomes from facilitated modelling interventions*: Most of the literature on facilitated modelling makes bold claims on the outcomes that it provides, as reviewed in this paper. However, the number of studies that tried to systematically assess such outcomes is quite limited (e.g. Rouwette et al., 2002; Schilling et al., 2007; Westcombe et al., 2006). There is thus wide scope for further studies in this area, both in the laboratory and the field.

- *Test the validity of design dimensions for facilitated interventions*: This paper suggested a set of dimensions that, in our view, should be considered when designing a facilitated modelling intervention. It would be interesting to conduct empirical research to test the validity of such dimensions.
- *Development of OR methodologies for facilitated modelling*: Most of the methodologies employed in facilitated modelling have been adapted to a facilitated mode (problem structuring methods being an exception, as they were specifically developed within a facilitation paradigm). We believe that the facilitated mode places constraints in the way an OR methodology should be designed (for example, on the type of data that it requires and how it displays information). Further research is required to understand systematically such issues and prescribe ways for re-designing OR methodologies in this context.

Concluding, we believe that the OR community has much to gain in better understanding facilitated modelling as an intervention tool. The nature of modern organisations, less hierarchical, more participative, with more distributed knowledge and power, tends to favour this type of intervention, particularly for tackling complex strategic decision problems. We hope this paper stimulates more research in facilitated modelling, and encourages more operational researchers to adopt this form of OR intervention.

Acknowledgement

We would like to thank the detailed and insightful feedback of two anonymous referees, which helped to improve our draft.

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