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On Evaluating the Performance of Problem Structuring Methods: An Attempt at Formulating a Conceptual Model

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Abstract   In the past decade there has been a discussion on the need for and degree of empirical evidence for the effectiveness of problem structuring methods (PSMs). Some authors propose that PSMs are used in unique situations which are difficult to study, both from a methodological and a practical perspective. In another view experimental validation is necessary and, if not obtained, PSMs remain substantially invalidated and thus 'suspect' with regard to their claims of effectiveness. Both views agree on one point: the necessity of being clear about the important factors in the context in which a method is used, the method's aims and its essential elements through which these aims are achieved. A clear formulation of central variables is the core of a theoretical validation, without which empirical testing of effects is impossible. Since the process of PSMs is sometimes referred to as 'more art than science', increased clarity on the PSM process also supports the transfer of methods. In this article we consider goals important to most PSMs, such as consensus and commitment. We then focus on outcomes of group model building, and expectations on how context and group modeling process contributes to outcomes. Next we discuss the similarity of these central variables and relations to two sets of theories in social psychology: the theory of planned behavior and dual process theories of persuasion. On the basis of these theories we construct a preliminary conceptual model on group model building effectiveness and address its practical applicability for research on PSM.

Keywords   Problem structuring methods · Group decision support · Group model building · Group decision making · Evaluation · System dynamics

1 Introduction

In his 1995 article Eden compares the view on evaluation, held by proponents of the mainly UK-originated 'wide-band' group decision support systems, to the view dominating the

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US-based workstation approaches. In subsequent discussions different terms were used to refer to the two traditions. Morton et al. (2003) refer to 'technology-based' (workstation approaches) and 'model-based' traditions ('wide-band' systems). In this paper we refer to the 'wide-band' or model driven approach by the term problem structuring methods (PSMs), which is used by Rosenhead and Mingers (2001) and Mingers and Rosenhead (2004). For workstation or technology driven approaches we use the term Electronic Meeting Systems (EMSs), (Pervan et al. 2004). There is some debate on the overarching term that includes both types, especially on the inclusion of 'decision' in group decision support systems (Eden 1995; Finlay 1998). We refer to group support system (GSS) as an overarching term that covers both types.

The different views on evaluation held by EMS and PSM proponents center on the empirical support for the effectiveness of either approach. Eden (1995, 2000) and other authors have repeatedly pointed out that the different views on evaluations in the PSM and ESM field are grounded in differences in philosophical and practical orientations. Below we first discuss the philosophical orientation of each stream and then address the consequences of this orientation for empirical and theoretical validation of methods.

EMS originated in the Information Science field which, according to Morton et al. (2003), makes the underlying computer system the central focus of research. The use of formal propositions, quantifiable measures of variables and sampling procedures point to a positivist philosophical orientation, which favors comparability of situations and experimental studies on effectiveness (see for example Zigurs 1993). Studies on EMSs share a meta-analytical framework (Pinsonneault and Kraemer 1989; Stevens and Finlay 1996) which makes results easy to compare. An important aim of EMS is effective and efficient data collection (Eden 1995), although Finlay (1998) extends their goals to supporting decision making.[1] In the last few years several meta-studies have appeared that provide an overview of EMS research (Pervan 1998; Fjermestad and Hiltz 1998, 2000; Dennis et al. 2001). Morton et al. (2003) conclude that the discipline seems to think of itself as offering a product that may improve decision making, which is reflected in a topic in the evaluation of workstation approaches which currently receives much attention: the lack of adoption of the systems in organizations (e.g. Briggs et al. 2003).

In contrast, the model-based approach originates in Operational Research/Management Science and focuses on the different sorts of decision models (Morton et al. 2003). Researchers working in the model-based tradition are concerned with the understanding of a phenomenon in its context and from the perspective of participants. Research is interpretivistic in nature and often takes the form of action research. Finlay (1998, p. 195) points to subjective idealism and normativism as the underlying philosophy of PSMs. Besides understanding the perspective of the participants, PSM proponents aim to help a group in deciding how to act and support the creation of commitment to future actions (Eden 1995). In contrast to offering a product, '… model-driven researchers are more likely to see themselves as offering a 'problem structuring' (…) or 'problem consultation' (…) *service*, a vital component of which is the skill of the change agent' (Morton et al. 2003, p. 115, italics in original). This service depends on the context encountered and the facilitator plays a central role. An important issue in the evaluation of model-based approaches is the transferability of the approaches, the 'transmission of their skills and tacit knowledge to potential practitioners of the method' (2003, p. 115).

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[1] Scheper (1991) points out that the meta-theoretical frameworks on EMS effectiveness in fact do not constitute a theory since they propose relations to categories of variables, whereas a theory would be based on relations between variables.

The philosophical underpinnings of both streams are reflected in their approach to evaluation. Eden (1995) feels that PSMs such as Soft Systems Methodology (Checkland 2000), the Strategic Choice Approach (Friend 2001; Friend and Hickling 1987) and Strategic Options Development and Analysis (now Journey Making) (Ackermann and Eden with Brown 2005) are criticized because empirical support for their effectiveness is said to be lacking. In contrast, the effectiveness of EMSs such as GroupSystems, SAMM and MeetingWare is tested in controlled experiments. If results of these experiments do not lead to a rejection of hypothesized effects, the impact of the methods on intended aims is established and the method in this sense 'proven'. Eden points out that controlled experiments are difficult to use in the case of PSMs. Controlled experiments require an extensive structuring of the complex situation in which a method is used, and may in the case of PSMs lead to a 'controlling out of the experiment' of key elements of the situation and intervention (Eden 2000, p. 219). The scope of the goals and the uniqueness of the situations in which 'wide-band' systems are used make it difficult to evaluate their performance. Since experimental evaluation is founded on the repeatable characteristics of situation and intervention, Eden feels using this type of research for 'wide-band' approaches is 'positively misleading rather than just inappropriate' (1995, p. 303). Nevertheless Finlay (1998) points out that even in the complex situations encountered by PSM proponents, regularities must be present and field experiments and questionnaires can be used to study these. In contrast, Eden (1995, 2000) proposes to use all data available but carefully weight the pros and cons of each research approach. Questionnaire research provides valuable data, but there are several drawbacks. Participants are difficult to use as research subjects, structured answer formats are often unfeasible and respondents' recollections might be biased. Follow-up in-depth interviews sometimes put the conclusions from questionnaires in a new light, which leads Eden (2000, p. 220) to question the reliability of questionnaires as a data source for PSM studies. Video-recordings of PSM sessions are another source of data. Since the object of study is a complex social phenomenon, he prefers to use collaborative research, action research (see also Checkland 2000, p. S41) and case studies (see for example Burt 2000; Burt and Van der Heijden 2003). Eden (1992, 1995) reserves an important role for theoretical validation, which concerns questions such as: are the theories on which the method is founded coherent? To what degree does the method's design and process reflect the theory? In addition to the practical and methodological implications of using different data sources, the formulation of evaluation criteria is an issue of concern in PSM research. Eden and Ackermann (1996) point out that academics might prefer a particular set of evaluation criteria but developers, facilitators, clients, key actors and vendors of PSM approaches might employ other criteria to judge the effectiveness of an approach. The effects of model-based approaches have been documented in numerous case studies, and meta-analyses are beginning to appear (Mingers 2000; Rouwette et al. 2002; Mingers and Rosenhead 2004).

Besides the differences of opinion, the debate between researchers on PSMs and EMSs also reveals an important point of agreement. Both sides seem to agree on the importance of a clear conceptual model for GSS effectiveness. Without a clear idea of central concepts and their relations, outcome variables for experimental or survey research cannot be defined and operationalized. In addition, context and process variables need to be identified and clearly distinguished. 'The internal validity of the findings from the 'wide-band' GSS is extremely low. There is confounding of many things—of the facilitator him/herself, of the methodology, of the situation in which the methodology is used, the implementation of any computer-based aid etc.' (Finlay 1998, p. 199). Nevertheless, the conceptual model informing the design of an intervention is also a central subject in the PSM community. Eden (1992, 1995) sees theoretical validation as a goal in its own right. He states that a PSM should be clear on

group decision making *as a process*, decision making *in organizations* (…), and the nature of support *and intervention* by a "system" (1992, p. 213–214, italics in original; see also 1995, p. 306). He feels there is no common set of goals for all PSMs, but a specific PSM should be clear about its assumptions with regard to these three subjects. In their overview of PSM research, Morton et al. (2003) see the following important explanatory variables: the type of model, various dimensions of facilitation, the role of the client and the stage of decision making (for example divergent–convergent). Important process variables are negotiation (of agenda and meaning), elicitation and accommodation of problem views. Central outcomes are commitment to future action and learning. In the PSM tradition there appears to be no equivalent to the meta-analytical framework which is used in EMS research. In addition, as Morton et al. (2003) show, the central concepts in both disciplines are substantially different so that the EMS framework cannot readily be used in PSM studies. Increased clarity on central variables in GSS would also help in making the tacit knowledge of PSM proponents more explicit. Indeed Eden and Radford (1990) speak about the 'method in use' which can be very different from the 'espoused method' which is featured in the textbooks. Eden (1995) identifies as one of the main points of criticism of PSMs that they are only successful when used by their proponents. In applying a PSM the facilitator makes many consequential judgments, which are important factors in the evaluation of the intervention (Eden and Ackermann 1996, p. 510, 2006). However, a dependence on facilitation makes transferability and broader use of PSMs problematic (Eden 1995, p. 307). Finlay (1998, p. 199) calls for articulating the understanding of important aspects of an intervention, so that experiences can be used in other applications of the method. In a recent series of viewpoint papers, increased transparency is identified as one of the key challenges for the future of PSMs (Eden and Ackermann 2006; Westcombe et al. 2006; Checkland 2006).

The above discussion on evaluation of PSMs leads to three conclusions. First, there is a clear need for a conceptual model on the context, process and outcome of PSMs for several reasons: (a) a conceptual model helps to test the coherence of the method's theory and its similarity to the practical use of the method; (b) the model is useful for identifying and defining central variables for research; (c) the model provides more clarity on central aspects of context and process, which help to identify practical guidelines that can aid a novice in the use of the method.

Second, such a conceptual model is currently not available. Although there is some overlap in the concepts used by various PSMs (Morton et al. 2003), at present there is no shared conceptual model of PSM effects available. Transferring a conceptual model from EMS for use in PSM research is difficult since central concepts are different, and the model of EMS is meta-theoretical in nature (Scheper 1991).

Third, the degree of overlap between goals of PSMs is a debated issue. Each PSM has specific goals (Eden 1992) and uses a specific type of model and possibly facilitation (Morton et al. 2003). However, in evaluation studies of most PSMs goals such as commitment and consensus play a prominent role (Mingers and Rosenhead 2004). It seems therefore that there is some overlap between goals on a general level, but as one delves deeper differences between PSMs will surface. In this study we first identify goals which are to some extent shared among PSMs, and then select one specific approach to identify more detailed ideas on context, process and outcome.

The remainder of the paper is organized as follows. In the following section we first look at central variables in the evaluation of three widely used PSMs (SSM, SODA/Journey making and SCA). We choose these three methods as our focus since they are the most widely used and recognized PSMs (Eden and Ackermann 2006; Rosenhead and Mingers 2001). We then select one particular approach as our focus. For this method, group model building, we

explore the literature to identify assumptions on central elements of context, process and outcome. In the subsequent section we translate these central elements into variables and relations in a preliminary conceptual model. The concepts and relations in this model can be addressed from many different theoretical perspectives. The prominent role of subjectivism and concepts at the individual and small group level, lead us to choose theories from social psychology as a basis for a conceptual model. In the conclusions we address the practical usefulness of the conceptual model in evaluation of group model building and PSMs.

2 Context, Mechanism and Outcome Variables in the PSM Literature

In this section we look at generic context, process and outcome elements of PSMs. Morton et al. (2003) describe the following process variables that are generic to PSMs: elicitation, negotiation and accommodation of problem views. They also identify two outcomes common to methods: commitment to future action and learning. Descriptions of three PSMs, SODA/Journey making, SSM and SCA, reveal other similarities with regard to process and outcome. Consensus and commitment are two central goals of SODA/Journey making (Eden 1989, p. 22; Eden and Ackermann 2001a). Checkland (1989, p. 77) and Checkland and Scholes (1990) describe SSM as a process in which autonomous individuals through negotiation arrive at shared perceptions and an accommodation of interests. Friend (2001, p. 142) describes how SCA aims to facilitate decision making and involves the creation of a commitment or progress package. Individual ideas, cognitions and evaluations are also discussed in descriptions of these methods. SODA is based on Kelly's (1955) theory of personal constructs (Eden 1989). Checkland (2000, p. S33) points out that problem definitions are of necessity generated by human beings. Differences in evaluations of options lead to differences in actions, which result in issues with which a manager must deal (1989, p. 79). SCA explicitly takes uncertainties on guiding values into account (Friend 2001, p. 117; Friend and Hickling 1987).

Similarities with regard to process can be identified as well. Eden (1989, p. 25) describes the central role of concepts in structuring problems and 'language as the currency of organizational life'. Friend (2001, p. 120) sees the support of communication among decision makers as the main purpose of problem structuring. Eden (1992, p. 205) identifies information exchange and egalitarianism as two central elements of PSMs. He also seems to refer to different paths for changing mental models in the following (Eden 1992, p. 208):

> In group decision making we expect to see a shift in emotional attitudes as well as a cognitive shift to the problem situation. Changes in emotional attitude reflect, in part, the role of intuition and hunch which leads to a feeling of comfort about the path ahead (…). Cognitive shifts are about someone "changing their mind" – changed beliefs, changed values, and changes in the salience of particular values (…) As I have argued above, it is more likely that the procedural rationality will influence emotional attitudes, and substantial rationality will influence shifts in cognition; however, each supports the other.

Procedural rationality is concerned with following the proper process, while substantive rationality refers to the arguments that can be brought to bear on a person's position. Checkland (1989, p. 83) refers to negotiation and debate as the vehicles through which people learn and arrive at shared perceptions. Both Checkland and Eden refer to the comparison of individual models to achieve learning. It seems that SSM and SODA/Journey making attend to facilitated (egalitarian) discussion in order to achieve changes in participants' ideas and goals (mental models) (see also Pidd 2003). Checkland (2000, p. S33) for example points

to two foci of SSM that inform each other: the sensemaking and action-oriented orientation. Changes in mental models are expected to contribute to consensus and commitment to future actions.

3 Context, Mechanism and Outcome Variables in the Group Model Building Literature

In this section we look at central factors discussed in the literature on group model building. Before we turn to the group model building literature, we first address similarities and differences between this particular method and PSMs.

Group model building is based on system dynamics and seeks to involve clients in the modeling process. Thus, similar to PSMs, group model building rests on a combination of modeling and facilitation (Morton et al. 2003; Richardson and Andersen 1995; Vennix et al. 1996; Andersen and Richardson 1997). Mingers and Rosenhead (2004; Rosenhead and Mingers 2001; Rosenhead 1996) see system dynamics as falling outside the category of PSMs but similar in some of its modes of use. We would argue here that system dynamics in the mode of group model building resembles PSMs in important respects (Andersen et al. 2007). Most importantly, PSMs and group model building share a focus on people's perceptions (Woolley and Pidd 1981). Rosenhead (1989) and Rosenhead and Mingers (2001, p. 11) describe a number of characteristics of methods for problem structuring: the approaches seek alternative solutions which are acceptable on separate dimensions (not focusing on optimization), integrate hard and soft data with social judgments, are simple and transparent, view people as active subjects, facilitate bottom-up planning and accept uncertainty (see also Ackermann and Eden with Brown 2005; Eden and Ackermann 2006). Lane (1994, p. 115) notes that most system dynamicists would be comfortable in using these characteristics to describe their own field. Some authors from outside the field argue that system dynamics does not see people as active subjects, but instead as controlled by system structure (e.g. Flood and Jackson 1991). Lane (2001a) however shows that system dynamics is not deterministic in this sense, but also that the approach is difficult to place in terms of traditional social theories (2001b). He identifies various modes of using system dynamics and points to a realist strand in the field's thinking (2001a, p. 106). Zagonel (2004) concludes that models constructed in group model building sessions have a dual identity: at some points in the modeling process they are seen as descriptions of the real world (micro-worlds) and at other times as socially constructed artifacts (boundary objects). Although the product of group model building and PSMs might not be identical, the process of both approaches has much in common. Thus we think it is useful to review the group model building literature to see which central terms practitioners in this tradition use to describe their approach.

The two generic goals of PSM, commitment to future action and learning (Morton et al. 2003), can also be found in the literature on group model building. Forrester's founding ideas of system dynamics (1958, 1961) include an integrative perspective on material and information flows and decisions, and the explanation of system behavior from the closed loops between the state of the system and stakeholders' decisions. The ultimate purpose of system dynamics interventions is then to improve the performance of the system, and it was readily recognized that stakeholders' opinions, convictions or ideas on system functioning are crucial in accomplishing this. Stakeholders' mental models include important information on the issue of concern, part of which cannot be found in other information sources (Forrester 1961; Morecroft 2004). Mental models do not only provide information on the functioning of the system as a whole, but are also the base for an individual stakeholder's

Table 1 Goals of group model building

Level	Intervention goal
Individual	Positive reaction
	Mental model refinement
	Commitment
	Behavioral change
Group	Increased quality of communication
	Creation of a shared language
	Consensus and alignment
Organization	System changes
	System improvement or results
Method	Further use
	Efficiency

actions. Policies within the larger system are founded on the decision maker's limited store of information and decision rules. The mental model determines which system variables are scanned for information as well as the goal to be reached. It is therefore not surprising that mental models are central to modeling practice. Doyle and Ford (1998, p. 4) formulate this as follows:

> Mental models are thus the stock in trade of research and practice in system dynamics: they are the "product" that modelers take from students and clients, disassemble, reconfigure, add to, subtract from, and return with value added.

It seems natural that the dual need to ensure access to stakeholders' mental models and to transfer insights gained during the modeling process, would lead to participation of stakeholders in the modeling process. Benefits of involvement have been described early on in the literature (Roberts 1978), and are more systematically explored in publications on participative modeling formats (e.g. Randers 1977; Richmond 1987; Wolstenholme 1992). Early publications focus on exploring methodological guidelines for involving stakeholders and clients in the modeling process and from the 1980s on evaluation studies on the effectiveness of these approaches have appeared regularly (Rouwette et al. 2002). Group model building approaches, used in a broad sense to refer to participative system dynamics modeling generally, are widely used (see the special issues of European Journal of Operational Research in 1992, System Dynamics Review Summer 1997 and Fall 2001). Similar to the PSM literature, evaluation of group model building often takes the form of case studies focusing on a wide diversity of outcomes. A systematic research program is missing (Vennix et al. 1997; Andersen et al. 1997; Rouwette and Vennix 2006). A couple of attempts at reviewing the existing research have tried to extract and define central outcomes of group model building.

Huz et al. (1997) propose a comprehensive model for evaluating system dynamics modeling. On the basis of these goals and the literature analysis by Rouwette et al. (2002), four levels of intervention goals were formulated: individual, group, organizational and methodological (Table 1).

At the individual level four goals can be identified. Several authors stress the importance of clients' reactions to the model or other elements of the intervention, such as trust in the modeler (Lane 1992). All approaches underline the importance of learning; clients are

encouraged to take a broader perspective on the problem modeled. In the system dynamics literature, learning, increase in insight and mental model refinement are seen as closely related (Morecroft 2004). Richardson et al. (1994) distinguish three elements of a mental model. A representation of prerequisites for actions such as strategies, tactics and policy levers is referred to as a means model. The ideas on the dynamic system are stored in a means/ends model. The ends model contains goals. Commitment to results and the resulting changes in behavior are also widely agreed on as important goals of client involvement (e.g. Eden 1992; Morton et al. 2003). Discussions on shared language and communication are relatively scarce in the methodological literature in system dynamics (although see Akkermans 1995, p. 201 for a discussion of the central role of communication). If mentioned, they seem to be considered one of the elements affecting insight. The impact of group model building on consensus and alignment of mental models has been the central topic of a recent dissertation (Huz 1999). In many descriptions of the phases of modeling (e.g. Richardson and pugh 1981), the implementation of system changes forms the final step. However, more and more authors describe implementation as a goal pervading the complete process of model construction (e.g. Roberts 1978; Vennix et al. 1996). It seems logical to expect system improvement to be a goal even higher in the hierarchy, for which commitment and implementation are a prerequisite. Behavioral change is the equivalent of implementation at the individual level. The methodological goals in the table above are less often discussed and do not bear directly on the topic addressed here. We refer the reader to Rouwette et al. (2002) for more information on this level of goals. It is worth noting that placing goals in a single list might confer the erroneous message that goals are equally important across all modeling projects. This is probably a simplification. Depending on the situation or modeler, specific goals might be emphasized and others ignored (Zagonel 2004).

A further question is how these goals are brought about in applying the method. Why does the intervention lead to insight, consensus or behavioral changes? In the system dynamics literature as well as in the PSM literature (Morton et al. 2003) two crucial elements of the methodology are distinguished: facilitation and model construction. Vennix et al. (1996); Vennix (1999) sees facilitation as a way to overcome the drawbacks of freely interacting groups. The group process is for instance designed with an eye to separating production and evaluation of ideas, in order to minimize process losses. A facilitator enacts the behavior expected from group members and limits the need for face saving operations. Modeling also operates as a shared language, which can bridge the differences between separate functional departments (Richmond 1997; Campbell 2001). The mainstream of publications on system dynamics methodology is however not concerned with group decision making or facilitation, but instead focuses on model content: analysis of structure and behavioral patterns, validation and testing, and policy experimentation. The system dynamics model and participants' mental models are expected to be closely related. Most system dynamicists would probably consider the development and analysis of a model as the main vehicle to produce insight. This resembles the view of models as transitional objects or items people can play with in order to refine their understanding of a particular subject (Morecroft 1992; Zagonel 2004; see also Eden and Ackermann 2001b). Lane (1992, p. 74) sees the function of models as making the view of participants more coherent: '…goals which seemed reasonable when only part of the system was viewed are seen as inconsistent or impossible in the context of the whole system.' Vennix (1995) provides a clear example in his study for the Dutch Department of Transportation and Public Works. The central issue in the study was the declining size of the Dutch-registered merchant fleet. The three strategic areas in the department, the ports, maritime traffic at the North Sea and the Dutch fleet, had widely different goals with regard to the merchant fleet. The model constructed in the study showed the effects of fleet size

on the two other areas, and in so doing revealed unexpected relations between the strategic interests. While the representatives of the three groups were at first unwilling to support further subsidies for the merchant fleet, they all agreed to a proposal to continue funding after the modeling intervention. This points to an impact of modeling on the ends model (Richardson et al. 1994). In a more general sense, Vennix et al. (1996); Vennix (1999) relates the construction of a system dynamics model to individual perception and retention processes. The human information processing capacity cannot deal adequately with complex systems, as humans are biased in their decision making and fail to see feedback processes (Sterman 1994). A model helps participants to structure the problem and enables them to put their problem definitions to the test.

After reviewing the group model building literature to identify central concepts in outcomes, process and context of the approach, it appears that there are many similarities with ideas in the PSM community. What is also similar is that neither in the PSM nor in the GMB literature a generic conceptual model on intervention effectiveness can be found and there is no systematic testing of central assumptions. The PSM and group model building communities have been implicit in answering questions such as 'does the approach work?' and 'how does the approach work?' In addition, context variables receive little attention. What are the relevant conditions for an intervention to work, and which context variables are especially effective in influencing its outcomes? One could for example expect that group model building has different effects in a highly political context than in a less political setting. Pawson and Tilley (1997, p. 69) argue that a realistic comparison of evaluation studies boils down to discovering which combinations of mechanism and context lead to which outcomes. Similar statements on the importance of context variables can be found in the literature on other interventions, such as EMSs (McGrath and Hollingshead 1994, p. 78) and Delphi (Rowe and Wright 1999). In the following section, first the main goals, process elements and context elements are reformulated as variables in a conceptual model of intervention effectiveness. Next, theories of social psychology are used to describe relations between concepts.

4 Conceptual Model

So far intended outcomes of methods been described, and two general features of the intervention that help in creating these outcomes: modeling and facilitation. The question then becomes how goals and intervention elements can be related to one another. A myriad of disciplines within management and the broader social sciences can be brought to bear on each of the outcomes of group model building. There is for example a rich literature on escalation of commitment to failing decisions (e.g. Brockner 1992; Staw and Ross 1978). Commitment has been studied extensively in the management sciences, which has for example led to the conclusion that the concept may be difficult to use in non-Western cultures (Near 1989; Randall 1993). Thibaut and Walker (1975), Korsgaard et al. (1995) and others found that a sense of procedural justice increases personal commitment to decisions, see also Eden and Ackermann (1998, p. 53). Consensus is among others studied in sociology (Siegrist 1970), semiotics (Eco 1976; see Scheper 1991; Scheper and Faber 1994), strategic management (Markóczy 2001), group decision making (Stasson et al. 1988) and in relation to prescriptive approaches (Susskind et al. 1999). In what follows we focus on participants in a group model building or PSM session and the way in which their behavior is changed. This focus on the way in which elements of the intervention (including the group of other participants) influence an individual participant draws attention away from impacts at the level of organizations or the method, but makes it possible to draw on psychological theories to

relate intervention elements and goals. From the wealth of possible approaches we therefore choose social psychological theories to frame the central elements of group model building. There are a couple of reasons for choosing to construct a preliminary conceptual model from this perspective. First, group model building and PSMs start from personal views on the problem at hand and descriptions of the various methods focus on work with individuals and small groups. Individual ideas or mental models are the starting points for modeling and the facilitated communication process. Although, for example Ackermann and Eden with Brown (2005) refer to strategic management theory, their major concern is with the individual stakeholders. PSMs do not take the organization to be the client of a project but rather focus on an individual or small group. Second, central goals such as consensus and commitment are formulated at the level of individuals or small groups. Even though the process of intervention and implementation of results is clearly influenced by the organizational context, individual learning and commitment to action is the focus of the intervention. Taking a closer look at the individual level, it seems that group model building and PSM practitioners assume that there is a relation between communication, cognition (in the form of mental models and consensus) and behavior. In the following we first focus on the relation between cognition and behavior, and then turn to the relation between communication and cognition.

4.1 Relation Between Cognition and Behavior

In their review of social psychological research, Eagly and Chaiken (1993) concentrate on a particular cognitive structure whose relation to behavior has been studied extensively. They refer to attitudes, which are distinct from other cognitive structures in their emphasis on evaluation. Eagly and Chaiken (1993, p. 1) use the following conceptual definition of attitude: 'a psychological tendency that is expressed by evaluating a particular entity with some degree of favor or disfavor.' The term evaluating is used in a broad sense and captures overt as well as covert responses, cognitive, emotional and behavioral. As a central topic in social psychology, the relation between attitudes and behaviors has generated some controversies. From the mid-1960s to the mid-1970s, the idea that attitudes were poor predictors of behavior was accepted widely. This assumption was supported by a number of studies showing no or weak relationships between the two concepts (e.g. Wicker 1969). According to Eagly and Chaiken, the popularity of research into the impact of behavior on attitudes (e.g. Festinger 1957) made it difficult to consider the causal link in the reverse direction. Reactions to these criticisms focused on the bias towards laboratory studies in Wicker's study, that mainly measured attitudes low in importance and involvement, on the situational barriers against expressing some behaviors (e.g. negative behavior towards minorities) and on the level of aggregation of attitudinal and behavioral measures. Fishbein and Ajzen (1975) make an important contribution in this regard when arguing for compatibility between measures in order to ensure a substantial correlation. They suggest that general attitudes with respect to organizations, institutions, groups, individuals or ideas are good predictors of general behavioral categories summed over multiple behaviors. In contrast, specific attitudes will be good predictors of specific actions. Ajzen (1991, 2001) proposes a theory of the impact of attitudes on behavior which is based on influential earlier work by Fishbein (1967) and Fishbein and Ajzen (1975). Figure 1 shows the central variables and relations in Ajzen's model.

In the model, a central role is reserved for a specific attitude called the attitude towards behavior. Attitudes towards behaviors are evaluations of the subject engaging in a single behavior or set of behaviors (Eagly and Chaiken 1993, p. 164). The attitude towards a behavior is the emotion for or against this action on a scale of good versus bad (Van den Putte 1993, p. 5). Fishbein and Ajzen suggest that the attitude towards behavior relates to behavior
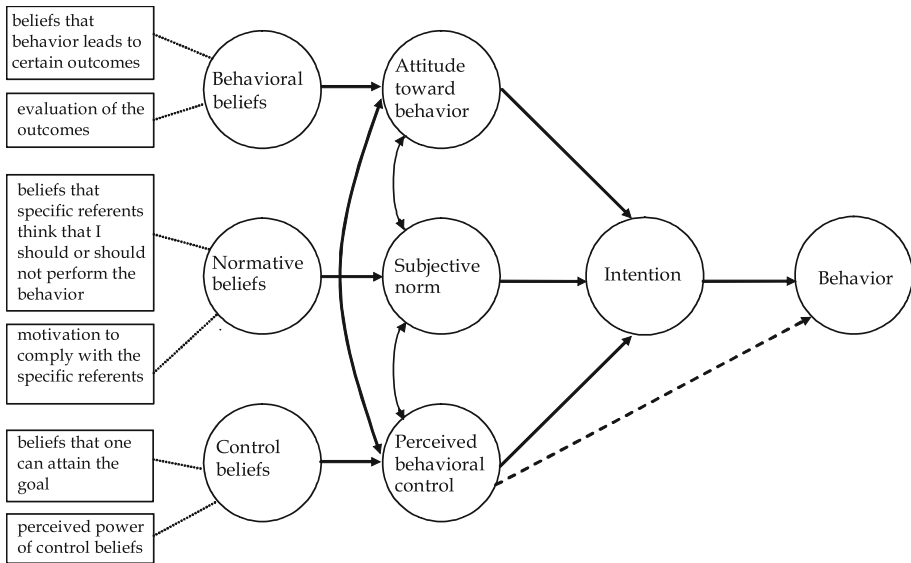
Fig. 1 Theory of planned behavior (adapted from Ajzen 1991, p. 182). The broken arrow at the right-hand side indicates that perceived behavioral control is only predictive of behavior if it is an accurate estimation of actual control

through its impact on intentions. The attitude influences intention, which forms the basis for action. Ajzen (1991, p. 181) describes intentions as follows:

> Intentions are assumed to capture the motivational factors that influence a behaviour; they are indications of how hard people are willing to try, of how much of an effort they are planning to exert, in order to perform the behaviour.

In other words, intentions motivate the decision to act in a particular way. In addition to attitude toward behavior, intention is also determined by the subjective norm. The subjective norm reflects a subject's belief that significant others think he or she should engage in the behavior. Significant others are the referents whose preferences a person takes into consideration in a certain domain of behavior. Above evaluations were described as cognitive, emotional and behavioral responses to a particular entity. The description so far makes it clear that in the theory of planned behavior emotional (attitude and subjective norm) and behavioral aspects of evaluation (intention and behavior) are separated.

The theory also considers the cognitive foundation of attitudes. Attitudes are seen as a function of behavioral beliefs about consequences of an act. An example might illustrate this. Suppose an important action is recruitment of additional personnel by the HRM department of a telecommunication provider. A person's attitude towards this action is formed on the basis of two sets of beliefs. The first is the *value* placed on outcomes of this action. The second belief concerns the *expected likelihood* that the action brings about this outcome. A possible outcome is for example an increase in innovation potential of the organization. Let us suppose that a human resource manager positively values this outcome. Considering only this action (increasing recruitment), the chance that the valued outcome will be realized is the expected likelihood that recruitment leads to an increased innovation potential. If either innovation is valued more, or the relation between recruitment and innovation potential grows stronger, we expect the attitude towards recruitment to become more positive. In other words,

values and expectancies combine to form evaluations. Fishbein and Ajzen (1975) propose to sum expectancy times value products over all beliefs to arrive at an indicator for behavioral beliefs.

Likewise, subjective norm is a function of normative beliefs and motivation to comply. A normative belief captures the perceived likelihood that a referent approves or disapproves of performing the behavior. This is multiplied with the motivation to comply with the specific referent, and again summed over all salient beliefs. In the above example, the human resource manager might have the following normative beliefs and motivation to comply. An example of a belief of a normative belief, is when the manager thinks that the telecommunication provider's HRM department strongly favors increasing recruitment. If we also suppose that this person has a strong inclination to follow the opinion of the HRM department, his subjective norm towards increasing recruitment will be positive. Since both normative beliefs and motivation to comply are positive, we expect a positive subjective norm.

The third influence on intentions in the theory of planned behavior, is perceived behavioral control. Perceived behavioral control is again determined by control beliefs, beliefs about the likelihood that one possesses the resources and opportunities thought necessary to execute the behavior (Eagly and Chaiken 1993, p. 187). First, there is the chance that a threat or opportunity will occur. In the previous example on recruitment, this could be the likelihood of a tight labor market on which few applicants can be recruited. Second, there is the degree to which the threat or opportunity is expected to influence implementation of the action. If a tight labor market prevents recruitment of employees, this lowers perceived behavioral control. Apart from its influence on intention, Ajzen also maintains that perception of control directly influences behavior to the extent that it reflects actual control (the broken arrow in Fig. 1). Only if a person's estimation of perceived behavioral control is accurate can it be used to predict the probability of actually performing the behavior.

The concepts in the theory of planned behavior can be related to the goals of PSMs and group model building discussed earlier. First, intention is similar to the commitment in that both capture the effort a person wants to exert in order to reach a goal (Vennix et al. 1996). The attitude toward behavior is closely related to the ends model described by Richardson et al. (1994). Huz's (1999) operationalization of the ends model resembles the cognitive foundation of attitude toward behavior in beliefs about outcomes and evaluation of outcomes. Huz asks respondents to evaluate a list of system goals by rating their importance. The subjective norm and normative beliefs closely resemble consensus. Consensus and subjective norm are similar in their emphasis on the subjective or personal definition of the important aspects of a situation. Consensus is based on concepts, properties and relations between concepts, which is cognitive in orientation (Scheper 1991). Subjective norm is defined as an emotional evaluation, while its cognitive foundation in the theory of planned behavior is sought in beliefs about important referents. With regard to the scope of the definition, the definition of subjective norm seems to be more restrictive. Ajzen and Fishbein (1980, p. 76) suggest that a limited set of beliefs are considered when forming an evaluation, i.e. only those beliefs that are salient. Scheper essentially does not place any boundaries on the concepts or relationships that are considered. Consensus and subjective norm thus differ with regard to the level at which they are defined, but subjective norm can be interpreted as the individual perception of the consensus view in a group. Placing it alongside attitude towards behavior is in line with Faber's (1994) separation of cognitions on the personal and consensus view. Lastly, perceived behavioral control seems important as single participants are expected to implement behavioral changes after a group model building intervention, while a participant is not in complete control over a behavior. Similar to attitude toward behavior, a person's perception of control is an affective evaluation. The cognitive foundation in control beliefs and power

of control beliefs again resembles Huz's (1999) operationalization. Huz asks respondents to evaluate a list of functions or means of the system modeled, by rating their importance.

The factors considered important for evaluation of group model building discussed above, are all included in Ajzen's theory of planned behavior. A couple of remarks are in order. First, as mentioned before, outcomes at the level of the organization or method are not considered here. Nevertheless, a relation between action and system changes seems likely. If an organizational problem is modeled, it is difficult to conceive of system changes which are not implemented by an individual actor. Second, Ajzen (1991) maintains that all influences on intention and behavior operate through changes in attitude, subjective norm or perceived behavioral control. Thus, at the end of the previous section we concluded that the relations between communication, cognition and action are crucial to intervention effectiveness. We have now considered the relation between communication and cognition, and between cognition and action. From Ajzen's assumption it follows that, although logically possible, there is no direct relation between communication and action. Third, in the remainder we will refer to attitude, subjective norm and perceived control as 'evaluations' for reasons of simplicity.

4.2 Relation of Communication and Cognition

The intervention elements identified as important in the previous sections are modeling and facilitation. How are modeling and facilitation related to cognitions and evaluations? Eagly and Chaiken (1993; Wood 2000, p. 551) discuss two important models of evaluation formation and change, the Heuristic Systematic Model (HSM, Chaiken et al. 1996, 1989) and the Elaboration Likelihood Model (ELM, Petty and Wegener 1998; Petty and Cacioppo 1986). Although these models concentrate on attitude change, we assume that similar processes operate in changing subjective norm and perceived behavioral control. In the HSM and the ELM two routes are available through which evaluations can be changed. One route consists of understanding and evaluation of arguments. A persuasive message is received and understood, arguments in the message are identified, contrasted with existing knowledge and judged on their validity. This route is termed the systematic (HSM) or the central route (ELM). Following the second route, evaluations are changed on the basis of simple decision rules or heuristics (for example: 'the expert's information can be trusted'). Both the HSM and ELM refer to this as the peripheral route. The content of both information and heuristics can be either negative or positive, leading to a change in evaluations in a negative or positive direction. For example when during modeling a new positive outcome of an action alternative is identified (a positive argument) we can expect the attitude towards that action to become more positive. According to the HSM and the ELM, the decision which route will be used depends on the person's motivation[2] and ability to process information. If both motivation to process information and ability to process information are high, the central route will be more influential in changing attitudes. Motivation is high when for example the situation is high in personal ('outcome') relevance. When a person is already knowledgeable about the subject, ability to process is increased.

Contrasting these routes available for evaluation change and the practice of group modeling, it seems clear that modeling and facilitation operate to make as much use of the central or systemic route as possible. The aim of group model building is to integrate and structure

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[2] Please note that motivation to process information is distinct from other forms of motivation referred to in this paper, such as motivation to comply with referents and behavioral motivation (intention). Whereas motivation to process information is a central concept in theories of persuasion (Chaiken et al. 1989, 1996; Petty and Wegener 1998; Petty and Cacioppo 1986), both motivation to comply with referents and behavioral motivation are used in the theory of planned behavior (Ajzen 1991, 2001).

available information about a problem, bypassing the heuristics used in 'traditional' decision making. The idea that modeling can serve the role of a shared language (Richmond 1997), increasing the ability to process information, points in the same direction. Thus modeling primarily affects the ability to process. Since participants are invited to contribute to group modeling sessions based on their expertise or stake in the problem, motivation can also be expected to be high.

Two other elements of communication in decision making are influence attempts and negotiation (Eden 1992). These elements can be placed in the HSM and the ELM as well. Participants can attempt to influence each other's opinions both by exchanging information (the central route) and by using heuristics such as their power or status (the peripheral route). To the extent that the participant group operates as a cohesive group or team, the influence of heuristics on participants' evaluations is limited because the influence of power and status differences will be limited. Vennix et al. (1996, p. 52) see the relation between persuasion routes and group model building as follows:

> We may assume that the managers in question are relatively knowledgeable about the subject. However, other factors, such as message comprehensibility and attention of the subject, have to be sufficient to enable a subject to consider all relevant information. Group model-building is generally helpful to process and integrate a large amount of information, provided that the facilitator succeeds in creating a sphere of open and supportive communication in which mental models can be shared and explored freely.

Influence attempts in group model building can therefore be assumed to operate largely through the central route. Before participants will change their opinions, another factor needs to be present: arguments. Exactly what makes information an argument that potentially changes a receiver's opinion, is only studied in general terms (Petty and Cacioppo 1986). In short, information needs to be new and relevant to the receiver if it is to be effective in changing evaluations. Participants will only consider arguments if they are of sufficient quality and find their content persuasive. This highlights the role of counterintuitive insights that are sometimes gained in system dynamics interventions (Forrester 1975). Through their impact on evaluations and intention, these insights can be expected to affect implementation. The ability to process information is influenced by the degree of support of the decision making process. The main contribution of group model building to the decision making process is to increase the ability to consider and integrate all relevant information. The second factor in the persuasion theories, motivation to process information, is an element of the context of the group model building intervention. The degree of motivation is determined by organizational and problem characteristics. If the problem is perceived as important, a high motivation to process information can be expected.

4.3 Conceptual Model

Figure 2 summarizes outcome, mechanism and context variables discussed so far. The conceptual model includes the following elements: context, mechanism and outcome variables. If group model building is seen through the lens of persuasion theories, problem and organization elements are important in so far as they influence the motivation to process information.

Modeling and facilitation were considered the main mechanism elements operational in group model building. Following theories on persuasion, modeling and facilitation can be said to support the ability to process information. The other important mechanism element is communication, which boils down to the exchange of arguments. Two aspects of arguments
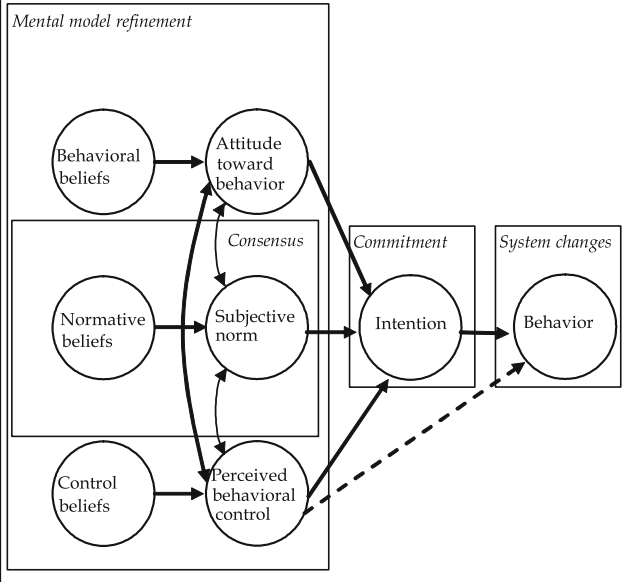
Fig. 2 Central variables in the conceptual model and their relation to context, mechanism and outcome elements (context, mechanism and outcome elements depicted in *italics*)

are important in this study: argument quality and persuasive content. Both can be expected to influence the direction of evaluation change.

Of the outcome variables described in the group model building literature (see Table 1), positive reaction, system improvement, further use of the method and efficiency of the method cannot be related to the Ajzen model. The remaining outcome variables can be related to the concepts in the Ajzen model. Implementation of system changes is related to behavioral changes; commitment is similar to intention (Vennix et al. 1996). Mental models relate to all of the three evaluations and corresponding beliefs in Ajzen's theory: goals models can be equated with attitudes and outcome beliefs, means models are captured by perceived behavioral control and control beliefs. Subjective norms and normative beliefs are on one hand an element of mental models and on the other hand represent consensus. Communication, which was listed as an outcome variable, changes to a mechanism variable. Shared language is one aspect of the ability to process information. System improvement is not captured in the Ajzen model which focuses on the individual level, but must be the result of individual behavior to implement a decision. These considerations allow us to summarize the context—mechanism—outcome relations as depicted in Table 2.

Table 2 Basic context, mechanism and outcome elements

Context		Mechanism		Outcome
Stakeholders in a highly complex problem who are motivated to engage in a decision making process	+	A method that increases ability to process information and identifies arguments that are either positive or negative	=	Change in beliefs and evaluations, intentions and behavior of participants

5 Conclusions

The aim of this paper was to test whether an existing conceptual model is suitable for relating the main outcomes, mechanism and context variables in PSM interventions. Theories from social psychology, on persuasion and the impact of attitudes on behavior, were used to this end. In this section we reflect on whether the conceptual model meets the purpose we identified beforehand, the practical applicability of the conceptual model for evaluation of PSM interventions, and the limitations of this study. In the first section of this paper we identified three purposes of a conceptual model on intervention effectiveness: (a) to test the coherence of the method's theory and its similarity to the practical use of the method; (b) to identify and define central variables for research; and (c) to point to central process and outcome elements in order to increase the transferability of the method. We discuss these points in turn and then focus on the practical applicability of the conceptual model for evaluation of interventions. We end this paper by addressing the limitations of the proposed model.

It seems possible to place most discussions in the group model building field in the model, indicating that the model has a significant degree of similarity to group model building practice. The two sets of theory (persuasion and the theory of planned behavior) on which the model is based are well-tested in various domains of behavior and in this sense seem coherent: central variables are defined and operationalized, relations between variables are articulated and (in most cases) tested. The combination of the two sets of theories and their application to group decision making is however a novel application. In Finlay's (1998) opinion, the adequacy of the model for describing group model building interventions is ultimately an empirical question, but at a theoretical level the model seems to be similar to group model building practice and (largely) coherent.

The second purpose of the model was to identify and define variables for research. The previous section included the definitions of central variables in the theories on which the conceptual model is based. The conceptual model consists of specific variables and thus avoids the shortcoming of the general model used in evaluations of EMS, which consists of categories of variables (Scheper 1991). Below we address questions with regard to operationalization and research methodology.

The third rationale for developing a conceptual model was its clarification of important elements and outcomes to novices in the use of the method, which might increase the method's transferability. In particular the theories on persuasion are helpful here. Following these theories, a PSM's primary aim is to increase the ability to process information. This means that a facilitator tries to remove distractions such as unclear communication and peripheral cues insofar as they hinder the flow of information. In addition we pointed to the role

of new and relevant arguments. In system dynamics this is reflected in the counterintuitive insights (Forrester 1975) that make up a large part of the learning process in modeling. Eden (1992) expects that substantive rationality (arguments) will lead to changes in cognition, while procedural rationality (a fair process) will change emotional attitudes. It seems ELM and HLM have the potential to identify elements important to PSMs and facilitation, and further exploration of these theories is warranted.

With regard to the practical ability of the conceptual model in evaluating interventions, two approaches can be distinguished. The model can be used to interpret outcomes of a case study after the intervention. In two cases (Vennix et al. 1996; Delauzun and Mollona 1999) this approach has been used to capture the central outcomes of group model building, focusing primarily on the Ajzen model (1991, 2001). Using the conceptual model as a basis for comparison of cases has the advantage that we can use a common terminology. Alternatively, the conceptual model can be used as a starting point for empirical research. The concepts in the theory are then operationalized in line with existing studies on the persuasion theories and the theory of planned behavior. The most commonly used data gathering method in this line of studies is the written questionnaire. Using this approach to evaluate group model building would then require us to identify relevant behaviors, their related attitude, subjective norm, perceived behavioral control, beliefs and finally information that could potentially change these beliefs. A direct benefit of connecting to well-established theories from social psychology is that standard measurements using Likert items are available for the variables in the theory of planned behavior (see e.g. Ajzen 1991, 2001) and persuasion theories (see Rouwette 2003). This questionnaire could then be administered to participants in the modeling sessions before and after the intervention (and possibly in a control group). Using the conceptual model in this way we move closer to the research approach traditionally used in EMS, with its focus on quantified measures and testable propositions. We would then firmly place ourselves in the type of research approach Eden (1995) suspects to be impractical, since managers are unwilling to participate in answering these questions. To this we might answer: 'the proof of the pudding is in the eating'. Rouwette (2003) and Eskinasi and Rouwette (2004) have used a pretest posttest questionnaire based on the conceptual model in six modeling projects for a total of 39 managers. Although there were some indications of overload and the questionnaire might be improved on this point, in general managers agreed to cooperate in the evaluation in addition to the intervention. More importantly, follow-up open interviews produced similar answers as the written questionnaires with regard to the central outcomes in the conceptual model (Rouwette 2003). Measurement of the role of information in participants' learning (questions on the mechanism of modeling) proved to be more problematic. The doubts expressed by Eden (2000) with regard to the reliability of written questionnaires may thus be more relevant to mechanism than to outcome measures, but this point clearly deserves further study. A special point of concern is the identification of relevant behaviors. Group model building and PSMs are used in messy problems where relevant behaviors (options in the problem) differ between participants and are difficult to define before the intervention. In the questionnaire described above, this was circumvented by asking participants to define actions themselves rather than asking them to evaluate a predefined action. This is different from studies carried out in social psychology where all respondents evaluate identical behaviors. Clearly there are points where the connection to social psychological theories needs to be expanded and the measurement procedure further refined. Nevertheless there seem to be no insurmountable practical objections to using the conceptual model for the evaluation of real life applications of modeling.

In considering the limitations of the proposed conceptual model, it is worth reconsidering Eden's (1992, 1995) remarks on the essential elements of a theory on PSMs. A conceptual

model should cover group decision making, decision making in organizations and the nature
of the intervention. In the conceptual model organizational decision making is only repre-
sented in the factor 'motivation to process information'. It is clear that the model is silent
on important elements of organizational decision making such as agenda setting and power
(Hickson et al. 1986). Both the proposed conceptual model and intervention methods might
benefit from a more systematic incorporation of these factors.

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