Decision-support and Complexity in Decision Making

ACADEMIC TRACK

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Abstract

Organisations increasingly have to deal with complex problems. Multidisciplinary teams are needed to cope with such problems. In such teams, different people have different perspectives, knowledge and approaches. For decision-making on complex problems, this knowledge has to be shared, and new knowledge has to be constructed, in order to develop solutions for the problem. Theory suggests that ICT-tools can support the quality of decision-making on complex problems. ICT-tools may facilitate knowledge elicitation, knowledge sharing, reaching common ground, and, ultimately, knowledge construction. Furthermore, this facilitation may positively affect the quality of the proposed solutions. We propose research on external representations used in multidisciplinary teams to test these expectations.

Business organisations are increasingly confronted with complexity in decision-making situations (e.g., Courtney, 2001; Rotmans, 1998; Sterman, 1994). Changes come at ever-increasing pace, and developments in communication and transportation allow for worldwide competition. In such a competitive environment, novel approaches are needed to attain and maintain business advantage. However, traditional approaches to decision making (i.e. adaptive, incremental approaches) fail to generate those innovative solutions necessary for keeping such advantage (Lomi, Larsen, & Ginsberg, 1997).

ICT-tools are used to enhance the quality of the decision-making process. These generally aim at facilitating formal and informal communication, harvesting knowledge, and building knowledge repositories (Courtney, 2001). Such ICT-tools can be regarded as responses to complexity. However, it is not clear by which mechanisms ICT-tools are able to support decision-making for complex problems.

In this paper, we present a conceptual framework for the analysis of ICT-tools. Such a framework can guide in distinguishing between a variety of ICT-tools, and act as a basis for development of new ICT-tools for support of decision-making. We explore how ICT-tools can be used to facilitate decision-making on complex problems in multidisciplinary teams. The leading thread in this paper is the question how ICT-tools can effectively support the quality of decision making for complex policy problems.

First we describe various aspects of complexity and decision-making, from which we gather requirements for decision making on complex problems. We then discuss group processes in decision-making teams, to identify key processes for decision support. After that, tools for supporting these key processes are dealt with. From an integration of these topics we gather research hypotheses, for which we propose some first designs for empirical study.

Complexity and decision-making

The higher the number of factors and relations within a system, the more complex this system is (cf. Evans & Marciniak, 1987). Small changes in parts of a complex system may result in considerable changes in the system as a whole. This is caused by the intricacy of the various relationships. Feedback mechanisms and delays can cause non-linear behaviour (Rotmans & Van Asselt, 1999).

Complex problems in decision-making often exist across disciplinary boundaries, and thus require a multidisciplinary approach (Rotmans, 1998). To enable such an approach, decision-making for complex problems is often done in multidisciplinary teams. In such teams, every team member has his or her own perspective, which can be seen as a coherent and consistent description of the perceptual screen through which (teams of) people represent the world (cf. Van Asselt, 2000). The way people represent problems is subject to their individual perspective, hence multiple representations of a decision-making problem exist in multidisciplinary teams.

Decision-makers in multidisciplinary teams confronted with complex problems have to take the existence of multiple problem representations into account. Multiple representations lead decision-makers to regard problem solutions they normally (i.e. when considering only one problem representation or perspective, or only a limited synthesis of multiple perspectives) would not regard. Or, as Vennix puts it, "the more different perspectives are taken into account, the smaller the chances of premature problem definition and 'solving the wrong problem'" (Vennix, 1996, p. 1). The risk of only considering business-as-usual strategies (i.e., adaptive, incremental) is averted, and innovative designs can be developed if multiple representations are taken into account.

The nature of complex problems requires identifying and articulating multiple problem representations, and taking both innovative and adaptive solutions into consideration. We hypothesise that effective decision-support will help articulation of multiple problem representations, and developing both innovative and adaptive solutions.

Group processes

Decision-making teams engage in several social and knowledge processes, which result in shared and newly constructed knowledge, and in the development of problem solutions. During the process, social relationships between team members evolve, influencing the decision-making process. We see the developed solutions as the result of knowledge processes, which in turn are affected by the evolving social processes. Both need to be regulated for effective decisions to ensue (cf. Mulder & Swaak, 2001).

One way of decision-support aims at the regulation of group reasoning processes. For example, Suthers uses a tool called Belvedere to enhance scientific argumentation in groups (Suthers, 2001). Belvedere asks evidence for every statement made by the group. It also asks for evidence opposing a statement. Thirdly, Belvedere prompts checking whether stated evidence supports statements other than the one it was given for. Such measures may support decision-making by helping teams distinguish between strong and weak statements.

With respect to knowledge processes, regulation refers to structuring the processes of knowledge elicitation, knowledge sharing, and knowledge construction, and balancing their respective importance. The same sort of government is needed with respect to the social processes, because of the relationship between social and knowledge processes. A positive social environment in a decision-making group is a prerequisite for effective knowledge processes. In other words, regulative processes can be seen as the guidance of group attention to specific knowledge and social processes, and decision-support as an example of such guidance.

Regulation also refers to monitoring the decision-making process. Dealing with complex problems means performing a number of decision-making steps, like problem definition, articulation of perspectives, development of solutions and alternatives, testing those solutions, and implementing them (cf. Van Asselt, 2001, and Courtney, 2001). Regulation then refers to monitoring the performance of these steps by the decision-making group.

Knowledge processes

To be able to develop solutions for complex problems, decision-making teams have to construct a shared representation of the problem. Individual team members, with individual problem representations and mental models, embark on discussions about the problem. A number of knowledge processes are important to these discussions. These involve knowledge elicitation, knowledge sharing, and, through reflection and elaboration on, and synthesis of shared knowledge, knowledge construction. All these processes are aimed at dealing with the present problem.

Knowledge elicitation, knowledge sharing, and knowledge construction each play a role in a specific knowledge transformation. Knowledge elicitation refers to the transformation of implicit knowledge into explicit knowledge. Knowledge sharing means that internal knowledge becomes external, or sharable knowledge. If various group members add to a pool of external knowledge, they can all internalise each other's knowledge, enabling reflection upon the pooled knowledge. Finally, knowledge construction can occur (see Figure 1).

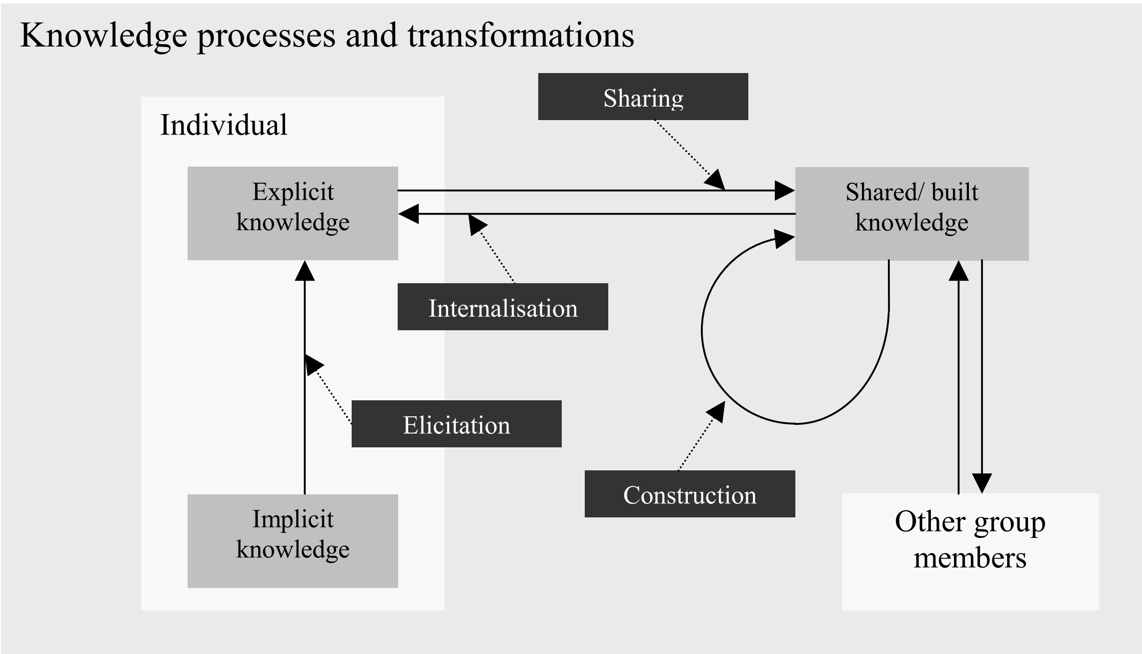

Figure 1: Knowledge elicitation, sharing, internalisation and construction change knowledge from implicit state to shared state, and, through group reflection, enable knowledge construction. Knowledge construction is portrayed here using the circular arrow.

Common ground and knowledge construction

Decision-making for complex problems requires decision-makers to share their individual knowledge with the rest of the group they are working in. Sharing knowledge is not simply a transmission of information from one person to another. Knowledge from one member to the group has to be heard and understood, and then, through negotiation, accepted (e.g., Ostwald, 1996; Van Boxtel, 2000). The understanding created through communication can never be absolute or complete, but instead is an interactive and ongoing process in which common ground, i.e., assumed mutual beliefs and mutual knowledge, is accumulated and updated (Clark & Brennan, 1991).

As visualised in Figure 2, knowledge from a team member, either already being explicit, or newly elicited, finds its way to the rest of the group, by being uttered. Some of the knowledge thus uttered is heard and understood by the rest of the group, after which it can be disputed through negotiations. Outcome of negotiations can be either that knowledge is put down, or that knowledge becomes part of the group's common ground.

Starting from the common ground, new knowledge can be built, which would consist of adding new relations and concepts to the common ground. Knowledge construction is based on the common ground the team has built, and will broaden and deepen the common ground because the constructed knowledge becomes part of the common ground.

Although common terminology is not vital to reaching common ground (cf. using different terms for common concepts), adding such terminology to group interactions may speed reaching common ground. The above example of the Belvedere tool can be seen as artificially regulating conversation, because it leads team members pay attention to argumentative aspects of their reasoning.

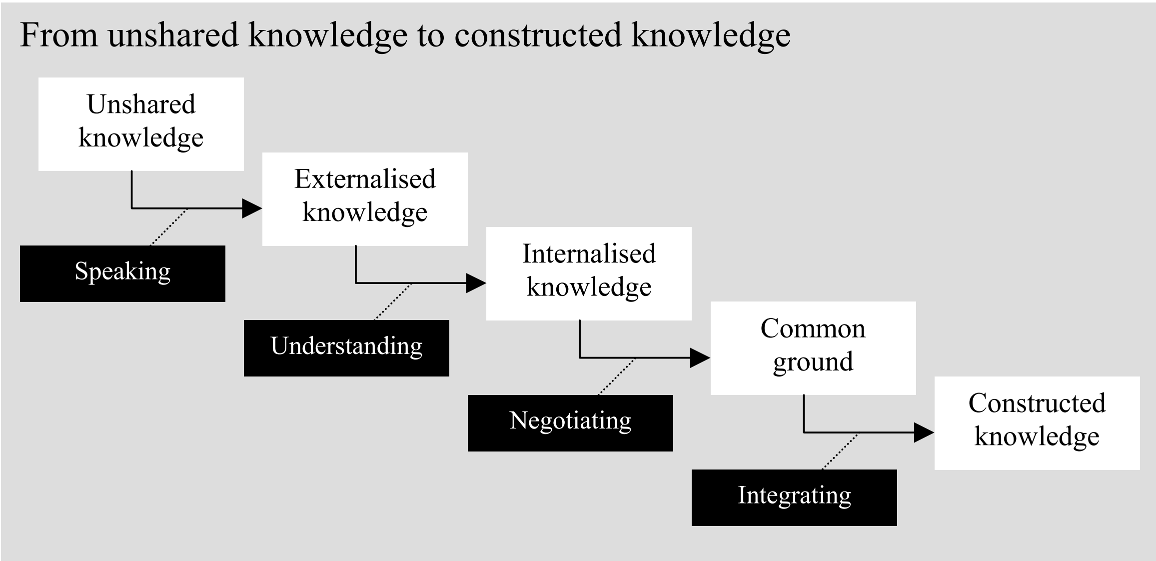

Figure 2: From unshared knowledge to constructed knowledge.

External representations for supporting knowledge processes

Representations of abstract concepts, for example, complex problems, can exist both inside and outside our heads. In many cases, a representation of a certain concept turns out to exist part in our heads, and part in our environment. (Zhang, 2000). The internal part of a representation can be partly externalised. External representations can take many forms. For example, Roth has studied a modelling process in which pupils were to design an earthquake-proof tower. To explore this process, Roth had the groups make use of small wooden joints and sticks, so they could build a model of the tower (Roth, 2001). In this example, the wooden model is an external representation of the group's design problem. External representations can take virtually any form. Other examples are the cognitive map, the drawing, the computer model, and the game-board.

Externalising a problem representation affects group knowledge processes. Zanting used external representations for knowledge explication (Zanting, 2001). By using an external representation, we free working memory, which we then can fully attend to reflection. Try, for example, as a non-expert in chess, to play a game without a chessboard and pieces and you will notice how hard it is to play without an external representation of the game. Instead of being able to reflect upon your position, you need much of your mind-power to remember it.

External representations can be used for facilitating all group knowledge processes distinguished in this paper. There is, however, one drawback; research shows that an individually externalised representation puts extra strains on other people when they try to internalise the represented knowledge (Rutkowski & Smits, 2001); not only do they need to comprehend the represented knowledge, they also have to apprehend the often idiosyncratic formalisms the maker of the representation has used while making it. Also, the more complex a representational system is (often for optimal disambiguation) the more difficult it is to learn formalisms and the higher the cognitive load (i.e., negotiation of the presumed cognitive off-loading effect of external representations), as well as the amount of time devoted to discussion of the representations.

External representations consist of two parts, i.e., the represented knowledge on the one hand, and the form of representation on the other (Suthers, 2001). We hypothesise that prescribing a specific formalism for knowledge sharing regulates group knowledge processes. It may do so because it serves as a basis for common ground. If all group members use the same formalism for external knowledge representation, they do not have to adapt each other's personal formalisms. It may help create mutual understanding between group members, and therefore facilitate the sharing of knowledge. Furthermore, after every group member has become familiar with the formalism, more attention may be directed towards the shared knowledge itself (cf. Rutkowski & Smits, 2001).

The form of the representation affords the sharing and internalising of some forms of knowledge better than others. For example, many researchers advocate system-dynamics for representing complex systems, because it adds salience to feedbacks and delays (e.g., Rotmans, 1998; Senge, 1990; Sterman, 1994; Vennix, 1996), those aspects of complexity that make complex problems hard to deal with. We hypothesise that specific formalisms can be tuned to specific problem ontologies.

Hypotheses and research methodology

We have identified a number of possible mechanisms by which ICT-tools may be able to facilitate decision-making on complex problems. First, external representations can be of use because they are expected to facilitate knowledge elicitation and knowledge externalisation, and because they allow for reflection, which in turn can help people construct new knowledge.

Second, by adding a formalism to external representations, decision-making teams are given a piece of common language. Use of such common language is expected to help reaching common ground, which in turn broadens the base for construction of new knowledge.

Third, type of formalism can be tuned to problem ontology. In the case of complexity, this means that formalisms that emphasise generic aspects of complexity are more fit for dealing with complex problems than formalisms that are less tuned to complexity. Use of such formalisms is expected to cause people to conceptualise the problem in terms of cause and effect, and in terms of delays and feedbacks. Below, we state some first ideas for testing these hypotheses. These ideas are still under development, and therefore should be regarded as tentative.

We want to study how external representations, with a variety of formalisms, affect the decision-making process on a given, well-known, complex problem. The various formalisms used serve as independent variable. A condition without the use of a prescribed formalism will be used as well. This will serve as a base for comparison. The dependent variable, quality of decision-making, is conceptualised as the extent to which a multi-disciplinary group externalises knowledge, the extent to which such a group reaches common ground, and the quality of the proposed solutions for the problem at hand.

Possible experiments may involve <u>observing</u> multidisciplinary teams working on a complex decision-making problem, <u>interviewing</u> the team members about their experiences during the process, and <u>evaluating the solutions and final problem representation</u> proposed by those teams. Data consist of the taped group interaction, interview transcripts, and proposed solutions.

Analysis of group interaction can concentrate on the number of concepts mentioned, outcome of negotiation of meaning, and the use of common denominators for discussed concepts. The resulting problem representations and proposed solutions can be analysed in terms of expert-judged "correctness", and innovativeness. Interviews can be used to assess to what extent group members have learned from each other's backgrounds. However, exact operationalisations of these variables are still under debate.

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