Searching for the right problem - a case study in water management on the relation between information and decision making

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Abstract
The solution of complex, unstructured problems in integrated water management is faced with policy controversy and dispute, unused en misused knowledge, project delay and failure, and decline of public trust in governmental decisions. Concept mapping is a technique to analyse these difficulties on a fundamental cognitive level, which can reveal experiences, perceptions, assumptions, knowledge and subjective beliefs of stakeholders, and can stimulate communication and learning.

Introduction
Integrated assessment consists of gathering, synthesising, interpreting, and communicating knowledge from various expert domains and disciplines, to help responsible policy actors think about problems and evaluate possible actions. But in the decision-making discourse scientific information is not taken for granted, can be explained in different ways, and is 'just another' element in the policy making process. And values, assumptions and limitations that are inherent in scientific models are often not communicated explicitly. Furthermore paradigm differences between actors from different stakeholder groups, between policy actors and scientists, and between scientists from different discipline groups influence the use and interpretation of information. But the assumptions and limitations present within a paradigm are seldom openly communicated. These difficulties result in lack of information and insight on policy alternatives, lack of exchange of information and communication, and lack of co-operation.
Current theories about the relation between science and policy give the following recommendations on the issue of knowledge production and knowledge use: 1) knowledge must not be produced from one single dominant paradigm, but from the whole range of paradigms that are present in the policy arena; 2) open debate is needed concerning choices and basic assumptions, which underlie the production of knowledge; 3) debate should also include non-scientific stakeholders from the policy arena, the intensity of this communication depending on the complexity of the problem.
The present research develops a new methodology that may support integrated assessment in the light of the difficulties and recommendations mentioned above.

Theoretical basis: Mental models
We start from the observation that in complex, multifunctional and multidisciplinary problems the meaning of information is socially construct, and guided by different frames of perception (Funtowicz & Ravetz, 1994; Schon & Rein, 1994). Frames are the structures of belief, perception and appreciation underlying policy positions. The frames held by the actors determine what they see as being in their interests. Frames are grounded in the institutions that sponsor them. Frame differences cause communication barriers that prevent mutual learning and understanding. Policy controversies are seen as disputes between conflicting frames. It is within the frames that information is judged and synthesised into a problem solution.
Instead of analysing frames, the present research follows Courtney (2001) and analyses the mental models that underlie frames. A frame contains actors' knowledge, assumptions, interests, values and beliefs. But it is the mental model that determines what data the actor perceives in the real world (as a 'filter' through which the problem situation is observed), and what knowledge the actor derives from it. Therefore the perspective from which alternative problem solutions are deliberated en decided upon is ultimately based on an actor's mental model. Different mental models of the problem situation, and mismatch of decision data with the mental models, will result in different opinions on the problem solution, and in this way constitute the basis of many problems in the policy cycle.
Ambiguity and confusion exists in the definition of 'mental model' between the many disciplines that use this term. Doyle (1998) argues that it should be used to refer to only a small subset of the wide variety of mental phenomena to which it is often associated, and proposes the following definition (:17):

> "A mental model of a dynamic system is a relatively enduring and accessible, but limited, internal conceptual representation of an external system whose structure maintains the perceived structure of that system".

A mental model includes not only knowledge but also information about interconnection and organization of that knowledge (in nodes and links). A mental model does not include ends (goals), means (strategies, tactics, policy levers) and connections between them (the means-ends model) – these are 'inputs' for the mental model. 'Running' a mental model is equivalent to propagating information through the conceptual structure. The 'model output' is used to plan actions, explain and predict external events.

Elicitation of a mental model

Novak (1984) used the term 'concept map', to denote the external representation of the mental model. This map is the researcher's conceptualisation of a subjects' mental model. All fields of research indicate that elicitation of mental models will reveal the experiences, perceptions, assumptions, knowledge and subjective beliefs that a 'model user' operates to reach his conclusion about some issue. Concept mapping assess tacit knowledge, broadens the narrow understanding of a problem by confronting one stakeholders' map with the map of others, makes aware of alternative perspectives on the problem, encourages negotiation and helps to reduce destructive conflict. The basic idea is to externalise a person's knowledge and consequently make it discussable. This is precisely how concept mapping may link to the needs signalled by many authors in the field of integrated problem solving.
Several tools are available to support concept map generation. The present research uses the IHMC CmapTools from the University of West Florida (Coffey, 2000). This tool facilitates generation and manipulation of concept maps, and allows map sharing over the Internet. It has been used to support learning processes and expert system development

Application of concept mapping

The Zwolle storm surge barrier is used as a case study to investigate the practical applicability of the methodological concepts described above. The research looks for confirmation of the theory. The research starts with analysis of available documents, e.g. the environmental impact assessment report (mer), and associated reports such as "Richtlijnadvies" and "Toetsingsadvies" of the EIA-commission, as well as research reports and publication. Documents from the earlier phases of the project are available to monitor the development of the conceptual model in time. Media messages are used to detail stakeholders' concepts. Based on this analysis a first version of stakeholders' conceptual maps will be constructed. Based on this selected actors will be interviewed to validate and refine the maps.

Conclusion

The complex, multifunctional and multidisciplinary nature of problems causes a large range of mental models to spring into existence. When all actors are not adequately involved early in the problem solution process, to share each others mental models, the (often implicitly) developed mental model could be insufficient to legitimise the preferred solution, and incomplete or even wrong knowledge could have been produced in the project or selected for inclusion in the project report. Comparison of mental models, decision process structure and actual use of knowledge will reveal potential points of conflict, which then could be dealt with. Concept maps can also identify blind spots in knowledge, give scientists clues they need to produce knowledge that fits into the frames of the diverse stakeholders in order that knowledge they produce can be of use to the stakeholders, enlarge insight in possible and desirable problem solutions, and support communication between actors. Applying concept-mapping techniques in the early phase of decision-making for these purposes thus could improve the problem solving and decision making process.
A main advantage of the analysis of mental models above the analysis of frames is the unchallenged institutional and normative position of the actors, because concept mapping does not doubt the validity of an actor's frame, but merely wants it illuminate it by focusing on the information used within a frame. Of course, this can be the starting point of a learning process or critical dispute.

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