Modeling as organizational learning: an empirical perspective

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ABSTRACT

Many system dynamics modelers consider the process of model-building more important than the model itself. Model-building is supposed to generate considerable learning about a policy problem. Not only at the individual level but also at the organizational level. From the point of view of empirical evaluation research the question is how the occurrence of organizational learning as a consequence of a model-building process might be established. In this paper we will explore some of the key issues and difficulties involved in establishing organizational learning from model-building empirically.

THE PROBLEM

Organizational learning is a common feature of organizations. It is part of the process in which organizations adapt to their changing environment. Adaptation of organizations, however, is not merely a passive process. On the one hand organizations adapt to changing circumstances, on the other hand they make interpretations (Daft and Weick, 1984) and actively manipulate their environment (Beer, 1979; Luhmann, 1976). Observation and interpretation of the results of this process of adaptation is called learning. As Hedberg puts it: "Learning takes place when organizations interact with their environment: organizations increase their understanding of reality by observing the results of their acts." (Hedberg, 1981, 3).
Learning about the environment and adapting to changed circumstances is an important prerequisite for an organization's survival, and survival might be seen as the ultimate criterium of organizational performance. For many organizations, however, environments have become more complex and dynamic and hence more turbulent over the last few decades (Emery and Trist, 1965; Hart, 1983). Consequently the process of learning and adaptation has been severely impeded, since the more turbulent the environment the more difficult the learning and adaptation process (Hedberg, 1981, 13). Particularly in turbulent environments it is not so much the learning process per se as the speed with which the organization learns, which is the key factor for the survival of an organization. As for instance De Geus points out:

> "In fact, the normal decision process in corporations is a learning process, because people change their own mental models and build up a joint model as they talk. The problem is that the speed of that process is slow-too slow for a world in which the ability to learn faster than competitors may be the only sustainable competitive advantage (....). The issue is not whether a company will learn, therefore, but whether it will learn fast and early." (De Geus, 1988, 71)

Various system dynamics modelers have recognized that model-building entails considerable learning about a complex policy problem (Meadows and Robinson, 1985; Morecroft, 1988; Lane, 1989). It is claimed that modeling promotes and possibly accelerates the organizational (or institutional) learning process (cf. Senge, 1989; Kim, 1989; De Geus, 1988; Stata, 1989).

However, the literature about organizational learning effects of model-building with organizational client groups is largely speculative. Empirical evidence on organizational learning effects as a consequence of model-building is scarce. This is partly understandable, since empirical research in this area is frought with problems. However, this type of evaluation research is important for at least two reasons. First, to test and possibly verify theories on organizational learning as a consequence of model-building. This will lead to refinement of these theories and provide more detailed insight into the process of organizational learning. Second, maybe even more important, it might improve the process of model-building with client groups itself. There is no doubt that evaluation research will generate insights, which can be used by modelers to adapt their model-building procedure, for instance with regard to the process of eliciting and mapping knowledge from client groups.
This paper will discuss the phenomenon of model-building as organizational learning from an empirical perspective. We focus on problems related to establishing organizational learning empirically, for instance by evaluating the learning effects of actual model-building projects. We first discuss the concept of learning and the differences between individual and organizational learning. Next, we introduce the cognitive mapping approach as a way to establish individual learning from model-building. In the subsequent section we will explore how cognitive mapping can be used to establish organizational learning. Finally, we will formulate some conclusions and discuss implications for the process of building system dynamics models with client groups.

INDIVIDUAL AND ORGANIZATIONAL LEARNING: THE CONCEPT OF ORGANIZATION

Research on individual learning has a much longer history than research on organizational learning. Hence, most of the literature on organizational learning somehow refers to the literature on individual learning. As for instance Hedberg phrases it: "Although the concept of organizational learning is widely used, the empirical observations are almost always taken from studies of how individuals and animals learn in laboratories." (Hedberg, 1981,3). Various authors have shown, however, that the concept of organizational learning is not a straightforward extrapolation of individual learning. An organization is not the mere sum of its individual members (Hedberg, 1981; Fiol and Lyles, 1985). On the other hand authors like Argyris and Schön (1978) and Shrivastava (1983) point out that *individuals* are the actual agents through which learning in an organization takes place. This clearly is a paradoxical situation. Or as Argyris and Schön put it: "...organizational learning is not merely individual learning, yet organizations learn only through the experience and actions of individuals." (Argyris and Schön, 1978). This paradox between the individual and the organizational level is also reflected in the various approaches to conceptualize organizations.
In the literature on organizations one can roughly distinguish between two major ways of observing the phenomenon of organization (cf. Miller and Rice 1967, Etzioni 1961, Dalton et al. 1970). The first one conceptualizes "organizations as such" (Etzioni 1961, 2) thereby largely disregarding individual organization members, while on the other hand, the second approach to organizations has as its basic assumption that in fact "organizations are people" (Perrow 1970, 2).
With respect to the first type of conceptualizing organizations ('organizations as such') the term 'organization' has several different meanings. First, organization is used to denote a societal entity (for instance a hospital, a corporation) which itself may have have an organization. Organization in this second sense refers to the organization's structure, which basically consists of a set of formal positions. The most general distinction that can be made regarding formal positions in organizations is between superior and subordinate. The relationships between these two positions can be organized in several ways. In this third sense organizing refers to the *process* of organization (cf. Peters and Scheper 1990). These processes of organization in turn may materialize in all kinds of regulations, formal procedures, rules etc.
Observing organizations from this point of view (organizations as such) means that the empirical researcher of organizational learning would employ indicators for organizational

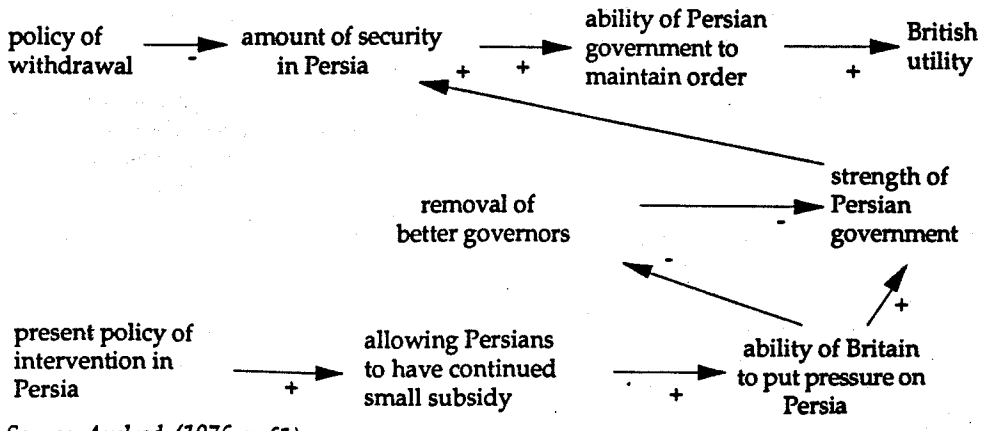
learning which have somehow materialized in written form: organization's regulations, policy documents, annual reports, information systems etc.
In the second approach to conceptualize organizations (i.e. 'organizations are people') it is not formal structures, rules and procedures which are believed to be of primary importance when studying organizations, but individuals. These individuals actually assume the various positions in an organization. As can be learned from the literature on organizations, organization members' actions are based on their perceptions or constructions of reality (Schutz 1973, Berger and Luckmann 1979), which in its turn is determined by the organization member's background, knowledge, values etc, in short -using Schutz' terminology- their biographical situation. From this perspective, psychological and social psychological phenomena become relevant. Taking into account the values, ideas, interactions, expectations etc. of organizational members becomes important because these determine the way organizational members perceive the organization (cf. Weber 1976, Schutz 1973, Berger and Luckmann 1979, Weick 1979), which in turn determines the way they will carry out their tasks (cf Weber 1976, Peters 1989). In this sense organizations are largely intangible, they are primarily conceptual entities residing in the heads of the members of the organization. Or as Weick and Bougon phrase it: "Organizations exist largely in the mind and their existence takes the form of cognitive maps. Thus what ties an organization together is what ties thoughts together." (Weick and Bougon, 1986, 102).
Taking this perspective as the point of departure, the empirical researcher of organizational learning would employ indicators which take into account these values, ideas, expectations and interpretations of individual organization members. In short the empirical researcher would observe changes in mental models as the way to establish organizational learning.
In this paper we will take this latter perspective as our point of departure for studying organizational learning. There are three reasons for this choice. The first has to do with sources of knowledge in organizations. As for instance Forrester (1961) has pointed out, only a very small portion of the institutional knowledge is laid down in written documents. Much of what is known in any organization resides in the mental models of its individual members. Consequently, taking these mental models into account in establishing organizational learning seems of major importance.
The second reason has to do with the way organizations function and the actual determinants of organizational behavior. Above we have pointed out that in the second perspective on conceptualizing organizations ('organizations are individuals') it is the way organization members perceive the organization which determines the way they will carry out their tasks.
Hence, organizational performance is *eventually* the product of individual actions of organizational members, which in turn is based on their view of the organization and its environment (i.e. their construction of reality). In trying to establish organizational learning it is thus important to take these individual 'constructions of reality' into account.
The third reason for taking the 'individual point of view' on organizational learning is related to the model-building process itself. Model-building with client groups aims at sharing individual mental models and integrating these into one overall view on the organization. In this sense model-building with client groups can be considered a participative learning system which is basically more individually than organizationally oriented (Shrivastava, 1983; Shrivastava and Grant, 1985). Hence, organizational learning as organizational adaptation to the environment will in this paper be studied from the viewpoint of the individual organization members. However, this point of view produces a problem.
Although learning about perceived changes in the environment by a single organization member is a *necessary* condition for organizational learning (individuals are the organization's learning agents), it is not *sufficient*. Individual perceptions must have consequences for the organization as a whole, otherwise only individual learning would occur. Stated differently, individual learning must have consequences for actions of other organization members. According to the above mentioned distinction between two ways of conceptualizing a organizations, this can be achieved in either of two ways. In the first alternative the insights are simply laid down in formal procedures and regulations that specify patterns of behavior.

No real exchange of thoughts between various organization members, no sharing of mental models, is required. In the second alternative the exchange of thoughts, whether directly or indirectly, is explicitly aimed at. As we are interested in organizations as composed of individuals, we consider the exchange of thoughts between different organization members to be essential for organizational learning. Organizational learning thus refers to the process in which the perception of environmental change made by an organization member results in an exchange of ideas (a sharing of mental models) in order for the organization to respond to the perceived changes. As such our understanding of organizational learning corresponds with the 'assumption sharing approach' to organizational learning as distinguished by Shrivastava (1983), since from the exchange of ideas eventually a shared understanding or a joint mental model will result.
Having discussed the problems resulting from the paradox of establishing organizational learning, we will now turn to the question how to elicit and employ mental models for the study of organizational learning.

USING COGNITIVE MAPS TO ESTABLISH LEARNING

Authors on organizational learning employ terms like 'mental maps' (Hedberg, 1981, 9), 'cognitive maps' (Weick and Bougon, 1986), the 'organization's policy maps' (Hall et al., 1989), and 'theories of action' (Argyris and Schön, 1978) in order to deal with the phenomenon of the learning organization. For instance Hedberg points out that: " To identify stimuli properly and to select adequate responses, organizations map their environments and infer what causal relationships operate in their environments. These maps constitute theories of actions, which organizations elaborate and refine as new situations are encountered." (Hedberg, 1981, 7) Hence, in this paper we will focus on the use of 'cognitive maps' (Axelrod, 1976) to establish organizational learning.
A cognitive map can be seen as an interrelated set of assumptions with regard to some phenomenon. In this paper we are concerned with cognitive policy maps, i.e. maps "...that are used to direct strategy and policy making." (Hall et al., 1989, 3) A cognitive map is usually represented by means of a directed graph containing concepts and relationships between concepts. These cognitive maps strongly resemble causal loop diagrams used in system dynamics modeling. Figure 1 presents an example of a cognitive map, derived from the study of Axelrod (1976).

Figure 1 Example of part of a cognitive map



Source: Axelrod (1976, p. 61)

Cognitive maps can be derived from interview protocols or written documents. This is done through content analysis of these documents (cf. Axelrod, 1976; Vennix, 1990). Basically this boils down to translating statements like "increasing strength of the Persian Government will raise the security of this country" into concepts connected by arrows as can be seen in figure 1.
Cognitive maps provide a strong means to capture a person's mental model. Research in the field of cognitive mapping has indicated that persons act largely in accordance with their cognitive maps (cf. Axelrod, 1976; Hall, 1984; Weick and Bougon, 1986). Hence, establishing a person's cognitive map allows to arrive at conclusions about the behavior of organizational members and consequently about organizational performance.
In the next subsection we will provide an example of the use of cognitive maps to establish individual learning from model-building.

Using cognitive maps to measure individual learning from model-building

Various authors have studied the behavior of research subjects interacting with complex computer models. For instance Dörner has made an extensive study of the decisions made by research subjects in simulated complex decision making situations (cf. Dörner, 1980; Dörner et al., 1983). In a related vein Brehmer (1989) and Sterman (1989a, 1989b) have studied dynamic decision making behavior in simulated situations in which feedback processes occur. These reseachers primarily focus on decision-making behavior within a simulated environment. Stated differently: the simulation is used as a laboratory in which decision making processes of research subjects can be studied. Although these studies do not primarily focus on the effects of learning through model-building, they shed some light on learning during the dynamic decision-making experiments. Sterman (1989a) for instance points out that in the investment-accelerator model subjects often start to avoid instability after three to five trials. Hence, it seems that learning takes place, although, as the author points out, the learning seems to be highly situational, which might be attributed to the dynamic deficiency of mental models. Hence, "Study of the processes by which people form and revise mental models of the feedback structure of their environment would appear to be a fruitful extension of the present research." (Sterman, 1989, 330).
In an exploratory study on the effects of computer models on mental models Vennix (1990) has used cognitive maps to establish changes in mental models. In his experimental study one condition is a computer-based learning environment, using an econometric model of the Dutch social security system, and the other consists of traditional classroom lectures and discussions. In order to establish differences in effects between both conditions Vennix presented both groups of students with a policy problem in the Dutch social security system and had both groups draft a policy document on this problem both before and after the experiment.
The research design is depicted in figure 2. The policy documents written by the research subjects were used as a basis to extract a person's cognitive map about the social security system. This was accomplished by following and slightly adapting Axelrod's method of coding policy documents to extract cognitive maps (Axelrod, 1976). Next a number of indicators for the quality of the cognitive maps were developed. These were primarily based on the Dutch literature with regard to the quality of policy theories (Hoogerwerf, 1984) or policy maps, i.e. the set of assumptions people have with

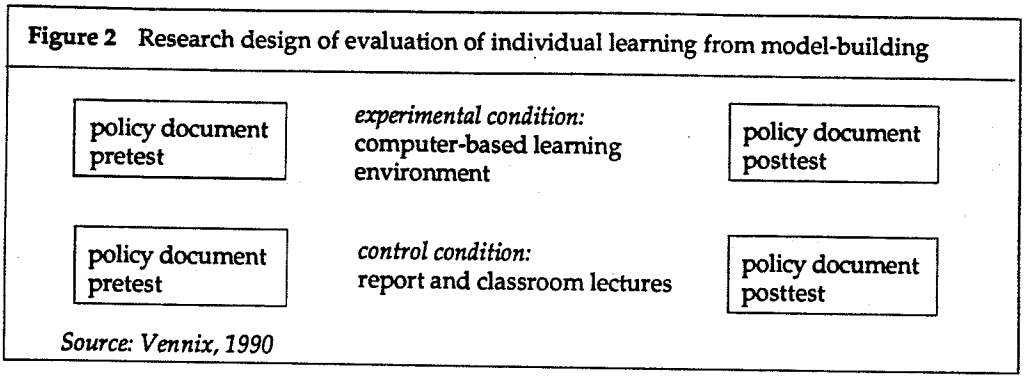


Figure 2 Research design of evaluation of individual learning from model-building

Source: Vennix, 1990

regard to a certain policy problem. Three important overall criteria to establish the quality of cognitive maps are identified: epistemological, implementary and strategic criteria. Among the epistemological are: validity of the theory, precision of concepts and relationships, consistency and quantifications. The implementary criterium includes elements like differentiation of the theory, the occurrence of (manipulable) policy variables and the integration of the theory. Finally, strategic criteria are the occurrence of time delays in the map and its accordance with societal conditions (cf. Leeuw, 1983, 1986; Kraan Jetten, 1986; Hoogerwerf, 1984). Each of these subcriteria was translated into one or more indicators with which scores, based on the cognitive maps, could be established. For instance the length of paths and feedback loops in the cognitive maps was employed as an indicator for the differentiation of the cognitive map. The integration of the map was established by calculating its density: the number of relationships in the map divided by the number of concepts. In sum about 20 different indicators were employed and scores on each of the indicators were determined for all 77 research subjects in the pretest and posttest. Table 1 gives a summary of the indicators used to assess the quality of the cause maps of the research subjects.

The results of the study show that there are only minor differences between both groups in the experiment, when it comes to changes in cognitive maps. This is due to the fact that both conditions in the experiment are more similar with regard to the way information about the simulation model was exchanged than was originally conceived (cf. Vennix, 1990). However, for the two groups together clear changes in a number of indicators based on these cognitive maps could be established due to confrontation with a computer model. For instance the number of delays and quantifications in cognitive maps increased significantly. This is also true for the density of the cognitive maps of research subjects. The interested reader is referred to Vennix (1990) for a more detailed description of the research procedure and the results of the experiment.

Recently new research projects have been initiated aiming at providing more insight in the learning effects emenating from model-building. For instance Gould (1989) has a research design in which she tries to establish learning effects from modeling using a variety of measurements: subjective as well as objective, both before and after as well as during the model-building process. Bakken (1989) is conducting a study which sheds some more light on the phenomenon of transfer of learning from models from one situation to another. Verburgh conducts an experiment to establish learning effects as a consequence of participation in a computer-beased learning environment for policy making in Dutch Health Care (cf. Vennix and Verburgh, 1990). The latter study also employs objective as well as subjective measurements to explore learning effects from model-building. To our knowledge, the three latter studies are, however, still in the stages of research designing and data gathering.

Table 1 Operationalization of the quality of a policy map

main crit.	subcriteria	aspects	indicators
epistemo-logical	validity	- empirical validity	- correct relationships
		- consistency	- consistency of relationships
	precision	- precision of concepts	- identical concepts - converted concepts - diffuse concepts - specific concepts
		- precision of relationships	- signed relationships - quantified relationships
		- precision of policy options and effects	- quantification of policy interventions - quantification of policy effects
imple-mentary	policy variables	- instr. variables	- number of instrument variables
		- goal variables	- number of goal variables
	differenti-ation	- scope	- number of concepts - number of fields
		- degree of detail	- length of paths - length of feedback loops
		- extension	- number of paths - number of feedback loops
		- complexity	- balancedness of paths
	integration		- density of map
strategic	accordance with societal conditions		- number of exogenous concepts
	time factor		- number of delays

Source: Vennix, 1990, 133

Using cognitive maps to establish organizational learning from model-building: deriving the collective map

Establishing learning effects from model-building implies that measurements are performed at least at two different points in time. This does not only go for individual learning as we have seen in the previous section, it also holds for organizational learning. Measuring individual learning from model-building can be accomplished by establishing changes in individual cognitive maps before and after the model-building process. In order to establish organizational learning empirically in a similar way as is done at the individual level (i.e. establishing changes in cognitive maps) one would somehow have to derive an 'organization's policy map' (cf. Hall et al., 1989) at two different points in time: before and after the model-building process. The question is how an organization's policy map can be constructed. Several methods have been used to arrive at collective maps.
One method that has been used in arriving at a collective map is 'averaging' individual cognitive maps (cf. Bougon et al. 1977; Ford and Hegarty, 1984). This is done by taking the indi-

vidual cognitive maps, adding these and inserting concepts and relationships between concepts in the 'organization's map' if they exceed a certain prespecified value. For instance if more than 80% of the individuals holds a particular relationship in their mental map, this relationship is inserted in the 'averaged' organization's map.

As we have seen, however, this way of using cognitive maps to establish organizational learning must be considered largely incorrect, since "...organizational learning is not simply the sum of each member's learning." (Fiol & Lyles, 1985) Or as Hedberg phrases it: "Although organizational learning occurs through individuals, it would be a mistake to conclude that organizational learning is nothing but the cumulative result of their members' learning." (Hedberg, 1981, 6)

In other words simply averaging the individual cognitive maps before and after a model-building process, does not tell much about the fact whether the organization has learned something. Averaging individual cognitive maps creates an artificial organization's cognitive map, which might be an innaccurate representation of the organization's knowledge base. This is also clear from the fact that the average organization's map from the pretest and the posttest in an empirical evaluation study might be the same while individual maps might have changed drastically in the model-building process.

Another method to arrive at a collective map is to build a composite map. For instance Eden et al. (1983), working in a consulting mode with client groups, extract individual's cause maps, 'add' these together and in the group process try to arrive at a joint cognitive map. This method, however, is not very appropriate to establish organizational learning from model-building. This is because it basically is a group model-building process itself. In order to establish organizational learning this way, one would first have to construct a joint map with the group (i.e. the pretest stage). Next the group would have to go through a model-building process and finally, it would again have to create a joint group map (i.e. the posttest stage). Hence, the group would have to go through a joint model-building process three times. Apart from the fact that this is very time consuming, measurements and the model-building process would most probably be heavily interfering. This would severly impede the accurate establishment of organizational learning effects from model-building itself.

A third way to establish a collective map would be to assemble individual cognitive maps by linking these through common concepts in individual maps. Under this procedure one derives individual cognitive maps before and after the model-building process, identifies common elements in these maps and link these through common concepts.

This procedure to arrive at an organization's policy map is for instance followed by Hall (1984). The cognitive maps of different departments in the Saturday Evening Post are linked through common concepts occurring in these departmental maps. This in turn produces the organization's policy map. As Hall points out, each of the departmental maps "...represents the causal paths from *policy variables* (...) through *intervening variables* to the department's *goals*." (Hall, 1984, 914). What constitute goal variables for one department often are policy variables for another. And as Weick and Bougon point out: "This common relevance of concepts is what ties these departments together into an organization." (Weick and Bougon, 1986, 111)

Weick and Bougon also point out that: "Cause maps can be coordinated with relatively little shared understanding, a characteristic that is important to emphasize given the current emphasis on shared beliefs in organizational culture. Concerted action is possible where there is common relevance of two concepts in two cause maps and a *double interact* to link the maps." (Weick and Bougon, 1986, 109-110) If this is supposed to mean that in organizations individual or department's cognitive maps do only have to overlap marginally, i.e. only contain a few common concepts, we disagree with them. As Hall's example clearly suggests policy making at The Saturday Evening Post was based on only part of the total organization's map (i.e. the map of the dominant coalition), which largely ignores important processes going on in the organization and its environment, contained in the maps of the other departments. Hall points out that the Saturday Evening Post went bankrupt because "...the policy elite of the old *Saturday Evening Post* seemed to be oblivious to the recursive relationships that tightly coupled

readers, advertising sales and magazine pages." (Hall, 1984, 923) In other words there was no overall view which guided the policy making process. Hence, although Weick and Bougon may be right from the point of view of organizational knowledge representation, from the point of view of organizational performance a marginal overlap between individual cognitive maps is not a sufficient condition for organizational survival, as Hall's example reveals. And this is particularly true as organizations become more complex.

Using cognitive maps to establish organizational learning: from sharing mental models to integrating mental models

A number of authors have shown that, particularly in large organizations, different persons might have different views of the organization's problems and the way to solve these. Each organizational member perceives the organization and its environment in his own way, depending on such factors as problem complexity, cognitive limitations and styles, selective perception, position in the organization etc. (cf. Hedberg, 1981). The existence of different viewpoints within organizations tends to be promoted by the coming of the organization of the future, the so-called knowledge-based or information-based organization (Drucker 1988, Applegate et al., 1988; Malik 1989). Information technology forms the foundation of the future organization. It provides organizations with new opportunities and new threats. In order to stay competitive, organizations will have to adapt. That is, information technology will have consequences for the organization's structure and the formal regulations as well as for the members of an organization. More specifically, the organization's structure will be flatter because middle management will be cut out. The disappearance of middle management will be accompanied by a shift from traditional departments towards task-forces or teams (cf. Galbraith 1973). In order to benefit optimally from opportunities provided by information technology, highly educated and qualified personnel is required. Members of knowledge-based organizations will be specialists and it is their autonomy that causes problems of control. In solving this problem an organization "...needs a view of the whole and a focus on the whole to be shared among a great many of its profesional specialists, certainly among the senior ones." (Drucker 1988, 51). In other words, organizational learning as assumption sharing (Shrivastava, 1983), as the proces of building and modifying the view of the whole is at the heart of the future organization. Without organizational learning, without the construction and changing of theories-in-use the future organization will have problems surviving.
Model-building with organizational client groups exactly aims at sharing mental models (Senge, 1989). It gets participants to exchange mental models and integrate these into one overall perspective, revealing the organization's view on its environment. However, exchange and integration of various mental models is not enough. As we have seen several authors point out that people act largely according to their cognitive maps (Axelrod, 1976; Hall, 1984; Weick and Bougon, 1986). Hence, in order to improve organizational learning and adaptation to the environment individual cognitive maps have to be restructured in the model-building process. Individual mental models need to be *enriched* with elements from mental models of other members in the organization in order to expand their view of the organization and its environment. One might expect that this will lead to actions of organizational members which are (1) more aligned to actions of other organizational members and (2) more in line with the interest of the whole organization.
Hence, from the empirical point of view of organizational learning this would mean that organizational learning would have taken place if cognitive maps of organizational members after the model-building process reveal more overlap, i.e. are more similar to each other than before the process. For instance overlap in the use of concepts to describe the problem, or in the kind of relationships deemed important. If measured twice, the degree of similarity between the individual's cognitive maps in an organization would be larger after the model-building process than before.
The study conducted by Vennix (1990) provides partial support for the hypothesis of greater similarity between individual cognitive maps as a consequence of model-building. As stated

above one of the indicators for the quality of the cognitive maps is the precision of concepts. This is amongst others measured by the proportion of concepts which can be directly related to one of the concepts in the simulation model during the coding process of the policy notes. In the posttest the percentage of concepts, which could be directly related to one of the concepts in the simulation model by the coders, is significantly higher than in the pretest. This, although policy notes from pretest and posttest were distributed randomly over coders. In the pretest this percentage is 87%, in the posttest this percentage is 92% ($N=77$; $p < .001$). Stated differently, research subjects tend to think more in terms of the concepts used in the simulation model, which indicates that their maps have become more similar to each other. A comparable conclusion can be drawn from considering the type of relationships between variables included in the cognitive maps. Currently this question of similarity of cognitive maps is studied in more depth by reanalyzing the data from the experiment using a number of criteria with which this similarity can be established. We think of such criteria as similarity in the use of policy variables, relationships, delays etc.

SUMMARY AND CONCLUSIONS: CONSEQUENCES FOR BUILDING MODELS WITH CLIENT ORGANIZATIONS.

In this paper we have argued that model-building with client groups can be considered to induce an organizational learning process. Seen from the empirical perspective there is a variety of problems in trying to establish organizational learning empirically. First there is the distinction between the individual and the organizational level. Second there is the problem of how to establish organizational learning from individual cognitive maps. We have shown that it is not so much the changes in individual cognitive maps per se, but rather the similarity between individual cognitive maps which should be used as an indicator for the degree of organizational learning due to a model-building process with a client group. The question now is what this means for the process of building models with client groups. In our view there are several important conclusions that can be drawn from this.

First, this view has profound consequences for the process of eliciting and mapping knowledge from model-building processes. Richardson et al. (1989) have pointed out that there exist a variety of techniques to elicit knowledge from individuals and groups. To arrive at a choice between these various techniques the authors introduce a number of criteria with which a selection from these techniques might be made. One of these criteria is learning form model-building. As the authors point out: "The process of eliciting and mapping knowledge to build system dynamics models is iterative--through successive cycles of refinement the ultimate model gradually appears. (...) So knowledge elicitation is not simply a process of uncovering a fixed body of knowledge and representing it. Participants learn, as their mental models are reshaped by discussion and interaction." (Richardson et al. 1989, 353) The authors conclude that as a consequence not only written documents and individuals must be included as a source of knowledge for model-building. Rather groups will always have to be included since it is through discussions in these groups that mental models become shared, improved and possibly converge towards each other. Group discussions in model-building should thus provide ample opportunity for each of the participants to learn from others in the model-building process. In this sense the model-building process is likely to go as slow as the slowest learner.

A second consequence that might be drawn from this paper is that model-building with client groups should be an ongoing activity rather than provide the one and final solution to a problem. Organizational learning itself is an ongoing process (Shrivastava, 1983). Mental models will continue to be reshaped during the process of carrying out organizational tasks. In carrying out the day to day tasks mental models will probably become dissimilar again through time. Hence, it might be important to repeat the process of model-building at regular time intervals, using the 'previous' model as the starting point for the discussions.

Since organizations continually interact with their environment, a third point is that the model-building process should allow to direct attention to developments in the organization's environment and exogenous events which possibly affect the organization's functioning. The

model-building process should aim at reducing uncertainty with regard to future developments in the organization's environment.

REFERENCES

Applegate, L.M., J.I. Cash, D. Quinn Mills. 1988. Information technology and tomorrows managers. *Harvard Business Review*, 66 (6): 128-136.

Argyris C. & D.A. Schön. 1978.*Organizational learning: a theory of action perspective*, Reading (Mass.).

Axelrod, R. 1976. *Structure of decision: the cognitive maps of political elites*, Princeton (NJ).

Bakken, B. 1989. Learning in dynamic simulation games: using performance as a measure. In: P.M. Milling, E.O.K. Zahn (eds.), *Computer Based Management of Complex Systems*, Proceedings of the 1989 International Conference of the System Dynamics Society, Berlin etc., Springer: 309-316.

Beer, S. 1979. *The heart of enterprise*. Chichester: Wiley.

Berger, P. and T. Luckmann. 1979. *The social construction of reality*. Norwich: Fletcher & Son Ltd.

Bougon, M., K. Weick, D. Binkhorst1977. Cognition in organizations: an analysis of the Utrecht jazz orchestra. *Administrative Science Quarterly*, 22: 606-639.

Brehmer, B. 1989. Feedback delays and control in complex dynamic systems. In: P.M. Milling, E.O.K. Zahn (eds.), *Computer Based Management of Complex Systems*, Proceedings of the 1989 International Conference of the System Dynamics Society, Berlin etc., Springer: 189-196.

Daft, R.L. and K. E. Weick. 1984. Toward a model of organizations as interpretation systems. *Academy of Management Review* 9 (2): 284-295.

Dalton, G.W., P.R. Lawrence and J.W. Lorsch. 1970. *Organizational structure and design*. Homewood, Ill.: Richard D. Irwin, Inc. and the Dorsey Press.

Dörner, D. 1980. On the difficulties people have in dealing with complexity. In: *Simulation and Games*, 11 (1): 87-106.

Dörner, D., H.W. Kreuzig, F. Reither, T. Stäudel (eds.). 1983. *Lohhausen: vom Umgang mit Unbestimmtheit und Komplexität*, Bern/Stuttgart/Wien.

Drucker, P. 1988. The coming of the new organization. Harvard Business Review 66 (1): 45-53.

Eden, C., S. Jones, D. Sims. 1983. *Messing about in problems: an informal structured approach to their identification and management*, Oxford/New York etc.

Emery, F.E. and E.L. Trist. 1965. The casual texture of organizational environments. *Human Relations*, 18 (1): 21-32.

Etzioni, A. 1969. *A Sociological Reader on Complex Organizations*.New York: Holt, Rinehart and Winston, Inc.

Fiol, C.M. and M.A. Lyles. 1985. Organizational learning. *Academy of Management Review* 10 (4): 803-813.

Ford, J.D., W.H. Hegarty. 1984. Decision makers' beliefs about the causes and effects of structure: an exploratory study. *Academy of Management Journal* 27 (2): 271-291.

Forrester, J.W. 1961. *Industrial Dynamics*, Cambridge (Mass.).

Geus, A.P. de, Planning as learning. 1988.*Harvard Business Review*, march-april: 70-74.

Gould, J.M. 1989. *Research Summary*, D-Memo D-4021, System Dynamics Group, MIT.

Hall, R.I. 1984. The natural logic of management policy making: its implications for the survival of an organization. *Management Science*, 30 (8): 905-927.

Hall, R.I., P. Aitchison, W.L. Kocay, H. Li. 1989.*The organization's policy maps: types of maps, methods for soliciting and recording them, and techniques for analysis*. Working document, Dep. of Business Administration, Univ. of Manitoba, Winnipeg, Canada.

Hart, S.L. 1983. *Strategic problem solving in turbulent environments: a description and evaluation*. Ph.D. dissertation, University of Michigan, Ann Arbor (Mi).

Hedberg, B. 1981. How organizations learn and unlearn. In Nystrom P. C. & W.H. Starbuck (eds.) *Handbook of organizational design*: 3-27. Oxford: Oxford University Press.
Hoogerwerf, A. 1984. Beleid berust op veronderstellingen: de beleidstheorie. *Acta Politica* 4: 493-531.
Kim, D.H. 1989. *Organizational learning and individual learning: where the twain shall meet ?*. Internal memorandum, MIT Sloan School of Management, Boston.
Kraan-Jetten, A. 1986. Reconstructie en evaluatie van beleidstheorieën. *Beleid en Maatschappij* 4: 186-196.
Lane, D. C. 1989. *Modeling as learning: creating models to enhance learning amongst management decision makers*. Paper presented at the European Simulation Conference, Edinburgh, sept. 1989.
Leeuw, F.L. 1983.*Bevolkingsbeleid en reproduktief gedrag: een studie naar de theorieën over gedrag die aan beleid ten grondslag liggen*, Ph.D. diss., R.U. Leiden.
Leeuw, F.L. 1986. Beleidstheoretisch onderzoek toen en thans. *Beleid en Maatschappij* 1: 27-39.
Luhmann, N. 1976. A general theory of organized social systems. In: G. Hofstede, M. Sami Kassem, European contributions to organization theory. Assen/Amsterdam: Van Gorcum
Malik, F. 1989. *Strategie des Managements komplexer Systeme*. Bern: Maupt.
Meadows, D.H., J.M. Robinson. 1985. *The electronic oracle: computer models and social decisions*, Chichester/New York, .
Miller, E.J.and A.K. Rice. 1967. *Systems of organizations*. London: Tavistock Publications.
Morecroft, J.D.W. 1988. System Dynamics and microworlds for policymakers. In: *European Journal of Operational Research*, (35): 301-320.
Perrow, Ch. 1970. *Organizational Analysis: A Sociological View*. London: Tavistock Publications.
Peters, G. 1989. *Organisation und Information: über den Zusammenhang von Interessen, Kenntnissen und handlungen*. Ph.D. dissertation, Utrecht University.
Peters, G., W.J. Scheper. 1990. *Organization, knowledge and information: theoretical issues*. Working document, Dept. of Gamma-Informatics, Utrecht University.
Senge, P.M. 1989. Organizational learning: a new challenge for system dynamics. In: P.M. Milling, E.O.K. Zahn (eds.), *Computer Based Management of Complex Systems*, Proceedings of the 1989 International Conference of the System Dynamics Society, Berlin etc., Springer: 229-236.
Schutz, A. 1973. *Collected Papers I*. The Hague: Nijhoff.
Shrivastava, P. 1983. A typology of organizational learning systems. *Journal of Management Studies* 20 (1): 7-28.
Shrivastava, P. and J.H. Grant. 1985. Empirically derived models of strategic decision-making processes. *Strategic Management Journal* 6: 97-113.
Stata, R. 1989. Organizational learning: the key to management innovation. *Sloan School Management Review* 30 (3)
Sterman, J.D. 1989a. Misperceptions of feedback in dynamic decision making. *Organizational behavior and human decision processes*, 43: 301-335.
Sterman, J.D. 1989b. Modeling managerial behavior: misperceptions of feedback in a dynamic decision-making experiment. *Management Science* 35 (3): 321-339.
Vennix, J.A.M. 1990. *Mental models and computer models: design and evaluation of a computer-based learning environment for policy making*. Ph.D. Dissertation, University of Nijmegen.
Vennix, J.A.M., L.M. Verburgh, 1989, *Organizational learning in a computer-based learning environment*. Research proposal, University of Nijmegen.
Weber, M. 1976. *Wirtschaft und Gesellschaft*. Tübingen: Mohr.
Weick, K.E. 1979. *The social psychology of organizing*. Reading (Ma): Addison-Wesley.
Weick, K.E., M.G. Bougon. 1986. Organizations as cognitive maps: charting ways to succes and failure. In: Sims, H.P., D.A. Gioia (eds.), *The thinking organization*, San Francisco/London.