SYSTEM DYNAMICS:
A PARADIGM FOR ORGANIZATIONAL LEARNING?

by

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Abstract

This paper investigates whether or not System Dynamics supports organizational learning effectively when it is applied within a currently used group problem definition technique. The results demonstrate that this question should be answered negatively. This is caused as described in the paper by 1) the nature of the mathematical model underlying System Dynamics and assuming an aggregate level of analysis in the sudy of complex organizational problems, and 2) the design of currently used group modelling techniques wherein group processes decrease or block the cognitive information processing by the participants.

1. Introduction

Societies today are subject to technologically induced changes, which follow one another at an ever increasing pace and in ever increasing multitudes. Not only does the complexity of societies grow exponentially but also the uncertainty about the directions in which it will unfold. During the last decade information technology has boosted this development up to rates and levels of change that become more and more unpredictable.

The conditions created by information technology for acquiring competitive advantage by profit and nonprofit organizations are well described in the seminal article of Porter & Millar (1985). Their analyses produced three important results. First, information technology may change the whole business of organizations by providing opportunities to produce entirely new sets of goods and services. Secondly, information technology enables organizations to cut their production costs significantly by altering their production methods. Thirdly, information technology enables organizations to differentiate each of its products within a wide range of customer specifications. These results imply that organizations are facing fastly expanding and changing markets for their products. But a promising market opportunity today may turn out to be a failure tomorrow. Consequently, there is a growing need for planning and coordination of an ever increasing number of business activities within organizations but also for an increasing pace of the adaptation of that planning and coordination. Here we face the paradox of modernization, namely the urge for more control of the less controllable.

Successful organizations sail through this paradox by learning from planning on the basis of modelling as De Geus (1992) puts it. And the modelling of complex organizational planning problems by the problemowners and stakeholders within an organization provide a method for improving the coordination of planning via the creation of a shared vision. In order to cope with the complexity of organizational planning problems induced by feedforward and feedback relations among organizational processes various researchers in this field of inquiry advocate a systemtheoretical approach (see a.o. Senge (1990), Wolstenholme (1990), Morecroft & Sterman (1992), Vennix (1996)). A tool often applied in this literature to support a systemtheoretical approach is mathematical system analysis, which had its first widely known application to organizational planning problems by Forrester (1961). Later on this tool has become known as System Dynamics, which is supported nowadays by userfriendly graphical interfaces contained in computerprograms like a.o. STELLA™ (Richmond et al,1987).

The question that will be addressed in this paper is: Can System Dynamics as a method for system analysis provide a paradigm for learning about complex organizational planning problems? In order to answer this question, the rest of this paper is structured as follows. First, the scientific nature of System Dynamics will be discussed in Section 2. Secondly, learning from applying System Dynamics to complex organizational planning problems is investigated in Section 3. After that the implications of the results derived in Section 3 are discussed in further detail in Section 4. Section 5 presents the conclusions to be drawn from the research presented in this paper.

2. The scientific nature of System Dynamics

System Dynamics is the mathematical representation of system analysis. In this representation the change in the state of a (sub)system is described mathematically as the result of the difference between the output and the input of the (sub)system. This mathematical description has a one-to-one relationship with the theoretical model of a (sub)system. Various subsystems may be interrelated to represent a larger system wherein the output of one subsystem acts as the input of another subsystem or contributes to the output of the entire system. Inputs of subsystems not originating from other subsystems but from outside the entire system are called the input of the system. Consequently, in system analysis only three concepts are distinguished namely "system", "input" and "output". These concepts are applied to specify the dynamics of the system, i.e. successive changes in the state of the system (i.c. the level variable) due to varying successive differences between the output and the input of the system (i.c. the flow variable). As these three concepts in system theory provide no indications of their empirical counterparts, Faber & Scheper (1997) conclude that system theory is a formal theory like logic, which lacks empirical content. Accordingly, system theory itself has no predictive or explanatory power in the empirical domain of, for example, complex organizational planning problems. From a philosophy of science point of view, system theory represents only cause-effect or stimulus-response relations, which by their interconnections constitute causal chains through time. However, by its nature system theory defines more clearly the scheduling in time and/or the direction of causal influences than other modelling methodologies like correlational maps or causal schemes do. The latter modelling methodologies represent only implicitly the time scheduling of (causal) relationships between the modelled phenomena. But, the question concerning whether or not a systemtheoretical or System Dynamics model contains a valid representation of any empirical situation cannot be answered from system theory itself. In sum, System Dynamics is a modelling methodology that does not produce a priori more valid representations of empirical situations than other modelling methodologies. The results of philosophical research into scientific explanation conducted by Faber & Scheper (1997) even imply that System Dynamics can never represent a valid explanatory model of any empirical situation. System Dynamics contains at its best only a valid descriptive representation of an empirical situation. This is due to the assumption made in mathematical system analysis that successive changes in the state of a (sub)system (or level variable) occur continuously in time. Continuity of processes of change can never be assumed at the level of the individual at any instance of time but only at the level of aggregations over time and/or individuals. For example, successive changes in the inventory of the total number of a certain (type of) commodity over time can be well represented in a System Dynamics model. But the paths of individual commodities through this inventory due to the application of a particular logistic principle, like a.o. FIFO or LIFO, cannot be modelled in System Dynamics. And the aggregation of paths of individual commodities through the inventory accounts for the change in the inventory of all those commodities. So, the System Dynamics model of the aggregate change in the inventory may very well represent a valid description of reality but it does not represent a valid explanation of that change, because the System Dynamics model does not represent the logistic principle that causes that aggregate change at the level of individual commidities.

3. Learning from applying System Dynamics

3.1 Organizational learning about complex planning problems

After having characterized System Dynamics in the previous section as a modelling methodology for specifying the temporal order of unidirectional causal effects among aggregate phenomena of interest, the question of how this methodology can support organizational learning about complex planning problems arises. In order to answer this question the concepts of "complex planning problems" and "organizational learning" need further specification.

An organizational planning problem is called complex when it concerns a large number of issues touching the interests of many stakeholders within the organization, while the stakeholders themselves are only aware of a limited number of these issues. In order to avoid counterproductive actions conducted by individual stakeholders within the organization that are aimed at solving their part of the organizational problem and to stimulate concerted actions that are aimed at solving the entire organizational problem, the creation of a shared vision among all stakeholders touched by the complex organizational problem is a necessary prerequisite. Vennix (1996) recalls that a Nominal Group Technique approach towards complex organizational planning problems is one of the best approaches to stimulate teambuilding among the individual stakeholders. And this teambuilding in combination with the use of System Dynamics as a modelling methodology is argued to support consensus formation within the group of stakeholders concerning the specification of the complex organizational planning problem at hand. In turn this consensus formation is reflected in a shared model of the relationships among all issues considered to be at stake. The implicit assumption often made in further research is that consensus about a shared model of the complex organizational planning problem resembles a shared vision on this problem. From a semiotics point of view this assumption is subject to several additional requirements, because one moves from the specification of the problem to the definition of the problem (cf. Scheper & Faber, 1995). For example,a variable in the System Dynamics model labeled "lagged execution of planning schemes" measured in days or weeks, which meets all criteria of System Dynamics with respect to dimensionality etc., may be interpreted differently by individual stakeholders in terms of the actual business processes and activities involved. These different interpretations depend on differences between the circumstances wherein the stakeholders work, that is, on differences between specific departments of the organization.

Organizational learning may be roughly subdivided into four parts. The first part is that the stakeholders learn from the application of System Dynamics within the Nominal Group Technique that consensus formation about a model of the complex organizational planning problem is a prerequisite for acquiring knowledge of and insight in the complexity of the problem, that is, knowledge of and insight in the multitude of feedforward and feedback effects in time among the issues recognized. This knowledge and insight should highlight the relative costs and revenues of the difference between counterproductive individual actions and concerted individual actions. The implementation of this knowledge and insight acquired by the stakeholders into actual business processes and activities via the adaptation of internally organizing and executing these processes and activities forms the second part of organizational learning. The third part of organizational learning consists of acquiring knowledge of and insight in how the Nominal Group Technique in combination with System Dynamics can be applied more efficiently when the next complex organizational planning problem is encountered. The fourth part of organizational learning consists of acquiring knowledge of and insight in how the implementation of newly acquired knowledge of and insight in actual (dependencies among) business processes and activities can be more quickly realized. The last two aspects of organizational learning represent the adaptive capacity of the organization to respond to and cope with complex organizational planning problems. But the first part of organizational learning is a prerequisite for the other three parts. Therefore, attention in this paper is directed at the first part of organizational learning.

3.2 Consensus model or shared vision?

An interesting point to be noticed is the translation of the shared System Dynamics model (at the aggregate level) into the adaptation of internally organizing and executing business processes and activities (at the individual level). This second part of organizational learning suffers from the semiotic problems mentioned before and belongs to the phase of operationalization in the empirical cycle of scientific research. Hence, the issue of face validity becomes actual. The face validity of any variable in the shared System Dynamics deteriorates if a stakeholder involved translates the variable into particular business processes and activities not meant by other stakeholders. Then the shared System Dynamics model may induce counterproductive actions instead of concerted actions; or, in other words, the consensus model does not represent a shared vision on the complex organizational planning problem at the level of the work floor. This issue concerns the identification and definition of actual business processes and activities as empirical indicators of the variables in the shared System Dynamics model. The other side of the coin is that the shared System Dynamics model may not represent a valid abstraction from reality.

Another issue that may frustrate the translation of the shared System Dynamics model into concerted adaptations of actual business processes and actvities concerns the incorporation of the causal scheme in the System Dynamics model into the cognitive causal schemes of individual stakeholders. If the causal scheme in the System Dynamics model is not shared in the cognitive causal schemes applied by individual stakeholders to the complex organizational problem then a shared vision on that problem does not exist and concerted actions, that is, concerted adaptations of actual business processes and activities can be doubted to be executed. This issue is called in methodology the construct validity of the operationalization (i.e.the implementation) of the shared System Dynamics model. This issue of construct validity has been tested by a.o. Vennix (1990), Vérburgh (1994) and Kenis (1995). Using test-retest designs, which did not meet all necessary criteria of experimental research (see Faber, 1994 and 1995), they found that the cognitive cause maps of the investigated complex organizational problem held by individual stakeholders were barely affected by the consensus System Dynamics model of the problem. In an educational research project for academic students with a sound experimental design, which was supervised by the author in 1992, the same result appeared. Ergo, the construct validity of the implementation of a consensus System Dynamics model of any complex organizational planning problem appears to be rather low. As a consequence, stakeholders in a complex organizational planning problem who participate in a Nominal Group Technique combined with System Dynamics seem more involved in social window dressing or in securing their positions than in solving the problem.

4. Discussion

The conclusion derived above will be contested by many researchers within this field of study. They may argue that the direct effect of the approach on the solution of the complex organizational planning problem at hand may be nil but that the clarification of the complexity of the problem will have a positive effect on the willingness to cooperate in concerted actions to solve future problems of the same kind. No empirical research into this hypothesis has been conducted yet. But some interesting experimental research into the question whether stakeholders are more effective in their cognitive information processing concerning a complex problem when they do it alone or when they participate in a group has been carried out by Stroebe & Diehl (1994). Their results demonstrate that stakeholders are better informed about their own opinions and others' opinions on the complex problem when they act alone than when they act within a group.

An explanation of this outcome goes as follows. When individual stakeholders participate in a group the vision of other stakeholders (or competitors within the organization) together with the vision of their nonverbal behaviour arouses so much attention that each participant acts under stress. This stress will be further increased by shortened reaction times for responding to verbally transmitted opinions of others on the problem and will result in limited or blocked cognitive information processing by the individual stakeholders. In line with this explanation it may be concluded that organizational learning about complex organizational planning problems is not effectively supported by currrent group problem definition techniques like the Nominal Group Technique or policy delphi in combination with System Dynamics.

5. Conclusion

The conclusion to be drawn from the analysis presented in the previous sections can be rather short. System Dynamics as a modelling methodology does not adequately support organizational learning, which is necessary for dealing with complex organizational planning problems. A System Dynamics model of such a problem reflecting the consensus reached among individual stakeholders about the specification of the problem will suffer from problems with the face validity and the construct validity of the implementation of the model into actual business processes and activities, which are carried out within the organization. This conclusion does not disqualify system theory as a useful framework for the analysis of complex organizational planning problems. But it should be applied at the level of actual business activities conducted by human individuals (i.c. the employees) and not at a more aggregate level of business processes taking place within (sub)departments of the organization (i.c. collections of individuals). Furthermore, coordination problems between actual business activities should be defined and solved in negotiations amg the employees involved and not in negotiations among their managers.

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