System Dynamics Projects That Failed to Make an Impact

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Abstract

The purpose of the paper is to discuss the phenomenon why some system dynamics projects fail to generate substantial impact in organizations—despite the fact that they are based on an apparently valid system dynamics model and are conducted by experts in the field. The approach followed in the paper is a conceptual discussion, extended by two short case studies. Findings are that the quality of the model and the expertise of the modeler are necessary, but not sufficient requirements for organizational impact. Further research should concentrate on the detailed analysis of additional requirements. Practical implications are an increased embedding of system dynamics projects in organizational intervention architectures. The originality of the paper lies in its focus and discussion of failed projects that are invaluable sources for insight generation.

Keywords: system dynamics, organizational impact, organizational intervention, project management

Over the last twelve years, the author has been involved in a substantial number of system dynamics based projects in companies as an academic advisor and external consultant. The companies are from a broad range of industries, for instance software companies, airlines, automobile manufacturers, or pharmaceutical firms. The topics that are analyzed comprise issues such as supply chain manufacturing, knowledge management, and the organization of production processes. The system dynamics models that resulted from these projects are usually well-received from colleagues at academic institutions; regularly, companies claimed to be satisfied with the outcomes of the projects. However, the results concerning longer term organizational impact, for example changed policies or structures in the companies, are mixed at best—the same is true regarding the sustainable application of system dynamics after the project's finish.

The purpose of this paper is to shed some light on the issue that organizational impact is often rather low, despite the fact that projects are considered a success from a system dynamics perspective. The structure of the paper is as follows: in the next section, the phenomenon of limited organizational impact is described in more detail on a general level. In the second section, two brief case studies are presented, in which an apparently successful system dynamics project did not lead to substantial organizational changes. The third section, discusses the integration of system dynamics projects into intervention architectures as a possibility to increase organizational impact. The paper closes with some short remarks on potential future research.

The implementation issue in system dynamics projects

When system dynamics projects yield only insignificant results concerning actual changes in organizations, it is often caused by too little focus on the implementation side—assuming that the model and the resulting simulations are appropriate. System dynamics projects do not stop with the identification of a new strategy, with making a decision, or with designing new organizational structures and policies. Rather, these outcomes have to be implemented in the organization. However, decentralization and empowerment have resulted in increased challenges for implementing change. New strategies can seldom be implemented only by formulating new guidelines or policies. It is required that (1) executives at an appropriate hierarchical level actively support the change process, and (2) a large number of employees understand why the organization must change as well as the reasoning behind the change process to be implemented.

Thus, implementation of insights gained in modeling and simulation projects is an issue in organizational settings. As Warren (2002) points out, researchers within the field of strategic planning devote much attention to the discussion of problems in the strategy process as implementations far too often remain unsuccessful. A parallel to the discussion of the problems of implementation of strategies can be found in Repenning and Sterman's (2002) discussion of improvement programs. They report that a successful implementation of new programs often represents a bigger challenge than identifying or learning about them, i.e. the implementation of a solution to organizational issues can constitute a bigger challenge than finding the solution.

Although system dynamics projects—in particular, participative modeling or group model building (Vennix et al., 1992; Vennix, 1996; Andersen et al., 1997; Andersen and Richardson, 1997)—are concerned with both cognitive and behavioral aspects, such as learning, alignment of mental models and creation of consensus and commitment among participants, system dynamics modeling efforts are typically centered around the decision process, not the implementation of decisions. Frequently, project reports or publications based on system dynamics projects discuss the structure of the model in great length. However, it is only sparsely reported, how results of model building and simulation should be implemented in organizational reality.

This does not mean that writers in the field of system dynamics have not perceived the implementation issue. From the beginning (Forrester, 1961), the results of system dynamics studies were conceived to be realized in organizations, not just being intellectual stimuli. This focus on implementation is emphasized in a later paper by Forrester (1994), when he explicitly sets "policy implementation" as the last step of the modeling process. The same is true for most textbooks on system dynamics, for instance, Richardson and Pugh (1981), Roberts et al. (1994), Maani and Cavana (2000). Roberts (1978) argues that sound scientific models not automatically lead to organizational change, emphasizing the implementation phase. Lane (1992) emphasizes the involvement of the clients of modeling projects. However, as also Weill's (1980) article on how system dynamics projects can have an organizational impact shows, implementation is often seen as a top-down process that is located at the end of a system dynamics modeling endeavor. In slight contrast, Coyle (1977) states that implementation is a problem that needs to be addressed from the beginning of a project. Based on Roberts' (1978) book, Sterman (2000) adds the insight that model-building processes usually are iterative, i.e. the implementation phase is not the end but also the start of a new modeling cycle. In addition, Sterman (2000) lists implementation as one of the challenging areas for system dynamics in the future.

To summarize, implementation has always been discussed as important in system dynamics. However, it is hardly mentioned that for an effective implementation of results the support of organizational decision-makers on appropriate hierarchical levels is important in the same way as the involvement, motivation and knowledge of organizational members from other levels are necessary and crucial for success. Missing executive support results in the phenomenon that projects are received well within the team working on it, but do not lead to any substantial changes. When organizational members from other hierarchical levels are not involved, immediate changes might occur (pushed by the top executives) but system dynamics is not anchored as an institutionalized method within the organization. Without being institutionalized by means of formal training and official recognition, system dynamics will not be used continuously. Thus, two degrees of low-impact of system dynamics projects can be identified: Grade 1 comprises seemingly successful projects with no changes in policies or structures; in grade 2 are seemingly successful projects that lead to immediate changes but no to a sustainable use of system dynamics.

Description of "low-impact" system dynamics projects

In this section, both "low-impact" grades resulting from system dynamics projects are exemplified with the help of two case studies. Clearly, two cases are no 'proof' for the existence and completeness of the two grades of low-impact projects and are not meant as one. Rather, they serve as illustrations on which the further discussion of low-impact system dynamics projects can be based.

The case studies are from the airline industry. While the first case describes a project regarding the general strategy of the company, the second is related to an internal organizational issue. Both projects were received well within the company. However, the first case resulted in no observable changes (grade 1); the second case led to changes but did not bring about additional interest in system dynamics (grade 2). The projects are documented in form of academic publications (Liehr et al., 2001; Schillinger et al., 2003).

Case study 1: Business cycles

The evolution of the airline industry is heavily influenced by business cycles. The industry's cyclical behavior has started to develop after the deregulation of the airline market in the USA. Often, singular incidents (Gulf war, oil crisis) are considered by managers and in the literature as the main causes for the cycles, besides the fluctuations in gross domestic product (GDP) of the major industrialized regions of the earth (North America, Europe, Japan).

Given the requirements of the global capital markets, it is necessary for airlines to show substantial growth in order to attract capital (Borgo and Bull-Larsen, 1998). The business cycles, which have impact on the profitability of the industry, are subject of growing interest to the companies' management, since the cycles are also observed by professional investors. As long as the inherent causes of these cycles are not understood and adequately managed, the airline industry suffers from a discount in stock prices, compared to other industries. This situation leads to the necessity to be able to understand, explain and manage the business cycles. Through forecasting, simulation and understanding it should be possible to manage cyclical behavior (at least as a single company) and, thus, to be able to keep profit up and outperform the industry.

The purpose of the system dynamics project conducted in the late 1990s was threefold:

- to gain insights into the dynamics of the cyclical movements and to identify the core structure of the problem;
- to develop a tool for the analysis of different scenarios, for example, exogenous demand-shocks;
- to test alternative policies in order to derive strategies for long-term capacity and fleet planning.

The period of the market's cycle is roughly eight to ten years, which is typical for Juglar waves. Juglar waves correspond to machine-investment-cycles and are considered as the classical economic cycle (Schumpeter, 1939). This contributes to the wide spread opinion that the cycles in the airline market are a response to fluctuations in the evolution of the GDP and that they lie beyond the range of the industry's influence. As a consequence, there is a lack of cyclical management strategies to smooth the oscillations and to reduce their negative impact on the carriers' profitability (Gialloreto, 1998). However, the system dynamics study showed that there is strong evidence that the cycles of the market are—at least partially—endogenously driven. With the help of modeling and simulation it was demonstrated that several strategic points of high leverage for the airlines exist, depending on their position in the cycle.

An abstracted micro-structure (Lane and Smart, 1996) of the airline market could be identified. It is a negative feedback loop with two delays—a structure that can lead to oscillations (Forrester, 1968). It illustrates the chain of causal relationships in the order loop of the airline industry. The first delay characterizes the aircraft manufacturer's lead-time, the second the delayed recognition of the industry's surplus passenger capacity. The lag between aircraft orders and deliveries is about 18–24 months before new jets increase the market's capacity. The latter is reduced by aircraft retirements. The great majority of jetliners are retired from passenger service before they reach thirty years of age. Over-capacity increases with seats offered and declines with higher demand. Growing over-capacity (which means lower seat load factors) reduces the number of aircraft ordered depending on the tolerated surplus level.

Besides the airline market there are various other cyclical industries and markets, for instance the paper industry, real estate markets, commodity markets, the shipbuilding industry. It is interesting to note that the dynamic behavior and core structures of these systems are almost identical to each other. The description of the aircraft order loop in action is similar to the causes and effects produced by commodity production systems (Meadows, 1970) or by delayed inventory systems, as simulated in the beer game (Sterman, 1989): Airlines strive for high seat load factors to maximize their revenue. Due to aircraft lead-times and delayed recognition of over-capacities, the system starts to oscillate around the desired seat load factor. The basic mechanisms underlying these expansion and contraction movements are the same as those of the economic long wave in production systems (Sterman, 1986).

The general model was the result of various consultations of experts who helped to identify the relations between the key variables and to define the system's boundaries. "Corporate system modeling policy sessions" for knowledge elicitation (Hall, Aitchison and Kocay, 1994)—group discussions and open interviews with the help of causal-loop diagrams, system flow diagrams and simulation results—proved to be conducive to an effective model building process.

Without intensive calibration, the model reproduced historical behavior of the airline market satisfactorily. The characteristics of cyclical variables and the two crises of the airline market in the early 1980s and 1990s can be duplicated by model simulations. Compare, for example, actual orders of new aircraft jets from 1970 until 1998 and data generated by the simulation model (Figure 1). Although the historical and the simulated curve differ on a point by point basis, the dynamic, cyclical behavior is obviously and intuitively the same. Furthermore, nearly 92 % of the error between actual historical data and simulated behavior is caused by unequal covariance. This can be supposed to be the effect of noise in the historical data series and, therefore, is not due to a systematic error in the simulation model (Sterman, 1984).

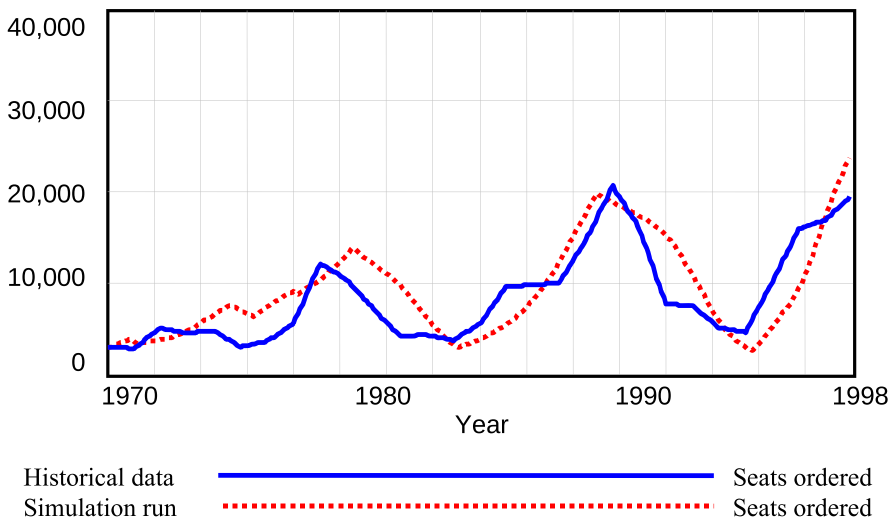

Figure 1: Comparison of historical and simulated data for orders of new aircraft jets

The modeling project helped to identify key variables and leverages for cyclical management strategies. Decision makers could learn that the cyclical behavior of industry's performance is to a significant degree caused by their decision rules and not by exogenous factors. The implementation of stabilizing policies can lead to structural changes at various leverage points which will be discussed in the following:

Aircraft ordering: Policies for aircraft orders are a key element in the cycle generating structure of the airline market. Growing slower in capacity than your competitor means losing market share (Skinner and Stock, 1998). Hence, the intense competition for regional and global market share is mainly decided by capacity management. With the underlying structure of the market, this leads to the emergence of capacity surpluses. In this situation counter-cyclical ordering yields several advantages for a single carrier, most of all lower prices and shorter lead times for aircraft, which result in quicker reaction times. Realizing counter-cyclical order policies is far from being a trivial task, both in reality and in the system dynamics model. An organizational prerequisite for management to engage in counter-cyclical strategies could be the foundation of an independent organizational unit that controls and manages all assets (aircraft) of the company. This concept creates the flexibility and independence needed for counter-cyclical asset management. The objective is to ensure a quasi continuous inflow and outflow of aircraft, regardless of fluctuations in the market. This includes leasing over-capacities to other airlines.

Network planning: "Open Skies"—the liberalization and deregulation of the airline market—made it possible for carriers to shift capacities from regions with low demand to those with higher demand. This practice could be observed in 1998 during the financial crises in the Asian region, when capacities were transferred from inside Asia to the Pacific and Atlantic regions (McMullan and Moreno, 1998). Hence, in the short term, network planning can be used as an instrument to react to unforeseen demand shifts (Hallerström and Melgaard, 1995) and to decrease over-capacity.

Flexibility: Adding flexibility to existing capacity is another important leverage in cycle management. The alternatives that were discussed are leasing and retirement policies. These require an increase in average life span of the fleet. The idea behind the strategy is to keep a certain percentage (10%–15%) of older aircraft in the fleet which are operated in case of a shortage in deliveries or seats offered; in downturns this part of the fleet is quickly retired, at low costs. This policy opens margins and flexibility for fleet planning. Simulation runs have shown that in periods of recession over-capacities can be reduced and thus oscillations dampened. However, such a quick relief requires a counter-cyclical order policy that ensures an adequate level of capacities when the market turns around. The last example shows that managing the business cycles in the airline market is often a combination of strategies using the different leverage points.

However impressive and conclusive these findings were, the usage of the project's outcomes has been low. Although the airline did relatively well in recent years, this is commonly attributed to improvements in cost structure and efficiency. One can doubt whether the insights gained during the system dynamics project actually induced changes in the policies for ordering aircraft and increased fleet flexibility. There are no indications that the model or the simulations were subsequently used after the original project had been finished. In addition, the cyclical behavior in the airline industry still prevails, with slow, but continuous growth in demand but oscillating profits for the total of airline companies (IATA, 2005). While the case airline's market share is not big enough to influence industry data directly, it can be assumed that changed and successful policies would have diffused through the industry in the course of eight years since the end of the project. This would have led to an industry-wide re-formulation of aircraft ordering policies and, thus, to a change in business cycles, which has not happened.

The low impact of the findings is caused by the non-involvement of top executives in setting-up the project. Although the airline's team was comprised of knowledgeable individuals that worked in the strategic planning department (which directly reports to the board of the company), during the project no connection to the decision-makers on the highest hierarchical level could be made, which alone would have had the power to change such fundamentals of the business. Most likely, the modeling experience had an influence on the project participants, also guiding their future recommendations and analyses. However, a direct consequence in form of changed policies was not observable because those people who had the ability to initiate such changes either did not understand the project or were reluctant to change policies because of the related changes in existing power structures or did not know about the projects and its findings at all. This is what has been labeled grade 1 of low-impact system dynamics.

Case study 2: Intranet implementation

Corporate intranets and portals have attracted increased attention among information managers (Detlor, 2000). Although intranet and portal developments aim to diminish the costs for internal information publishing and to increase corporate information dispersal (Rice, 1996; Thyfault and Marx, 1996), real-world projects show that for a successful installation of an editorial process no clear concepts have been established in the literature. This means that there are no decision rules or key process indicators for managerial decisions available that could, for example, help a manager to decide how many people are needed to maintain a given number of intranet pages that are subject to certain quality standards (e.g. design, layout, style and age).

To enable managing an intranet editorial process environment, the inherent dynamical complexity of the physical process needs to be understood in a more thorough way to support a sustainable success of an intranet project. This fact is reflected in the observation that most intranet process environments are managed in a deficient way if one compares the expected process results with the used resources and management concepts. The main reason for this situation is a missing quantitative understanding of the dynamical complexity of a typical intranet editorial environment. This finding is not surprising as it is in agreement with observations made in other process dynamics related studies (e.g. Sterman, 2000; Warren, 2002). It is a remarkable finding in these studies that even for structurally extremely simple process environment most organizations lack a clear quantitative and/or qualitative understanding of the related process dynamics (e.g. Warren, 2002). This situation can mainly be attributed to the insight that even simple process structures, especially if they include delays, can produce nonlinear relationships between process input and output parameters.

For a company with a decentralized organization the aspect of information structure and quality is of crucial importance, as it must ensure the employees' ability to locate all information they need. From a process point of view, an intranet environment is supported by two main processes: the editorial process and the process of application integration. In the following, the focus will be on the editorial process environment, as it establishes the natural framework for the process of application integration.

A simple structure of the editorial process consists of two negative feedback loops. The first one comprises the following dynamics: an increase of content leads to a higher rate of content aging, which reduces the level of content. The same feedback structure exists for old content, which is flowing out of the system. The more old content exists in the system, the higher the rate of content flowing out, which decreases the level of old content.

A base run of this simple editorial process model shows the typical goal-seeking behavior of negative feedback loops. Put into other words, the amount for content and old content reaches an equilibrium state. This behavior can be observed in Figure 2, in which the number of new and old intranet pages is depicted.

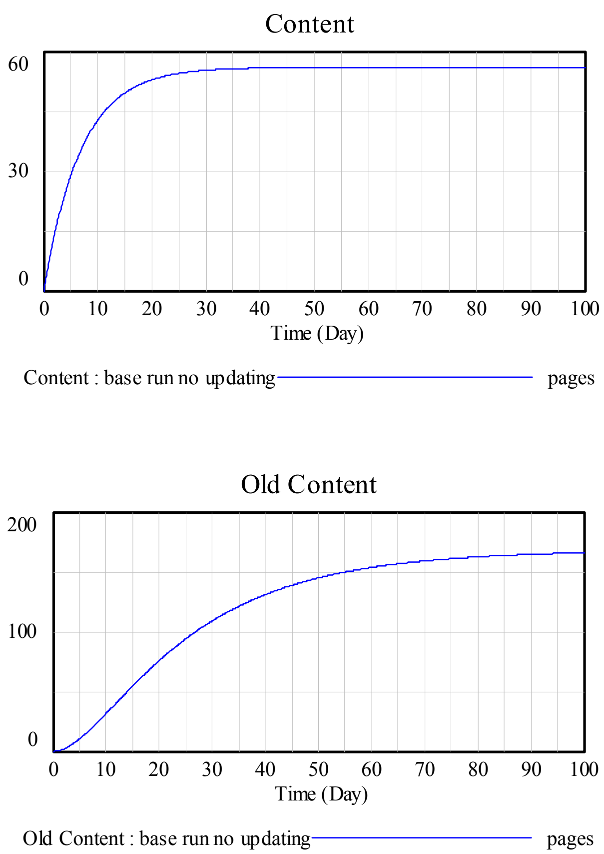

Figure 2: Dynamic behavior of content and old content in the basic model

By using a system dynamics model to portray the standardized editorial process, it was possible to simulate the dynamics of the editorial process. Additionally, a combined approach of process simulation and analytical equilibrium analysis allowed performing a scenario based system analysis, which provided several important insights:

- In equilibrium, in case of no updating, total content equals the product of the inflows and the average delay time. This relationship is known as Little's Law.
- In case of no updating, three considered performance measures are only dependent on two determinants: *time to age* and *time to flow out*. These time variables reflect the different types of content or the different quality criteria. Hence, a change in the ratios can only be caused by a change of the time variables, which means for example a change in the quality standards or the types of content.

- Although content production can be intensified by employing more resources the number of fresh pages in the system is always limited.
- Aging of content is a natural characteristic of every editorial process and therefore updating needs to be done to avoid system “senescence”.
- An archiving system should be implemented in each editorial process to avoid the draining of the system by old content.

In contrast to the first case study described in this paper, the intranet project resulted in changed policies. The project manager of the intranet initiative decided to change the resource allocation policy for maintaining intranet pages. With this change it was secured that more time was devoted to updating old information content relative to generating new content. Although the project manager was not a top executive she had the power and ability to induce the necessary policy changes, thus exploiting the key insights from the system dynamics project.

Despite this immediate transfer of findings from the modeling project to real world policies and the acknowledged importance of the results, system dynamics has not been used in further projects in the intranet division. The reasons for this are manifold: the project manager changed to a new position and her successor did not know about the modeling endeavor; most employees in the division did not know about the basis of the changed policy, some even felt uneasy with the new policy to update rather than to generate new information; the modeling project team members were not confident that they could conduct system dynamics projects themselves. In summary, the anchoring of system dynamics in the organizational structure as a useful and valuable method did not take place. This is what has been called grade 2 of low-impact system dynamics projects.

System dynamics projects as organizational interventions

Based on the large number of proven successful system dynamics projects, this article does not intend to change or challenge the system dynamics modeling process as such, but merely to propose the value of placing the modeling process in an organizational intervention context. In this paper, the focus is on using system dynamics as an intervention with a focus on change management. The approach aims at explicitly integrating system dynamics modeling with traditional change management disciplines. In this way, the system dynamics modeling process becomes part of an “intervention architecture”, as proposed by Zock (2004).

Schein (1999; 1969) identifies three basic models of organizational interventions: (1) the Purchase of Expertise Model, (2) the Doctor-Patient Model, and (3) the Process Consultation Model. In the two first approaches, the role of the interventionist is to provide recommendations, based on expert information and services (in model 1) or through an investigation of ‘symptoms’ followed by analysis and recommendations made by the interventionist (in model 2). These approaches rely heavily on the power of an external or internal interventionist. Both forms of organizational intervention principally do not prevent the two grades of low-impact of system dynamics projects to occur. While grade 1 issues are not necessary and might be absent when top executive support for the project is given, grade 2 issues that basically deal with the sustainability of the solution usually must be expected. This is to the regular low involvement of employees in finding a problem solution in these two forms of intervention processes. Therefore, both approaches are not further considered in this article.

The third of Schein's intervention approaches, the Process Consultation Model, focuses on helping organizations to identify the problem and find suitable solutions based on their own abilities. Thus, it is the Process Consultation Model that increases the chances to generate actual impact in the organization, regarding a change process to solve organizational issues as well as for a sustainable application of system dynamics. Figure 3 outlines the stages in a problem-solving project that follows the Process Consultation Model.[1]

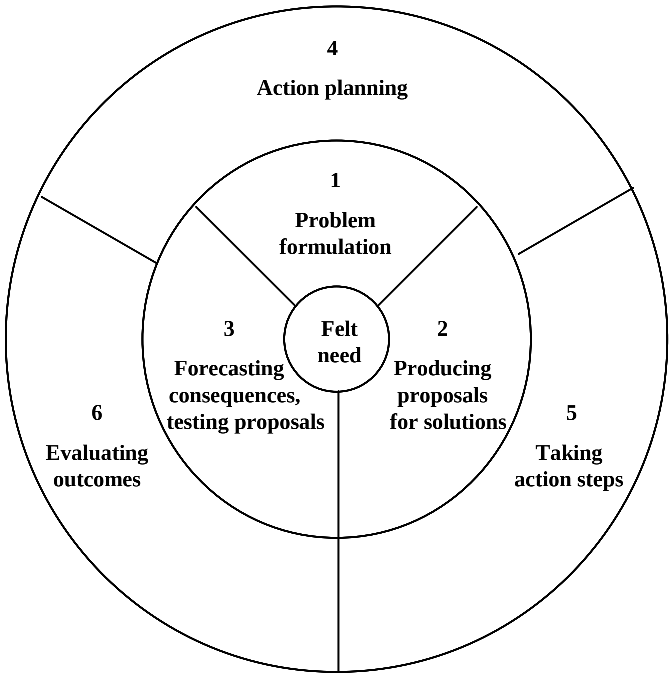

Figure 3: Stages of organization intervention projects (based on Schein, 1999)

In the center of the model and as a starting point for all organizational processes, Schein identifies the need for problem solving and organizational intervention. If a need for an organizational intervention is prevalent, business objectives and targets, the framing of the intervention, consultation relationships, roles and responsibilities in the project organisation, and the intervention planning are defined preliminarily. This stage is strongly iterative with problem formulation that marks the start of the actual intervention project. For example, identification of problem stakeholders and problem definition are mutually dependent: the group of stakeholders involved in the solution of a problem might change, once the problem is more accurately and thoroughly defined.

[1] Schein's work in general addresses this last intervention model type. I am indebted to Birgitte Snabe for originally combining Schein's framework and system dynamics modeling.

Also, the setting of business objectives and framing the intervention cannot be done independently from the problem formulation. The messier a problem, the more iteration can be expected between this stage and the later stages—including a continuous evaluation whether the need for change is still existent.

The process of organizational intervention, although assumed to be of iterative nature, consists of two major cycles. Cycle I includes (1) problem formulation, (2) producing proposals for solutions, and (3) forecasting consequences and testing proposals. Cycle II includes (4) action planning, (5) taking action steps, and (6) evaluating outcomes. Cycle I is represented as the inner circle in Figure 3, and cycle II as the outer circle. Frequently, organizational projects iterate more than once through the cycles; jumps between the cycles are necessary and important (usually, from step 3 to step 4 and from step 6 back to step 1).

For interventions that address organizational problems, the two cycles can be seen as representing two distinct phases: the phase of finding a solution and the phase of implementing it. While in the first cycle the scope of potential outcomes of interventions is usually broad and the main purpose is to generate alternatives and then select one, in cycle II it is different. Here, concrete action steps are planned and taken. Additionally, outcomes are evaluated. All activities of cycle II are framed by the results from cycle I and cannot be independent from them. Particularly, the step from cycle I to cycle II is important and difficult, which is the reason why many good potential solutions never were implemented. Cycle II comprises the activity planning of the implementation, including a communication plan and a clear assignment of responsibilities. These stages furthermore include establishment of procedures for reviews and corrective actions.

Stakeholder management is strongly iterative between all stages of the organizational intervention approach. The stakeholder analysis involves a thorough analysis of all major interest groups and individuals who have significant influence—directly or indirectly—on the success of the intervention. Focus is on interests and power, importance of solution, and relevant means of involvement and communication (Flood, 1995). The stakeholder analysis is a major input into the intervention project, in order to secure that relevant parameters are included in the process, and to secure that appropriate involvement and communication with executives and employees takes place (Cummings & Worley, 2001). The communication strategy and plan develop over the stages of the intervention and include elements such as motivating change and the communication of visions, results, implementation plan and successes.

It is the thesis of this paper that understanding of system dynamics projects as organizational interventions, with an emphasis on the implementation cycle and on stakeholder management, can lower the risk of low-impact projects. For instance in case 1, both requirements were not fulfilled: neither was the implementation of new policies in the focus of the project nor were important stakeholders involved, i.e. those people that had the power to implement such new policies. So, no direct changes in policies could be observed as a result of the study. In the second case, policy changes were not that wide-ranging and could be implemented easier, in particular because the intranet division leader was involved as an important stakeholder. However, it was not communicated to the majority of employees where the changes in the intranet updating policy came from and how system dynamics in general can support the decisions they have to make. Additionally, no efforts were made to train members of the intranet division to use system dynamics thereafter. Thus, a sustainable application of system dynamics did not result from this project, after the intranet division leader left. The usage of system dynamics modeling and simulation was not institutionalized in the organization.

Summary and further research

The argumentation in this paper started from the observation that—although implementation is recognized as the last step in system dynamics projects—there is no intensive discussion how implementation can actually be achieved. This neglect of taking implementation as more important leads to low-impact modeling projects in organizations. Such low-impact projects can be distinguished into projects that result in no changed policies and in projects that did not lead to sustainable application of system dynamics, after some changes to policies have been made. The two possibilities were called grade 1 and grade 2 low-impact system dynamics projects. A case study for each grade was presented. It was concluded that understanding of system dynamics projects as organizational interventions—including an implementation cycle and stakeholder management—is crucial for system dynamics in order to have a substantial impact on organizational policies and structures.

So far, the investigation how system dynamics projects can substantially alter organizations has only attracted relatively little attention in the system dynamics community. It is not enough to state that implementation should be at the end of modeling projects. How system dynamics can be combined with other tools and methods of organizational intervention and how system dynamics can be located into a more comprehensive framework of organizational intervention are open research questions. This article offers a preliminary perspective as a basis for further discussing this important issue.

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