Do Management Flight Simulators Really Enhance Decision Effectiveness?

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IMPROVING DECISION MAKING THROUGH SIMULATION AND MANAGEMENT FLIGHT SIMULATORS

Companies are complex and dynamic systems that have to be managed; information about the actual state of the system has to be analyzed, decisions have to be drawn and then transformed into actions. However, due to the complexity and the dynamics of the system „company", management is a very difficult venture. Therefore, tools, theories and methods are needed to make management easier and more effective. In our system dynamics community of researchers, lecturers and practitioners it is a fundamental and clear paradigm that system dynamics based modeling and simulation can enhance the understanding of complex systems and because of that it can improve decision making.

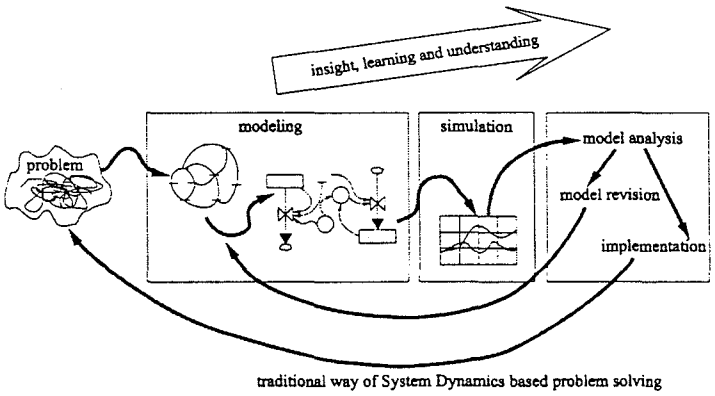

Fig 1: Insight, learning and understanding through modeling and simulation

This paradigm is convincing if we consider the whole underlying process as shown in figure 1. It starts with the definition of the problem, through modeling and simulation and the implementation of the solution. In this process the most important part is the iterative modeling, i.e., the identification of feedback loops and the explicit formulation of the mathematical equations. This process makes the underlying problem structures transparent. The simulation of the model then shows the dynamic behavior generated by the model. The analysis of the model behavior usually points out some inadequate representations of the model structure and therefore leads to

several revisions of the model (Richardson/Pugh 1983, Forrester 1994). Problem analysis, mapping of structural elements, and modeling without simulation is insufficient. Generating the dynamic behavior of a system – to simulate – is a prerequisite of learning and understanding in complex systems (Sterman 1994). Therefore this process in total allows insight into the structure and the behavior of a system. This in consequence makes the development, testing and implementation of improved policies possible (Forrester 1994). Simulations allow experimentation without being confronted with real world consequences. Simulation makes experimentation possible and useful, where in the real world situation it would be to costly or – for ethical reasons – not feasible; or where the decisions and their consequences are separated in time. Other reasons for the use of simulations are the possibility to replicate the initial situation and the possibility to investigate extreme conditions without risk (Pidd 1992).

However, among others due to the fact that modeling and simulation needs expertise, management flight simulators have been developed (1) to allow easier access to a specified model and to simulation (2) to facilitate learning and understanding about complex systems (Diehl 1992, Bakken et al. 1992, Sterman 1994, Goodman 1994, for an overview on ready-to-use management flight simulators see, e.g., Kreutzer 1994). The management flight simulator approach is commonly seen as such a tool to fundamentally improve the understanding of complex and dynamic systems. Several investigations discuss problems of using management games and management flight simulators. They analyze to what extend management flight simulators can improve learning and understanding, and how such learning laboratories should be designed (see e.g. Bakken et al. 1992, Paich/Sterman 1993, Senge/Sterman 1994, Lane 1995). Nevertheless, this approach covers only parts of the traditional way of system dynamics modeling and simulation as described in figure 1. The use of management flight simulators misses the iterative steps from the problem definition to the formulation of causal diagrams and mathematical models which are just as important as the simulation itself. Here one question arises which is not yet answered. Undoubtedly management flight simulators enhance learning and understanding in complex and dynamic situations. But does this also lead to more effective decision making processes? This paper describes the design and some preliminary results of an ongoing research project at the Industrieseminar of University of Mannheim to answer this question.

DESIGN OF THE RESEARCH PROJECT

To investigate whether the use of management flight simulators really can improve decision effectiveness, an adequate design of the study is necessary. The systematic examination of this question in a real world setting is almost impossible. Idealistically the measurement of decision effectiveness would require the investigation of several persons' decision outcome under similar circumstances; some using management flight simulators, the others without any possibility of simulation. However, there never will be two persons in the same dynamic situation who have to decide independently on the same problem. Considering this, the following design of the research project was chosen.

At the Industrieseminar of the University of Mannheim we use in management education since several years the competitive management game *LOBSTER* which was developed by ourselves. The underlying model is implemented with Vensim. Four groups consisting of 3 students

compete in a dynamic market and have to decide on investment for capital equipment and research and development, pricing and advertising, and among others personal recruitment. They have to decide for one quarter and input their decisions into the computer. After the simulation of the decisions by the game operator the results are given to the players and the game continues. They have to analyze the situation caused by their decisions and decide for the next period of time. In total, the game covers a time horizon of 3 years (for a description of the game see also Milling 1991, Milling/Lehmann 1994). This game is the setting for our investigation. It is used as a virtual reality and as a learning laboratory.

On the basis of the Vensim model underlying the management game *LOBSTER* we have developed the management flight simulator *LEARN!*. It was developed using Vensim's application interface Venapp. The management flight simulator has an identical structure and parameter values, but not identical initial condition. In *LEARN!* the three competitors are modeled by the computer using different policies. In *LOBSTER* the competitors are represented by real groups. In both, in *LOBSTER* and in *LEARN!* the players have to decide on the same topics. *LEARN!* is the management flight simulator which we use to investigate whether it can enhance decision effectiveness.

Two of the four groups in the management game *LOBSTER* have the management flight simulator *LEARN!* available. The other two groups serve as control groups. However, the control groups are allowed to use for example, spread sheet programs for decision support. Those groups using *LEARN!* can test all their decisions, analyze the results and get an improved understanding on the dynamic behavior of their virtual reality of the game. Finally, if the hypothesis that management flight simulators enhance decision effectiveness is true, they are expected to make better decisions which lead to an improved overall performance of their company. They also should get a better understanding of the system and a better feeling for system reaction.

For the investigation of the improvement of decisions several measures are used. The cumulative profits and the market share are used as an indicator for a group's overall performance. In addition the students were asked in each decision period to estimate some of the model variables like sales volume at the end of the next quarter, the quarterly profits, and the market share. These estimations can be compared with the realized outcome in the virtual reality of the game. The goodness of fit of estimated and realized over time then can serve as an indicator whether the groups having access to *LEARN!* have an improved understanding of system reaction. The students also had to present a paper where they had to define their strategy and to quantify their objectives. In addition to that each decision period is video taped and analyzed, and the players have to answer several questionnaires. These questionnaires allow to analyze whether the students using the management flight simulator have an improved understanding of system.

PRELIMINARY RESULTS

Since this investigation was performed the first time and a sample of four groups with 4 MBA students each – which is not representative – the validity and the reliability of the statistical results are only preliminary. However, it seems to be possible to recognize a trend. Figure 2 shows in an overview some of the results. The groups C1 and C3 have had *LEARN!* available. Anyway, only group C1 did use the management flight simulator. In total the members of C1 used

LEARN! for 14.75 hours – only 3.7 hours per student – which is a very low value. Group C3 did not use it for several reasons. Therefore they served as an additional control group. Investigating the performance measures cumulative profits and market share Group C1 is only ranked in the second place. Due to their use of *LEARN!* they have been expected to be the best performing group. Looking at the achievement of objectives they also rank in second place. The best performing group was C2. As we found out later, this group of students had detailled data and results of the management game lecture available which we gave the year before. Therefore they had very useful information to support their decision processes. They have spent much more time to analyze the last year's management game results, than C1 spent to work with *Learn!*.

Group	Access to *LEARN!*	Use of *Learn!* (in hours)	cumulative profits in million DM (rank)	market share (rank)	achievement of objectives (rank)
C1	yes	14.75	8.5 (2)	27.90 (2)	2
C2	no	–	21.1 (1)	46.27 (1)	1
C3	yes	0	5.9 (3)	17.71 (3)	3
C4	no	–	0.9 (4)	8.10 (4)	4

Fig. 2: Results in overview

For this reason we thought about removing C2 from the sample. However, we expected that C2's analysis of static data did not enhance the understanding of the dynamics generated by their decisions. They copied and tried to improve a strategy which has been successful in the game before. In some sense they learned from failure, but they could not use their data for better understanding of the dynamics. A look at the goodness of fit of estimated and realized values of sales volume and market share seems to support this hypothesis. As shown in figure 3 group C1 is the group with the best estimations. The mean error of estimations and the standard deviation are smaller then those of the other groups. The performance of groups C3 and C4 which did not use *LEARN!* is worse in every measured variable. Without the intervention of the game operator Group C4 even would have been bankrupt after 6 quarters.

Group / Access to *LEARN!*	Goodness of fit of estimations (a mean value of „0" would mean a perfect estimation)				rank
	sales volume		market share		
	mean	std. dev.	mean	std. dev.	
C1 / yes	0.0116	0.0942	0.0090	0.0888	1
C2 / no	0.0495	0.0981	0.0310	0.1079	2
C3 / yes, but did not use	-0.1078	0.1352	-0.0879	0.0667	3
C4 / no	-0.1136	0.1763	-0.1203	0.1742	4

Fig. 3: Goodness of fit of estimations

Due to the small sample these results are statistically not valid and reliable. Therefore the research project will be continued. Nevertheless, it seems that the use of management flight simulators could improve decision effectiveness, although the model structure was not known. It would be interesting whether management flight simulators using tools to allow insight into model structure like Vensim's causal tracing facility will lead to a furthermore improved understanding.