Facilitating learning through goal setting in a learning laboratory

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Abstract

Human beings are goal-directed, mental model is thus dictated by his/her goals inescapably. This study designed an experiment to examine the effects of two kinds of goals on learning in a "growth and underinvestment" archetype management flight simulator task. One kink of goal was total assets, a wholesystem and long-term goal, the other was order-growth, a subsystem and short-term goal. The results indicated that when the goal was assigned with the attainments of order growth, subjects pay more attention on order growth and allocate more resources on hiring to push the reinforce growth loop and apt to ignore the effects of balance loops. As a result, underinvestment behavior occurred and incorrect mental model and poor performance resulted. Given the findings, wholesystem and short-term goals settings were suggested here to facilitate learning in a learning laboratory.

Introduction

Previous works found poor performance in dynamic decision environment could be attribute to oversimplified mental model of complex task and people's bounded rationality (Diehl and Sterman, 1995; Paich and Sterman, 1993; Sterman, 1989a; 1989b). People's limited cognitive capabilities is hard to be overcome because we have not the ability to solve systems of high-order nonlinear differential equations intuitively. Nevertheless, if we could find the rule to manage the system, then computer techniques could provide optimal solutions. Thus, future efforts should be put on how to cultivate people's heuristics to recognize dynamic nature of systems, the capability of systems thinking. Recently, the idea of learning laboratory (Senge, 1990) have provided a viable environment for improving people's dynamic decision heuristics.

However, the design of learning laboratory needs theories to be guidance to facilitate learning. Goal setting theory is such a choice. Human beings are goal-directed. when challenge and specific goals are set for participants, the following are expected (Locke and Latham, 1990): (a) participants will use more of their total capacity and attention to attain the goal, (b) participants will spend more time to attain the goal, (c) goals orient participants toward goal-relevant activities and materials and away from goal-irrelevant ones, (d) participants activate stored knowledge that they possesses that are perceived as relevant to the task. More efforts and time are necessary for the learning of dynamic complex tasks. Participants produce their mental model by the retrieval of stored goal-relevant knowledge. A proper goal is important for a well conceived mental model. Therefore, goal setting theory could serve as a theory base for designing a learning laboratory.

Systems archetypes (Senge, 1990) could be selected as a principle of the design of management flight simulators for a learning laboratory. Systems archetypes provide insights and management heuristics of a general system. Participants in a systems archetypes based learning laboratory could learn the systems knowledge of interactions of structure, policy, and system behavior. Therefore, systems archetypes provide a useful guideline for design of management flight simulators in a learning laboratory.

Given the forgoing background, this paper reports a preliminary attempt to examine the effects of goals on dynamic decision making where the task was designed based on a systems archetype. The results are useful for the understanding of goals effects on dynamic decision behavior and for the guidance of designing a learning laboratory.

Method

Task

The task, a management flight simulator, as shown in Figure 1, was designed based on Forrester's "market growth" model (Forrester, 1984). The model was an insight into the structure of market growth as influenced by capital investment with a long-term view. The task structure is named "growth and underinvestment" archetype by Senge (1990) to represent a general dynamic nature that the behavior of seeking short-term growth and ignoring long-term investment would hinder long-term performance of order growth.

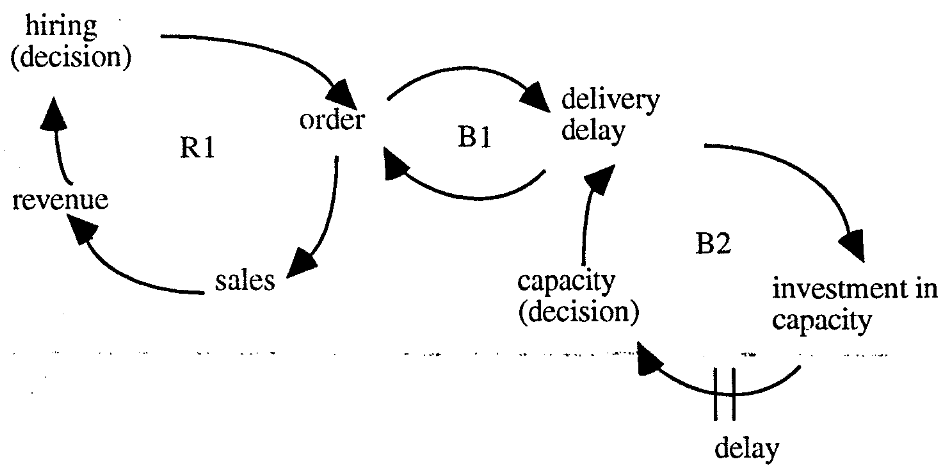

Figure 1 Causal structure of the task

The simulated company was managed for 32 quarter years. For each quarter year, two decisions were made including how many salesmen to hire/fire to increase/decrease the salesforce and how much capital investment to make to increase the production capacity.

Although the optimal solution of the task model could not be found, there were three prescriptive principles to manage the task system. The first principle was to match sales volume with production capacity to prevent delivery delay and to be efficient. The second principle was to match cash available and expenditure to prevent bankruptcy from the shortage of cash and to use available cash efficiently. The third was the consideration of time delay in decisions.

Design

Two kinds of goal setting were manipulated as following.

Total assets goal. Subjects assigned with this kind of goal setting were informed that their rewards depended on the score of attained total assets at the final quarter year. They could not assess their performance until the final quarter year. There was no particular standard to reach at each quarter year, i.e., no short-term goals. In addition, total assets was a measure of performance of whole system; it was a wholesystem goal.

Total assets and order-growth goals. The reward structure here was similar to the former setting except for a probable penalty. A penalty for total assets occurred when order growth rate of the simulated company was below thirty percent at any quarter year. Order growth was a subsystem goal of the loop R1 (as shown in Figure 1) and a goal to reach for every decision. Therefore, subjects were assigned with a subsystem and short-term goal in this condition.

Dependent Variables

Strategy of resources allocation. Subjects' decisions recorded by the simulator were analyzed to discover their strategy of resources allocation. The proportion of resources spent on hiring to total expenditure was used as an indicator of the strategy used.

Underinvestment. Degree of underinvestment was measured by the total time where delivery delay occurred. It meant that subjects could not manage the system systemically when underinvestment occurred.

Direction of attention. Information items searched by subjects were analyzed to discover the relative frequency of every piece of information item in order to assess subject's direction of attention. The direction of attention should differ between subjects assigned with different goals.

Correctness of mental model. To assess the correctness of mental models, subjects were asked to report their rules used for decision-making. Right after the decision-makings, subjects were asked to answer the question "Do you have any rule for deciding ?". If the answer was "yes", he was then asked to describe the rule and select the objectives (variables) he tried to control. The descriptive decision rule was compared with the three prescriptive decision rules above to assess the correctness of subjects' mental model.

Outcome performance. Two indicators were used to measure subjects' outcome performance, namely total assets and order growth rate. Goal effects were goal-specific, so outcome performance must be correlated with assigned goals (Locke and Latham, 1990).

Results

The effects were analyzed using 2*3*3*3 ANOVAs, with assigned goals and two unreported factors as the between-subject variables and trial block as a repeated-measures variable.

Strategy of resources allocation. The assignment of order growth rate as goals significantly affected subjects' allocation of resources. As shown in Table 1, mean proportion of hiring expenditure was 0.37 for total assets and order growth goals group and 0.30 for total assets goal group ($F(1, 54)=6.72$, $p<0.05$). The results revealed that for such groups the behavioral pattern was short-term goal directed, where short-term goal of order growth indeed led subjects to allocate more resources on hiring than total assets goal group.

Table 1. Means of dependent variables for the experimental conditions

	Total assets goal				total assets and order growth goals			
	Block 1	Block 2	Block 3	Mean	Block 1	Block 2	Block 3	Mean
Resources allocation	0.31	0.29	0.31	0.31	0.37	0.37	0.38	0.37
Underinvestment.	11.94	11.33	11.56	11.61	13.67	14.92	15.94	14.84
Persistence	2363	1540	1593	1832	2306	1595	1398	1766
Mental correctness	0.83	1.08	1.17	1.03	0.50	1.06	1.19	0.92
Total assets	8.98	10.14	11.16	10.09	8.18	9.55	9.89	9.21
Order growth	0.28	0.40	0.47	0.38	0.26	0.35	0.41	0.34

Note. The unit of persistence is seconds per block; total assets has been ln transformed.

Underinvestment. As shown in Table 1, subjects assigned with total assets and order growth goals suffered more problem of underinvestment. The result of statistical test was nearly significant ($F(1, 54)=2.709$, $p=0.106$). The results indicated that a subsystem goal prevented subjects from recognizing the side effects produced by the other two balance loops.

Direction of attention. Goals assigned significantly affected the direction of attention. Among all available information items (variables), order growth rate, total assets, cash, production capacity, revenue, backlog, and earnings were searched more frequently by subjects in the total assets and order growth goals condition, where the relative frequencies were 15%, 11%, 10%, 10%, 9%, 9%, and 8% respectively. For the total assets goal group, the perceived relevant variables were earnings, total assets, cash, production capacity, revenue, and backlog, where the relative frequencies were 16%, 11%, 11%, 10%, 9%, and 8% respectively.

The results described above revealed that subjects assigned with total assets and order growth goals perceived order growth rate, the short-term goal, as the most important variable. Compared with the total assets goal group, the difference of relative searching frequencies was significant ($F(1, 54)=13.45$, $p<0.001$). On the other hand, earnings, although not an assigned goal, was perceived as the most important variable by total assets goal group. Compared with the order growth goal group, the difference was significant ($F(1, 54)=13.95$, $p<0.001$). The significant concern with earnings revealed that subjects desired a short-term and specific standard to evaluate their decision efficacy.

Correctness of mental model. Subjects assigned with total assets goal had more correct mental models than the other group to begin with. As shown in Table 1, correctness of mental models was higher for the total assets goal condition than for the other in the first and second experimental phases, and a significant main effect was found in the first phase ($F(1, 54)=4.15$, $p<0.05$). In addition, a learning effect was found, where the main effect of the experimental phases was significant (Wilks' Lambda=0.50, $F(2, 53)=26.98$, $p<0.001$). The results revealed that subjects could learn to capture the correct decision principles by practicing. Moreover, a significant interaction effect was found between experimental phases and assigned goals (Wilks' Lambda=0.83, $F(2, 48)=5.00$, $p<0.02$), showing that learning effects deteriorated initially with assignment of short-term and specific goals.

Outcome performance. As presented in Table 1, mean levels of the two indicators were higher for the total assets goal condition than that for the other one. However, a significant main effect was found only for experimental phases on total assets (Wilks' Lambda=0.52, $F(2, 53)=24.91$, $p<0.001$) and order growth rate (Wilks' Lambda=0.48, $F(2, 53)=28.91$, $p<0.001$). Learning effect did exist, but it was not affected by assigned goals.

Discussion

When the goal was assigned with the attainments of order growth, subjects pay more attention on order growth and allocate more resources on hiring to push the reinforce growth loop and apt to ignore the effects of balance loops. As a result, underinvestment behavior occurred and incorrect mental model and poor performance resulted.

Those findings demonstrate that short-term goals dictate decision behavior strongly. Short-term goals affect direction of attention and resource allocation. Given degree of underinvestment, mental model correctness, and outcome performance could serve as measures of learning performance, the design of learning laboratory with management flight simulator should manage subjects' attention properly with goal settings. A shor-term and subsystem goal is disadvantage for the management of dynamic systems. participants are subject to have a bounded view of the systems to ignore the side effects of order growth subsystem.

How to conceive goals to evoke systems thinking in a learning laboratory program ? If we hope improve learning in the process of gaming, goals should induce systemwide attention and the awareness of systems side effects.

There are three dimensions to manipulate goals. The first is long vs. short term goals. Long-term goals do not provide performance feedback to participants until they finish the game trial. This may not a good idea for people could not detect the effectiveness of policy immediately (Bandura, 1986). Reflection and learning of subjects may not happen with just a long-term goal. Such as in the Beer Game, there is no short-term and specific cost goal as a criterion to evaluate their performance. As a result, most of participants use the same policy to make decisions and little has been learned in the game process. Further, as shown in this study, subjects who have no short-term goal found the earning as a short-term goal to evaluate performance automatically. The results demonstrated that short-term goal was necessary for a learning laboratory.

The second dimension of goal setting is wholesystem vs. subsystem goals. We could set goals to represent the overall performance of the system or just represent performance of subsystem. A subsystem goal as in this study of order growth produces bounded view to the system. To reach a wholesystem goal such as total assets, every subsystem must perform well simultaneously. Therefore, participants are more likely to make decisions systemically. Wholesystem goals should be preferred for a learning laboratory.

The third dimension of goal setting is single vs. multiple goals. Participants are more likely to find side effects with multiple goals, if every goal represents a subsystem performance. However, people are bounded rational (Newell and Simon, 1972). They couldn't handle many goals at the same time. Therefore, that how many goals are appropriate is still an open question to explore.

In conclusion, we can facilitate the learning of systems thinking with a learning laboratory by the management of attention via goal setting. Given the findings that participants are short-term goal-directed and that subsystem goals impede the recognition of side effects, wholesystem and short-term goals settings are suggested here. Multiple goals setting is also suggested if gaols represent performance of different subsystems . However, further researches are needed to examine the propositions.

References

Bandura, A. (1986). *Social Foundations of Thought and Action: A Social-Cognitive View*. Englewood Cliffs, NJ: Prentice Hall.

Diehl, E. and J. D. Sterman (1995). Effects of feedback complexity on dynamic decision making. *Organizational Behavior and Human Performance*, 62, 2, 198-215.

Forrester, J. W. (1984). Market growth as influenced by capital investment. in E. B. Roberts (Ed.), *Managerial applications of system dynamics*. Cambridge, Mass: The MIT Press.

Locke, E. A., and Latham, G. P. (1990). *A Theory of Goal Setting and Task Performance*. New York: Prentice-Hall.

Newell, A.& Simon, H. A. (1972). *Human problem solving*. Englewood Cliffs, N.J.: Prentice-Hall.

Paich, M. & Sterman, J. D. (1992). Boom, bust, and failures to learn in experimental market. working paper 3441-92-BPS, Sloan School of Management, Massachusetts Institute of Technology.

Senge, P. M. (1990). *The Fifth Discipline: The Art and Practice of the Learning Organization*. New York: Doubleday Currency.

Sterman, J. D. (1989a). Modeling managerial behavior: misperceptions of feedback in a dynamic decision making experiment. *Management Science*, 35, 321-339.

Sterman, J. D. (1989b). Misperceptions of feedback in Dynamic Decision Making. *Organizational Behavior and Human Decision Process*, 43, 301-335.