

Simulation of Learning: Comparison of Double and Single Loop Learning

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Introduction

The purpose of this paper is to simulate single loop learning and double loop learning and compare their behavior. It was done on a simple heating system.

Learning is very hot issue in management. It is also very attractive research area for SD (System Dynamics) practitioners. Although the roof of learning goes back to 1940 it was introduced into strategic management field by Argyris and Schön (1978). They proposed single and double loop learning. It has been popularized by Senge (1990). Researches on learning in SD are mostly concerned with management simulators, learning environment and learning behavior

Learning behavior analysis in SD has been done by analyzing behavior of a model of a system in question, or behavior of a player in a learning environment. Single loop learning is modeled in SD studies by means of negative feedback loop. No studies on modeling double loop learning have been found in literature by the authors. In this study, single loop learning and also double loop learning has been modeled for a simple heating system.

Learning

Argyris and Schön (1978) identified two kinds of learning; single-loop (error detection and correction within existing norms and objectives) and double-loop (error detection and correction involving modification of underlying norms and objectives).

All learning depends on feedback (Sterman 1994) based on information feedback about the real world. Feedback loop (see figure 1) can be seen in social sciences. economics, psychology, sociology, anthropology. According to Forrester (1961) all decisions take place in the context of feedback loops

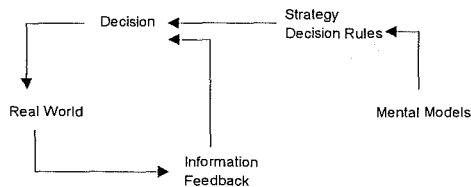


Fig. 1. Single Loop Learning
(From Sterman, 1994)

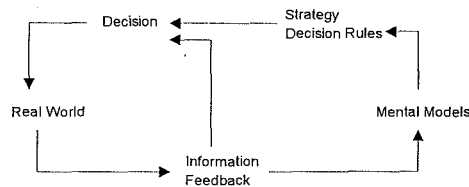


Fig. 2. Double Loop Learning
(From Sterman, 1994)

The single feedback loop shown in Figure 1 describes single loop learning. The loop is a classical negative feedback where decision makers compare information about the state of the real world, perceive discrepancies about the state of the real world to various goals, and take actions that will cause the real world to move toward the desired state.

Double-loop learning is illustrated in Figure 2 (Sterman 1994). Here information feedback about the real world not only alters our decisions within the context of existing frames and decision rules but feeds back to alter our mental models. As mental models change, we create different decision rule and we change the strategy and structure of our organizations. The same information, filtered and processed through a different decision rule, now yields a different decisions.

Simulation Model of Learning

In this study, a simulation model for learning was established on a simple wall heater to which heat is provided by a pump. The pump is commanded by a worker. The purpose of the system is to keep wall heater at a constant temperature.

How the system works can be explained as follows: Heating is regulated by the speed of the pump. The worker watches the temperature, reads it, and compares the temperature with instructions given to him. Obeying the instructions, he adjusts the speed of the pump. The speed of the pump

determines the heat flows to the heater. The instructions may be that if the temperature is hot then stop the pump, so on.

In single loop learning context, a worker is ordered to keep temperature constant around 75°C. To accomplish this, a worker observes temperature, compare it with instructions that has been given to him/her and take action that instructions imply. A worker is not allowed to change the instructions. In this case a worker has only authority to adjust accelerating according to varying temperature.

In double loop learning context, a worker is ordered to keep temperature constant around 75°C, and allowed to change instructions. In this situation, a worker has more authority than single loop learning. He/She can change instructions according to changing conditions. He/she has authority to question whether instructions he has applied are still valid. If he observe a change in environmental condition, he can generate new instructions that the changes imply.

In double-loop learning it is questioned whether actions taken by a worker have produced desired states or not. If existing rules that determine actions that are taken by a worker do not produce intended results, these rules will be changed.

In order to identify that there exist a change in environment, the worker uses the following mechanism,

- Calculate the trend of temperature
- Calculate the average temperature
- Compare the trend and average temperature, and determine whether there exist changes or not
- If there exist change, change instructions; otherwise use existing instructions.

Determining changes is based on concept of quality control chart: These charts say whether there is a change in process or not according to behavior of the variable over time. If there is a increasing or decreasing trend on the variable, it can be said that there is a change in process. For wall heater case, determining changes works as follow: if the trend is outside limits and average

temperature is outside normal temperature identify that there is a change, otherwise identify that there is no change in environment.

Experiments

To compare the behavior of single and double loop learning, both of the models were run under the same conditions. These conditions cover the different values of the cooling coefficient. All other factors were kept constant during the experiments. Three runs go for 0,01, 0.05 and 0.09 of cooling coefficient. Instructions that had been assumed to be given to worker were defined for 0.05 of cooling coefficient. Results of these experiments are illustrated in Fig. 3.

Single loop learning reached the goal around 75°C for only 0.05 of cooling coefficient. Otherwise it is out of the goal. Double loop learning reached the goal for all cooling coefficient. The reason for out of goal that single loop learning shows is structure of the instructions that have been defined for 0.05. In single loop learning, when cooling coefficient has been changed, instructions produce unintended results due to fact that instructions were defined for 0.05 of cooling coefficient. Double loop learning adjusts instructions according to value of varying cooling coefficient.

Conclusion

In this paper an attempt was made to simulate the learning on a simple heating system. Since this is a ongoing study results on the learning behavior should be treated in this narrow context.