A Framework for Problem Solving Using Systems Dynamics Modelling with a Japanese Management Technique

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Abstract

This paper reflects on a successful problem solving exercise that was carried out in a textile factory using a systems approach together with a Japanese management technique. The systems approach used was Systems Dynamics Modelling and the Japanese management technique was CEDAC (see appendix). The paper concludes that successful problem solving can be viewed as a group learning process and that this approach offers a useful framework for initiating and manageing perfermance improvement. The degree of success is largely determined by the degree of learning that takes place.

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1.0 Introduction

There seems to be a growing resistance to the fads that have dominated the popular management press over the past decade. An emerging recognition amongst practitioners is beginning to concede that effective organization and management needs to go far beyond the 'quick fix'. A few themes have proved their value by surviving the management 'fashion show'. These themes tend to acknowledge the complexity of organization and management rather than oversimplifying it. This is done by highlighting the value of systems thinking (such as System Dynamics Modelling) and the importance of managerial and organizational learning in the process. Research into the economic success of Japanese organizations suggest similar characteristics in Japanese Management (Nonaka, 1988).

A large part of the management is concerned with problem solving; with changing a less desirable behavioral pattern to one that is more desirable. Einstein said that it is not possible to solve a problem in the same consciousness that created it (Wheatley, 1993). This implies that complex managerial problem solving requires a change of consciousness. A change of consciousness is a change in the way a problem situation is viewed. Such a change involves a learning process. The development of a cybernetic view of an organization is a useful way of achieving this.

2.0 A Cybernetic View of Organizational Complexity

As Systems Dynamics Modelling (SDM) has its roots in the science of cybernetics it is useful to develop a cybernetic view of organizational complexity and then show how SDM can be used to deal with the complexity. Norbert Weiner, the father of cybernetics sees it as the 'science of information and control in animals and machines' (Weiner, 1948). W Ross Ashby, another pioneer in the field sees of cybernetics as functional and dealing with all forms of behavior that are regular, determinate, or reproducible (Ashby, 1964). Stafford Beer developed a powerful model for designing and building viable organizations based on cybernetics, the Viable Systems Model (Beer, 1979). He defines cybernetics as the science of effective organization. This paper sees cybernetics as a useful way raising organisational conciousness and thus increasing the effectiveness of the problem solving process.

The cybernetic approach offers a number of concepts useful in understanding organizational complexity of which the following are important when using SDM in a problem solving process: feedback, emergence, self organization and variety (Clemson, 1984).

2.1 Understanding organizational complexity

An organization is seen as a system of interacting parts. The complexity of a system is determined by the interaction of the following factors (Schoderbek et al 1980):

1 the number of parts that make up the system

2 the number of interactions between these parts

3 the number of attributes of these parts

4 the degree of organization within the system

These can be seen as either static or dynamic. It is the dynamic factors, the interactions between the parts, that dominate the behavior of organizations and are the concern of SDM. The most important interactions affecting behavior have a feedback structure which gives rise to two important characteristics of complex systems: emergence and self organization. Cybernetics also introduces the concept of variety to explain and measure complexity and to offer an approach for dealing with it.

2.2 Feedback

Traditional science has thought of causality in simple linear terms, ie causes and effects were thought of as X causes Y and Y causes Z. This could continue as far as you might want to trace it. The start of the systems movement in the 1940's began to see causality as circular i.e. X influences Y and Y influences Z and Z in turn influences X (Clemson, 1984). This circular causality is better known as feedback and is the foundation of control theory. There are two types of feedback: negative feedback and positive feedback. Negative feedback is goal seeking and works to negate disturbances experienced by the system. Positive feedback is growth orientated and works to amplify disturbances. Feedback structures, made up of positive and negative feedback loops, are useful for explaining the following characteristics of complex system behavior:

1 Many of the feedback loops that influence organizational behavior are not obvious. Some are dormant under certain conditions and only become active when these conditions change. Any managerial action that does not appreciate this has counter intuitive results.

2 For a range of inputs, ouput is largely determined by feedback rather than the input. Under these conditions increased management intervention has little or no effect on organizational behavior.

3 With insight into the feedback loop structures that influence organizational behavior management is in a far better position to take meaningful action. Lack of this insight explains many of the difficulties experienced in sustaining organizational improvements.

Different parts, attributes and interactions can result in many different behavioral patterns. The possible number of patterns increases exponentially as the number of parts increases.

2.3 Emergence

An important concept developed from the systems movement is that of emergence which states that the system as a whole exhibits properties that are not evident in its parts. These 'emergent properties' of the system are due to the interaction among the parts. These properties often produce unintended behaviors, which can either promote or counter the purpose of the system. In a sense the interactions are co-producers of the emergent properties. The presence or absence of an interaction influences the emergent property. Culture and norms are examples of emergent properties of social systems.

2.4 Self Organization

All complex systems are capable of organizing themselves to some degree through the interaction of its parts. The structural and behavioral patterns evident in complex systems are the result of such organization. This organization happens throught the mutual adjustment of the parts of the system in a process of continual interaction. This self organizing process is purposeful and is not necessarily aligned with the overall purpose of the system. The 80/20 phenomenon can be seen as a demonstration of the self organizing process, ie. 20% of the system produces 80% of its output.

Some of these resulting patterns are stable and others are not. If a system moves from a stable pattern to one that is unstable, it will tend to gravitate back or move to another stable pattern. Any management action that attempts to move an organization into an unstable pattern will be resisted. A system can only be held in an unstable pattern through high levels of resource utilization. Often, this includes coercion. Alternatively, insightful intervention can change an unstable pattern into a stable one.

2.5 Variety

Variety is a measure of the complexity of a system. It reflects the number of distinguishable patterns a system can assume. As the number increases, the variety of the system increases.

Management is largely concerned with regulation, ie maintaining those patterns that keep the variables that reflect organizational performance within desired limits. To do this, management needs to be able to cope with the variety of the organization, ie it needs to be able to respond appropriately to the different patterns the organization can assume. The variety of management is measured in terms of the number of ways it is able to respond to the variety of the organization. Therefore effective management requires a measure of variety that is close to or equal to the variety of the system it has to manage. In cybernetic terms management needs to achieve requisite variety. For any system to operate, no matter how well or how poorly, requisite variety has to be achieved either by design of by default. An important determinant of managerial effectiveness is the degree to which management can influence how and where in the organization requisite variety is achieved. The implications of this concept for management are enormous.

Organizations need to be designed and built to achieve requisite variety where it is most beneficial. Organizations operate in high variety environments and are managed by low variety people. The variety of management is largely limited by human information processing capability (Miller, 1963; Simon , 1967). Many of the problems plaguing organization and management can be explained in terms of requisite variety. Stafford Beer's Viable Systems Model is an approach to achieving requisite variety through planning and design, SDM can be seen as an approach to achieving requisite variety through learning.

3.0 An Application of Systems Dynamics Modelling

We have found that a crucial starting point when using SDM in a complex problem solving process such as those associated with socio-technical systems is to recognize:

1 that it is an approach to learning about, gaining insight into, and organizing your thinking about the behavior of complex systems, and

2 that it is not an attempt to construct the total objective reality surrounding the problem.

It is primarily concerned about identifying plausible strategies for changing undesirable behavior. The assumption is that this behavior is caused by the underlying structure of the situation. The term structure is used to describe organizational structure, processes, norms, values, culture, and the general pattern of resource deployment within the organization. Insights into structure make it possible to identify plausible interventions that would change undesirable behavior.

Since its development in the early sixty's SDM has gone through a number of developments and has been defined in numerous ways. A more recent definition is (Wolstenholme, 1990 p3):

'A rigorous method of qualitative description, exploration and analysis of complex systems in terms of their process, information, organizational boundaries and strategies; which facilitates quantitative simulation modelling and analysis for the design of system structure and control.'

This definition is useful when dealing with socio-technical systems as long as you recognize that you are not trying to describe, model or simulate a total objective reality. It is also important to note that both the qualitative and quantitative aspects are emphasized.

3.1 Background to the Case

The case concerns a medium sized textile manufacturer in Cape Town. The textile and clothing industry as a whole in South Africa has been under severe economic pressures over the past five years. The competitiveness of this particular manufacturer was threatened as a result of excessively long production lead times and late deliveries. We were approached by the manufacturer to assist them in dealing with this problem. After some analysis this problem was set as a research topic for a masters student (Van Veen, 1993). This paper reflects on the process of enquiry that followed from a learning perspective.

3.2 The Problem Solving Process

The general approach to problem solving that we have developed involves two distinct phases. The first is an immersion phase which involves a 'soaking in' period during which the enquirer attempts to get an in depth insight into the different perspectives held by the stakeholders involved in the problem situation. The success of the problem solving process depends to a large degree on how well this phase is done. In the second phase plausible implementation strategies are developed based on the learning that emerged from the first phase. It is often not necessary to explicitly select the most appropriate strategy as the participants in the process tend to gravitate towards a shared understanding of the most appropriate way forward.

The process started off with a qualitative analysis of the performance problems facing management; late deliveries and long lead times. This required an immersion into the actual situation through some form of interaction with the stakeholder: management, production staff and customers. Our experience is that SDM is not very useful in the early part of this phase, particularly when the stakeholders have no knowledge of the process. We have found Soft Systems Methodology (Checkland, 1981) far more useful during this immersion phase. In this case we were dealing with 'practical' managers at the 'coal face' and therefore decided to use a Japanese management technique presented in a language they understood. The technique used is known as Cause-and-Effect Diagram with the Addition of Cards (CEDAC). The technique is described in detail in Appendix A. This is an enhancement of the classical cause and effect diagram that has proved so useful in Quality Circles. CEDAC proved to be a powerful group process for identifying, interpreting and communicating the issues contributing to the problem.

Once the final CEDAC representations (i.e. the immersion phase) of the problems was complete it was possible to create a graphical SDM of the situation. This was seen as a plausible structure that produced the undesirable behavior of the organization. It consists of feedback loop structures involving resource flows and information flows. It provides a qualitative assessment of the interactions between the parts of the organization that give rise to the problem. An example of one of the feedback loop diagrams created in this case study is illustrated in Fig. 1. The development of this diagram involved the group in a rich learning process and it provided a useful starting point for speculating about the determinants of the system behavior and possible strategies for improvements. The process of developing the SDM significantly enhanced the group's sensitivity of the organizational environment and how it would influence the success of any intervention. They were able to hypothesis more 'intelligently' as to which strategies offered the most promise

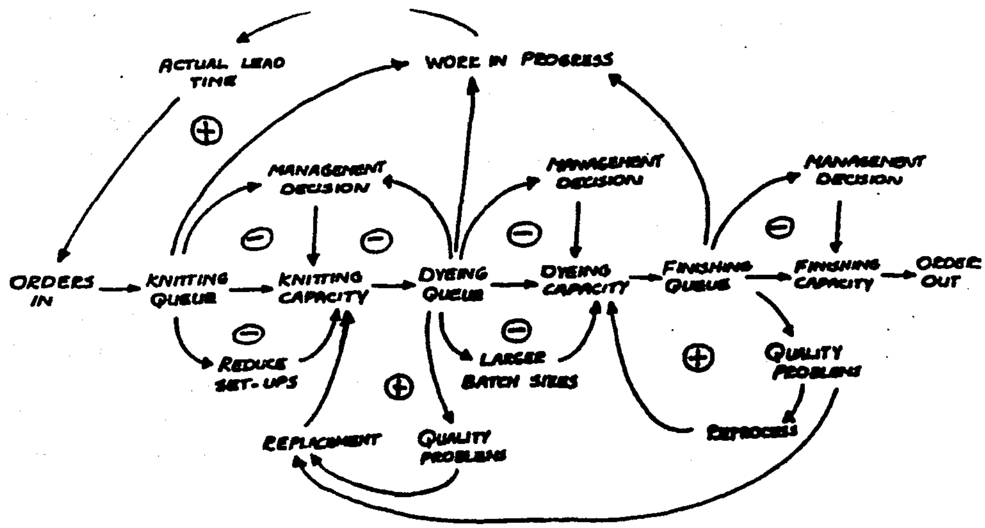

Fig 1 Production feed backloop diagram

The next stage was to examine the quantitative behavior of the key systems variables over time and to examine the validity and sensitivity of the model. This required a quantitative simulation of the SDM. This was done using the Dynamo computer software. One of a number of strategies investigated was the effect of changing the cycle time of various processes on the behavior of the system. The graph in Fig 2 illustrates the effect of changing the cycle time of a particular process, on the key performance variables.

Managerial learning is considerably enhanced when the confidence of the participants in the process increases. Management confidence in SDM is significantly increased when the key variables reflect historic behavior, both qualitatively and roughly quantitatively, when simulated over the same period. Fig 3 compares the actual production output and the simulated output over the same period. Considering that the group was not attempting to represent reality but to increase their understanding, these results are close enough to make them feel comfortable with the process.

4.0 Results

Once the group had completed both the CEDAC and the SDM exercise it decided rather than implement major changes to the system, it would focus on gathering and communicating relevant information. As an initial step it developed a series of performance measures which reflected actual performance. These consisted of two groups: external/customer orientated measures and internal/productivity measures. A CEDAC communications office was also established which would be accessible to all departments. Its main purpose would be to gather and communicate performance information for decision making. The result was a comprehensive information processing system which gave management a clear picture of the current status of the key performance areas in the organization. This enabled them to significantly improve their decision making. Furthermore it offered an opportunity for all stakeholder to participate in driving the improvement process.

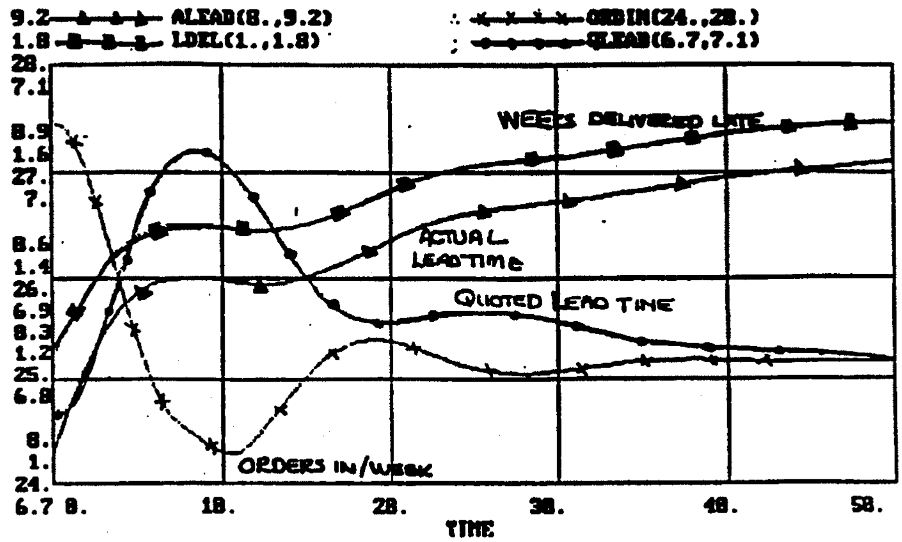

Fig 2 The effect of changing the cycle time of an operation

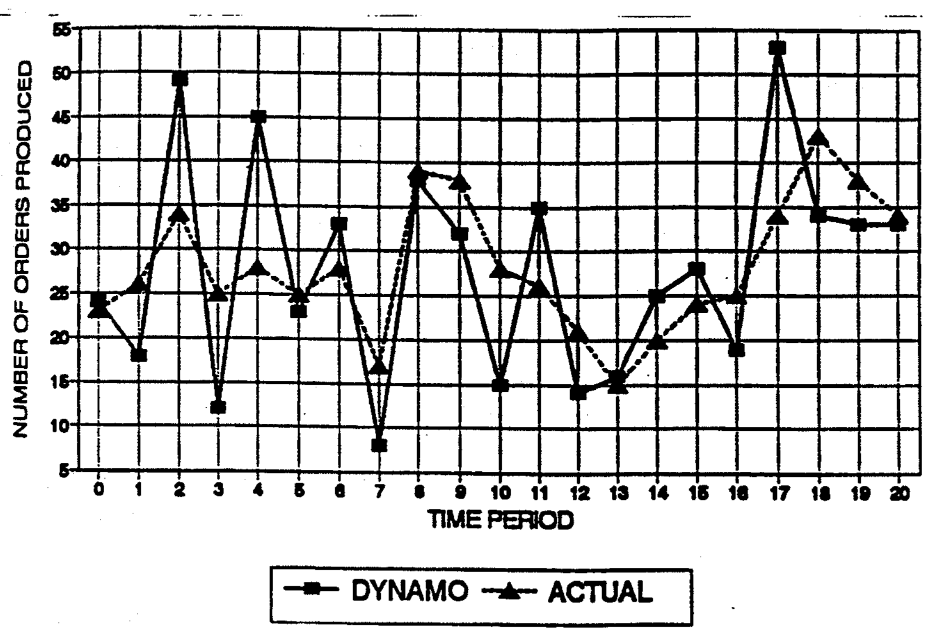

Fig 3 A Comparison of Actual and Simulated Production

Over a development and implementation period of seven months the following performance improvements were reported:

1 Average production lead time improved by 30%

2 Average 'on time' delivery improved by 55%

3 Average time for late delivery improved by 50%

5.0 Reflection

This improvement was gained with relatively few formal structural changes to the system. This begs the question "what change then, caused these improvements?" One obvious change was the improvement in communication and information flows. What started out as a problem solving activity turned out to be a rich learning exercise for the participants and the organization. The answer to this question seems to rest in understanding the managerial learning process.

The idea of a learning organization has been a recurring theme in the management literature of the past five years. The idea can be traced back a lot further than that, to a little known paper 'The Enterprise as a Learning System' by Reg Revans (Revans, 1982). In this paper he articulates the concept of a learning organization and the symbiosis between work and learning. You, as manager can not create meaningful organizational change unless you change as well, ie unless you go through a learning process. He contends that effective managerial learning takes place in the context of work and through interaction with fellow managers. The process involves groups of managers, who are facing real problems, getting together and asking new and penetrating questions about their problems. Solutions emerge from the process and the managers come away more competent in dealing with such problems.

Argyris has further developed the idea of organizational learning with their concepts of single and double loop learning (Argyris, 1982). The initial objective of this exercise case was single loop learning, ie error detection and correction which is the domain of traditional problem solving. What actually happened was double loop learning ie learning that changes current mental models, norms and values. This involves deeper inquiry and asking new and penetrating questions. This increases management's ability to deal with complexity.

In this exercise the CEDAC and the SDM exercises complemented each other in taking the group to a higher level of consciousness through double loop learning. This enabled them to see and deal with problems that were adversely affecting organizational performance which they were not previously aware of. In cybernetic terms the interactions that took place in the problem solving process resulted in the emergence of double loop learning. Requisite variety was achieved at a more beneficial level within the organization in the following way:

1 by moving to a higher level of consciousness management had amplified its own variety, and
2 by introducing the performance measures and the CEDAC communications room the level of self organization was increased in a positive way, resulting in an attenuation in the variety flow in the organization as a whole.

This exercise has demonstrated the value of rethinking problem solving as a group learning process and managing it as such. The value can be further enhanced by adopting a systems approach such as cybernetics and SDM in particular. When dealing with practical managers the process can be facilitated by introducing proven Japanese management techniques.

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Appendix

CEDAC is an acronym for Cause and Effect Diagram with the Addition of Cards. It is an enhancement of the classical cause and effect diagram (also known as the fishbone or Ishikawa diagram). It is a 'whole system' rather than simply a diagram and works in the following way:

1 A problem area is identified.

2 The variable representing the behavior of the problem is plotted on a control chart together with a target value which is set as an objective.

3 Causes of the problem are identified by operators, supervisors and management.

4 Each cause is written on an individual card.

5 Causes are grouped into similar categories as in a cause and effect diagram and attached to the CEDAC diagram.

6 Possible solutions to the problems, which may be suggested by any of the actors, are written on different coloured card and attached to the relevant cause.

An example of A CEDAC diagram in illustrated in Fig. A1

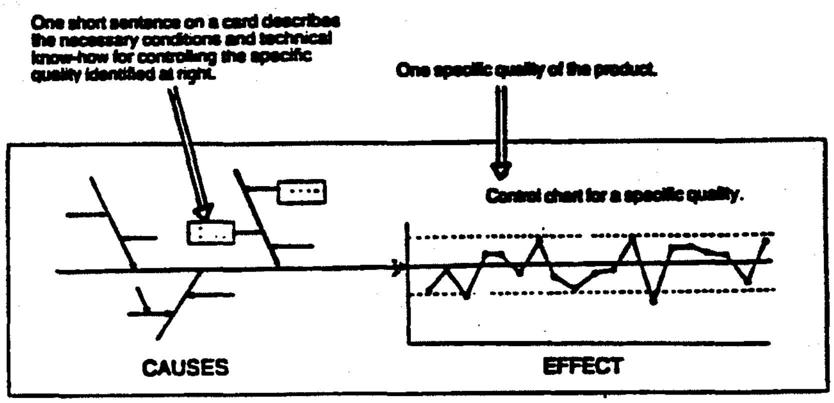

Fig A1 An Example of a CEDAC Diagram

CEDAC is a communication tool for managers and the shopfloor for communicating objectives and ways of achieving them. It also visible monitors the progress towards these goals. It facilitates policy deployment and promotes coherence between improvement strategies and business objectives.