Comparing Improvement Programs for Product Development and Manufacturing: Results from Field Studies

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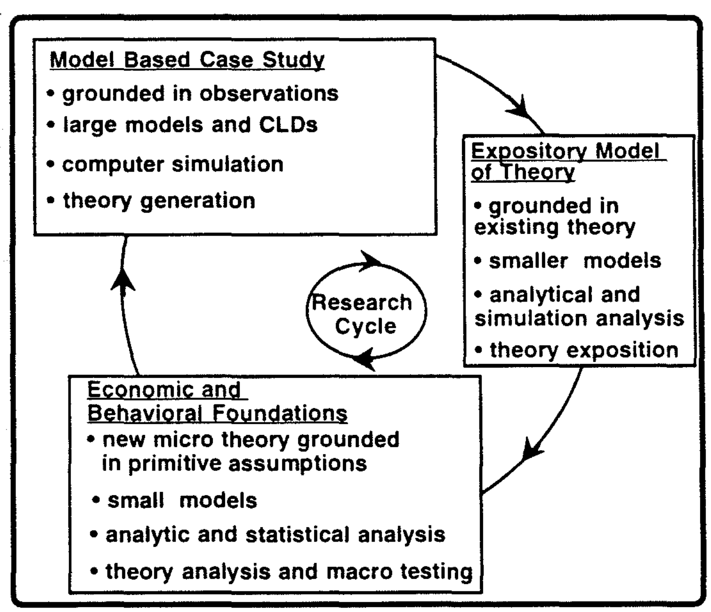
Introduction

The research described in this paper is part of a study being led by John Sterman and Nelson Repenning at the Massachusetts Institute of Technology. The overall study explores why even initially successful improvement programs often fail, and aims to help practitioners in designing sustainable improvement programs. Due to its role as part of this larger effort, the initial research has focused on exploring direct parallels with the case of Analog Devices[1] as well as searching for additional tight interdependencies between improvement programs and a company's other organizational functions and routines. This paper focuses gives an overview of our research sites and the major findings emerging from the research. For a detailed description of research objectives and methods see Sterman et. al (1996)[2] or visit our web site.

Methodology

We study the development of sustainable improvement programs using an inter-disciplinary research methodology designed to develop rigorous theory that is of use to both academics and practitioners. Our research methodology requires continually iterating between different types of models and data analysis. As show in the figure below, we rely on three types of models. Our research was initiated with a series of 'model based' case studies. Case studies are an important tool within the social sciences for building theory that is both rigorously generated and grounded in the experience of real organizations. We supplement the traditional case study method, which requires extensive interviews, archival data collection, and field observation, with the development of large scale system dynamics simulation models. Developing models gives us a rigorous method for reducing the 'degrees of freedom' within each case analysis as well as providing a powerful tool for comparing the results of the different cases.



Having developed new hypotheses from the model based case studies, we turn our attention to generalizing the ideas to a wider setting. Generalization takes the form of the expository model of theory shown in the second box of figure one. The purpose of these models is to distill the essential insights of the model based case study in a parsimonious form. The smaller scale of these model allows the rigorous comparison the model to existing theories as well as complete analysis of the model's behavior through both analytical and simulation methods. The final phase of the research cycle is to test the economic and behavioral foundations of the theories explicated in phase two. Such testing can take the form of large scale statistical analysis or grounding the theory in behavioral axioms as in game theory and economics. The goal of this phase is to fully articulate and test the core assumptions of the theory developed in the previous steps. Finally, the theories developed in phase three provide the basis for the next round of field studies and case analyses.

Field Studies with Partner Organizations

We are currently working with four companies to develop the field studies that provide the basis for our modeling efforts.

Lucent Technologies

Research Site.

Based in North Andover, Massachusetts, the Merrimack Valley Works (MVW) facility houses the manufacture of transmission equipment, long distance digital switching systems, lightwave systems as well as wire and coaxial cable systems. The product development supporting the transmission equipment manufactured at MVW is conducted both on-site and in New Jersey. MVW is the largest facility in Lucent Technologies, reporting gross sales valued at over $1 billion along with sizable contracts for new and existing products. A series of quality improvement initiatives were launched by the Transmission Systems Business Unit in the late '80s and early '90s that led to winning the Malcolm Baldrige National Quality Award in 1992. Since 1992 the demand for products from MVW has been increasing rapidly.

Project Overview. Our research has focused on documenting and analyzing the improvement programs that lead to the intense focus on quality that culminated in the Baldrige award in 1992. Three improvement initiatives are being explored:

- Manufacturing Quality – Using the Baldrige Quality Award as measurement criteria for quality and running business, a set of voluntary improvement efforts were deployed in MVW applying the tools and methods proven successful by Florida Power & Light. The unanimity of purpose at AT&T and the eventual success of the quality drive constitute an excellent example of participatory improvement efforts.
- Reduction of Product Development Interval – An adaptive methodology yielded substantial results – 50% reduction of the PD interval – during the first two years of its application. The effort eventually faced some counterforces that stopped the improvement rate leading to total abandonment of the initiative. A system dynamics model is under development to explore the key issues raised by this approach to improving the product development process.
- Improvement of Supplier Quality – Components and parts comprise the majority of the cost of MVW's products. Over the past decade, supplier quality has increased dramatically, while the supplier base has shrunk. The process was not without conflict and false starts, and recently the supplier base has begun to grow again. A feedback theory of the supplier initiative has been developed, and is being contrasted with the supplier quality experience at Ford (see below).

Ford Motor Company

Research Site. The Electronics Division (ELD) of the Ford Motor Company has primary responsibility for the design and manufacture of the electronic content of Ford cars and trucks. Among other products, ELD manufactures electronic engine control modules, electronic steering and suspension systems, air bag diagnostic modules, driver information systems (instrument clusters, etc.), and audio products. Due to the increasing electronic content of automobiles, ELD has grown significantly in the last decade Currently, ELD has eight manufacturing facilities. In 1992, ELD had revenue over 2 billion dollars.

Project Overview. We are studying three different initiatives within ELD.

- Manufacturing Cycle Time – Between the 1988 and 1995, the ELD was able to reduce its manufacturing cycle time by over 75%. In this project we study that strategies and techniques that made the effort such a dramatic success.
- Product Development Process – Based on the success of the cycle time reduction effort, ELD attempted to make similar improvements in the product development function. These efforts were less successful. Our study identifies a number of important feedback process that limited the success of the effort. For example, we find that the success of the manufacturing effort actually hurt, rather than helped, the product development effort.
- Total Quality Excellence – Like many large companies, Ford has a supplier certification program, the Total Quality Excellence award, modeled on the Malcolm Baldrige National Quality Award. To improve quality, Ford has used this program to drive continuous improvement by allowing divisions within Ford to also apply for the award. We study the impact that this program has had on the quality and productivity of divisions that attempt to win the award.

Harley Davidson

Research Site. Harley-Davidson is the only US based manufacturer of motorcycles. Harley has two major manufacturing facilities: one dedicated to engine production, the other to motorcycle assembly. Since coming within hours of bankruptcy in the early 1980s, Harley has experienced a dramatic turnaround. Using such tools as statistical process control and just-in-time inventory management, Harley has dramatically improved the quality of its motorcycles and the efficiency of its production facilities. Since the turnaround, Harley has experienced dramatic growth in demand, and has responded by increasing capacity. Still, Harleys are currently in short supply around the world.

Project Overview. The project focuses on the strategies, techniques, and institutional structures necessary to maintain continuous improvement while the organization is growing rapidly. We are studying the trade-off between boosting production and quality related activities as well as the effect that growth has on both skills and commitment of the workforce. We have also developed a simple model to analyze the transition to a new product development process and its short and long run impacts on product quality.

National Semiconductor Corporation

Research Site. Built in 1963 as an assembly site for Fairchild Industries, the South Portland site of National Semiconductor Corporation (NSC) currently houses both the design and manufacture of semiconductors. The site is particularly interesting due to the significant improvements made over time and the number of improvement programs introduced. In 1982 seven of every ten semiconductors produced at the South Portland Maine fabrication site of NSC were defective and had to be scrapped. Manufacturing yield increased rapidly and dramatically after the introduction of statistical process control techniques (SPC). By 1986 yield was 70%, and by 1994 it was 90%. It would be grossly inaccurate to credit the application of SPC techniques with the entire yield improvement. Advancements in basic science and production technology have contributed to increased yields across the semiconductor industry, and many other individual and company-wide programs have improved yield and other critical performance measures. Employees of the South Portland site have undertaken more than 30 identifiably different improvement programs in the last 10 years alone. Clearly, as new improvement programs and technologies become available managers must decide which ones to implement. Our research has focused on the interaction among programs for which this relatively small, and program prolific, site is particularly well suited.

Project Overview. A system dynamics model has been built to explore key issues raised by the research at NSC. This model has been recast as a flight simulator, called the "Program Life Cycle" flight simulator, and approximately thirty managers from all four partner companies have used the model. The Program Life Cycle model focuses on the management challenges faced by companies when they launch multiple simultaneous improvement programs or a series of successive programs. While the model was originally built to investigate issues at NSC, most of the key relationships in the model have proven to be generalizable to the other research settings.

A learning history based on the NSC study is currently under review. The learning history documents a number of the individual improvement programs undertaken at NSC's South Portland site over the last fifteen years. The individual program histories are used to understand the overall history of improvement effort at the site and provide empirical grounding for relationships within the Program Life Cycle model. Analysis of those program histories have provided insight into several areas including:

- External pressures for launching programs – The need to keep pace with rapidly improving competition and satisfy the specific requests of customers often provides the impetus for adoption of new programs.
- Endogenous pressures for launching improvement programs – Programs when launched draw resources from current production and limit the time available for subsequently added improvement programs. This resource drain leads to a perceived need for additional improvement and a conservative approach to estimating the benefits of subsequent programs.
- Complementarity and competition across programs – Many programs provide skills and other resources which allow for later programs to be adopted more quickly and at lower cost. Programs also compete for resources and for credit for improvements. Competition among programs may limit the success or lead to abandonment of otherwise promising efforts.
- Institutionalization of programs – Only a fraction of all programs become embedded in the patterns of daily work. While implementation methods, leadership, chance events, and other programs all affect the chance of any program making a lasting contribution to business performance, the programs that appear most successful are those that become embedded in the routines and physical layout of daily work.

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[1] Sterman, J., N. Repenning, and F. Kofman. Unanticipated Side Effects of Successful Quality Programs: Exploring a Paradox of Organizational Improvement. *Management Science*. Forthcoming.

[2] Sterman, J.D., N.P. Repenning, R. Oliva, E. Krahmer, S. Rockart, A. Jones. The Improvement Paradox: Designing Sustainable Quality Improvement Programs. Proceedings of the 1996 System Dynamics Conference. Cambridge, MA. 1996.