System Archetypes as a Diagnostic Tool: A Field-based Study of TQM Implementations

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ABSTRACT

System dynamics provides an important set of principles and methods for helping people gain a better understanding of complex systems. The use of computer simulation models is often positioned as the culminating outcome of most system dynamics efforts. As a field, system dynamics has traditionally downplayed the usefulness of simple pen and paper level tools because the real value is perceived to be in the computer model. Total Quality Management (TQM), on the other hand, utilizes almost exclusively, pen and paper types of tools and has had a high level of success in having them used widely. This is the case despite the fact that causal loop diagrams and systems archetypes often capture a much richer picture of a system than most TQM diagramming tools. In this paper, we outline a general approach to diagnosis using systems archetypes, causal loop diagrams, and semantics in the development of a structured process for mapping organizational change efforts.

Total Quality Management (TQM) utilizes almost exclusively pen and paper types of tools and has had enormous success in having them used widely. This is the case despite the fact that causal loop diagrams and systems archetypes often capture a much richer picture of a system than most TQM diagramming tools. One reason for the relative widespread use amd acceptance of TQM tools and methodology is that the tools are designed for "mass consumption." Ishikawa (1982), for example, presents an easy to use guidebook for using the seven tools of quality control. These seven tools are useful for looking at numerical data. Mizuno (1988) also covers the seven new tools for quality management using a similar approach for using tools to look at qualitative data in a rigorous way. TQM tools and methodology have been refined so that they pose no intrinsic barrier for a person at any level in the organization to learn and apply them. What makes them accessible are three important features: (1) each tool is presented in bite-sized steps, (2) each step has clear guidelines for ease-of-use, and (3) all the tools have been systematically tested in the field.

In this paper, we present a process that will help make a part of the system dynamics methodology more accessible to the uninitiated. We have developed and tested a process for using systems archetypes and causal loop diagrams as diagnostic tools for gaining a better understanding of organizational systems. Specifically, TQM implementation maps are built by using archetypes (such as "Shifting the Burden" or "Tragedy of the Commons") in an iterative process of zooming in and zooming out of macro and micro levels of detail. Semantics are used as guidelines for clarifying the clutter. We then apply this general framework to specific field-based TQM implementation efforts to gain better insights about what happened and why, and identify preventive measures for future efforts. This field-testing is conducted through iterative interview sessions with the managers who were actually involved in the case under study. Insight from this preliminary structural analysis of TQM false starts may help lay out a possible typology of common patterns of archetypes that play out in TQM implementation efforts.

Accessibility of System Dynamics Tools

System dynamics tools have traditionally been very focused on preserving the rigor of the modeling discipline. The traditional textbooks have treated the computer model as the ultimate output of the system dynamics method. Both Richardson and Pugh (1981) and Richmond, et. al. (1987) focus on developing models in a particular modeling language (DYNAMO and STELLA, respectively); Roberts, et. al. (1983) presents a more general treatment of simulation models; Randers (1980) covers the principles underlying the system dynamics method. For the most part, system dynamics has been positioned and viewed as a computer modeling discipline.

There is another side to system dynamics, however, that is of equal importance. Fundamentally, system dynamics is about understanding the interconnections, feedback, and dynamics of complex systems. From that perspective, computer models are just a piece of the whole picture, albeit an important one. System dynamics embraces a particular view of reality that is very powerful for understanding dynamic phenomena. As a field of study, system dynamics encompasses many tools that can be helpful at various levels of analysis.

There is a new wave of activity that is beginning to broaden the methodology beyond the modeling realm. In Richmond (1990), system dynamics is positioned within a broader field of inquiry called systems thinking. Richmond argues that systems thinking encompasses at least five different types of thinking skills—generic, operational, scientific, dynamic, and structural. Each of these thinking skills is required in system dynamics, but they have never before been made explicit, and hence, never explicitly taught. Kim (1990) proposes a set of ten systems thinking tools that explicitly maps the tools that are currently in use into the different thinking skills.

In *The Fifth Discipline*, Senge (1990) presents a set of systems archetypes that provides rich insights about dynamics without a steep learning curve. The archetypes provide a way for lay managers to quickly get "up to speed" in thinking more dynamically and structurally about their issues. The archetypes address the first of the three features of mass-consummability that have worked so well for TQM tools: each archetype is presented as a bite-sized chunk. Efforts to provide ease-of use guidelines for using the archetypes can be found in Kim (1992). In order to make these tools more suitable for mass consumption, field testing is needed to further develop and refine the guidelines.

In this study we used the systems archetype as a diagnostic tool to better understand the TQM implementation process. More specifically, we wanted to see if the archetypes could reveal a coherent theory of how organizations can fall into "structural" patterns of failure that may be common across organizations. In the process, we will outline some guidelines for using archetypes as a diagnostic tool and offer the two-company case study as a first step in the field testing process.

GENERAL APPROACH TO DIAGNOSIS

Systems Archetypes as Diagnostic Tools

Systems archetypes[1] can be powerful diagnostic tools for understanding complex organizational issues. The archetypes meet the "mass consumable" criterion because they provide a simple framework for casting vexing problems in a systemic context. Each archetype represents a dynamic structure that comes with a coherent story line which people can readily understand. Unlike the use of free form causal loop diagramming, the archetypes provide a way to identify a starting point and ending

[1] See Appendix 2 in Senge, (1990) for a summary and description of systems archetypes.

point, as well as help to decide what to include in the diagram. Archetypes help novices see the circular feedback structures that are producing the problematic behaviors they are trying to solve.

For example, a company may have a lot of defective parts coming off of the assembly line. Traditionally, this problem was often "solved" by having quality inspectors weed out the bad parts. This strategy worked in keeping defective goods from reaching the customer, but it did nothing about eliminating the production of defective parts. In fact, the use of such inspectors actually contributed to the continued production of bad parts by hiding the symptoms. We can use the "Shifting the Burden" archetype to show how the use of quality inspectors can take attention away from eliminating the source of the defects.

The "Shifting the Burden" archetype can capture the long-term effects of a policy that "shifted" the burden of providing defect-free products from design and manufacturing to the quality inspectors. The success of the inspectors means that customers are not getting bad parts, even though the number of defective parts may have been increasing. In the "Shifting the Burden" structure, the leverage lies in recognizing how short-term fixes can undermine investments in long-term solutions by covering up the "symptoms" that would signal the need for implementing more fundamental solutions.

Semantics as a way of "Cleaning" Verbal Data

One of the main difficulties in using an archetype is in the selection of variable names for "filling in" the archetype. A useful guideline is to borrow from a TQM technique called the KJ (or affinity)[2] diagram on the use of semantics for creating variables for inclusion in an archetype. According to Shiba (1990), we need to distinguish among and understand the four characteristics of language processing that is relevant in generating variable names:

1. The dual role of language
2. The use of inference and judgment
3. The ladder of abstraction
4. Multi-valued vs. two-valued thinking

Shiba distinguishes between the language of reports and the language of affection. The first is for communicating information; the latter is for communicating emotions. When using language to transmit the same meaning of information to everyone, one needs to use the language of reports. In our everyday communication, we usually use a mixture of both, so it is not surprising that most people include both when formulating variable names. "Cleaning" verbal data into a commonly understood and usable form requires stripping away qualifying adjectives (e.g., smart managers) as well as judgment and inference.

The ladder of abstraction is another important semantic tool because it makes the user very conscious of how far away the variables are from concrete facts and directly observables. For example, Johnnie Walker Red is a specific brand of Scotch. If we are talking about alcoholic beverages, it would be very low on the ladder of abstraction. System dynamics models are generally constructed at a highly-aggregated level while most people's day to day experience is rooted at a much lower level. The ladder of abstraction can serve as a useful guide for walking people down the ladder to a level at which the dynamics makes more sense to them.

The fourth guideline is a very familiar one. We want to use terms that can vary over time, not just switch back and forth like an on-off switch.

[2]See Mizuno (1988) for a description of this method.

STEP BY STEP METHODOLOGY

Data Collection

There are two primary tasks associated with the data collection stage of the research: identifying the system or event to be investigated and collecting the appropriate data. In selecting our field sites, we focused on well-defined TQM implementation "false starts" in order to ensure the system we would be investigating was well-bounded. There are three main advantages to clarifying the target early in the investigative effort. First, since the system is bounded, identifying the most appropriate informants is manageable. Second, the informants are able to reflect on their actual experience rather than hypothetical or abstract events. Third, the amount of time required to conduct the analysis is minimized.

Our data collection relied solely on informant interviewing. In addition, we interviewed three different people in each organization which allowed us to cross-check the stories for accuracy. We asked each person to relay the story of the "false start" chronologically, often laying out a time line in order to anchor specific reference points. This emphasis on obtaining verifiable data usually requires advance preparation by the informant, so an interview outline was sent in advance. Two field researchers conducted each interview (one person led the interview while the other was responsible for taking notes).

The lead interviewer was responsible for the flow of the interview. The note taker's job was to capture the conversation as accurately as possible (tape recording the sessions may be counter-productive due to the potentially sensitive nature of the subject—people may be reluctant to share their experience freely if a tape recorder is running). After the interviewee finishes telling his or her story in chronological order, the field researcher leads the interviewee through a force-field analysis. A force-field analysis is a simple device for structuring data by identifying those forces which are helping the change effort and those forces pushing against it. In the final step of the interview, the person is asked to identify the dominant forces at work and trace through the causal explanations behind those forces.

Model Building

After gathering the interview data, the model building step is next. The goal is to convert the "raw" interview data into a meaningful systemic story about the false-starts. We have three primary stages in developing the model: defining the mess[3], simplifying the mess and explaining the mess. In defining the mess each story is represented with causal loop diagrams. In simplifying the mess semantics are employed to abstract concepts which describe clusters of variables in the causal loop diagrams. In explaining the mess, archetypes are employed to explain the underlying structure which determines the dynamics of the pattern of events.

I. **Defining the Mess**

Select an issue that is of interest, identify a systems archetype whose structure and behavior matches the selected issue and map the issue into the selected archetype, adding additional loops as required (at a high level of abstraction),

Redraw the loop diagram at a more detailed, operational level for each major subpoint in the loops (e.g., training, rewards, etc.), .

[3]The term "mess" was coined by Russell Ackoff and is meant to be a technical, yet descriptive concept for the complex interconnected system of problems that managers are faced with in their organizations.

Integrate all the pieces, identify similar terms and reword to remove repetition, and "scrub" all the variable names to be free of judgment and inference.

II. Simplifying the Mess

Condense the integrated diagram by walking back up the ladder of abstraction and "scrub" terms as needed,

Review the integrated diagram and clarify levels of detail, differing time horizons, difference between goals, rewards, performance, and effects.

III. Explain the Mess

Identify other archetypes that are embedded in the final causal loop diagram. Reposition loops as necessary to make the archetypes more clear.

Compose a story line that captures the insights generated by the diagramming process and develop other archetypes as stories to be told. The archetypes convert the many loops into larger "chunks" which are easier to understand and communicate.

We begin defining the mess by creating simple, high-level, causal loop diagrams for each individual "story" in the false start case. Each story is then fleshed out by successive iterations of ever-increasing details. We have found it helpful to use the interviewee's language as much as possible in creating these diagrams. After each story is captured in a causal loop diagram (CLD), all of the individual casual loop stories are integrated into one large causal loop diagram. At this point it will be necessary to refine terminology across stories in order to combine common features and eliminate redundant ones. It is not uncommon to have a CLD which looks like a large bowl of spaghetti at this point.

In simplifying the mess the goal is to eliminate variables and loops which do not add substantially to explaining the dynamics associated with the false starts. The first step is to identify "clusters" of similar activities which can be abstracted into a single higher order concept, without loss of the underlying activity. Then, identify the remaining loops as primary, secondary, tertiary loops, etc. Eliminate loops which were not identified in the discussions as being particularly influential. At this point, redraw the CLD along the path of the story.

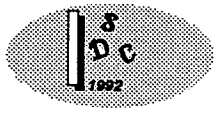
In explaining the mess, the dominant loops associated with the stories should be reviewed to see if they contain structures that can be condensed into archetypes. If an archetypal structure is evident, attempt to explain the story from the vantage point of that archetype—if the story still holds, the archetype represents a good match. Finally, the model should be verified with the interviewees for "face validity": can they look at the model and agree that it reflects the dynamics of what had happened.

FIELD APPLICATION

A Look at TQM Implementation

We begin by looking at a typical model of TQM implementation as viewed from a "Limits to Growth" archetype. A "Limits to Growth" archetype is characterized by a positive loop and a negative loop (see Figure 1). When performance growth begins to slow, the leverage in most "Limits to Growth" cases lies in developing a better understanding of the negative loop(s)[4]. The more obvious action that people take is to

[4]Although we use the traditional notations of pluses and minuses and refer to the loops as positive and negative in this paper, we did use a different notation in our fieldwork involving managers. We followed a



"do more of the same" that had worked before, namely, keep pushing on the positive loop(s). In the long run, this leads to diminishing returns from the positive loops and continuing shift in loop dominance to the negative loops.

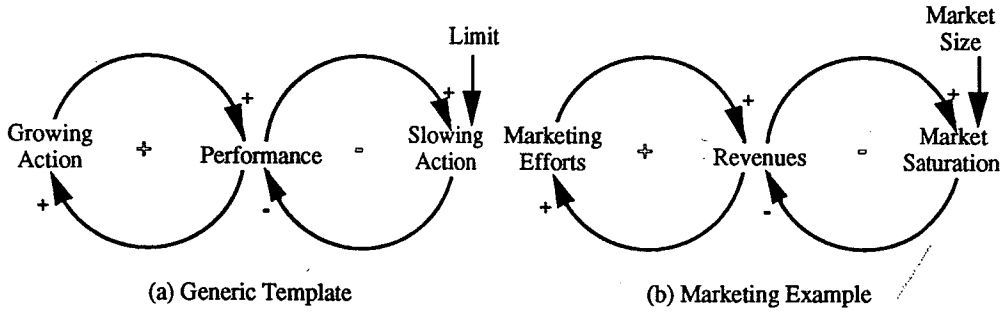


Figure 1. Limits to Growth Archetype. A performance measure (Revenues) continues to grow as more is invested in the growing actions (Marketing Efforts). Over time, slowing actions (Market Saturation) can stifle the performance growth as the system hits a limit (Market Size).

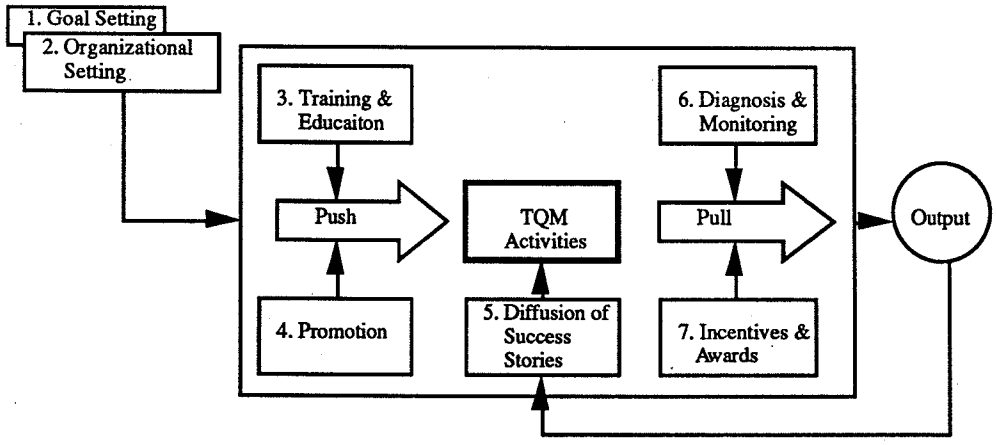


Figure 2. TQM Implementation Model. All the activities outlined in this model are engines of growth. No factors that may be a part of negative loops are identified.

In the proposed seven-point TQM implementation plan shown in Figure 2, we identified all of the factors to be a part of positive feedback loops. An implicit assumption in the model is an expectation that if one does all the right things to drive the positive loops, the implementation process will be self-sustaining and growing. In reality, a TQM implementation is much more likely to resemble some of the other possible outcomes shown in Figure 3 than to follow a smooth exponential growth

notation developed by Innovation Associates (Framingham, MA) that is free from the evaluative connotations of the words positive and negative. Instead of a plus we used an "s" to represent a change in the same direction. Instead of a minus, we used an "o" to denote a change in the opposite direction. Positive loops were referred to as reinforcing loops and negative loops were referred to as balancing loops. We recommend adopting such a notation for fieldwork because it communicates the message with less ambiguity.

curve. What is missing in this TQM implementation model are all the negative feedback loops that will resist the effects of the growing loops.

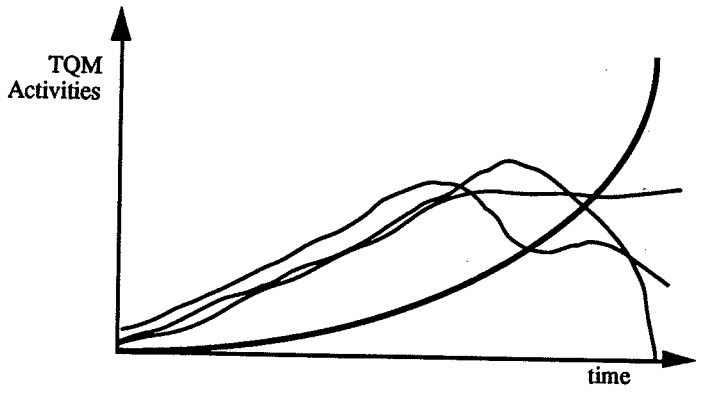


Figure 3. Various possibilities for TQM Activities. If all goes well, the positive loops can drive TQM activities to exponential growth. More often than not, the pattern follows one of the other possibilities shown.

The limits to growth archetype is an appropriate starting point to begin looking at this implementation plan more systemically since its behavior modes match real life experience. As mentioned above, the fundamental lesson of this archetype is that the leverage often lies in working on the limiting condition or the negative loop and not the positive loop.

Field Application

One of the field sites we investigated is a division of a multinational manufacturer of semiconductors and related components. This division has approximately 1000 employees with worldwide annual corporate sales in excess of $500 million. This company began its quality initiatives with the "Crosby" approach in the early 80s, evolving into the "Juran" approach in the mid 1980s. It is now embracing the broader philosophy of Total Quality Management.

We conducted a case study of their shipping performance activities. This activity was selected based on their assessment that it constituted a quality improvement "false start". In other words, improvements were made and then subsequently lost. In this analysis, the Division's General Manager, Quality Manager and Operations Manager were interviewed[5]. Each interview took approximately 2 hours.

The following is a mini-story which captures the essence of what kinds of stories were told by the interviewees. Mini-stories, like the one in the following section, represent the first round of interpreting the interview data into systemic models and stories. A more complete set of these stories can be found in Brown and Tse (1992).

Dimming the Spotlight

The Quality Manager discussed in his interview the importance of a corporate measurement system which highlighted to senior management the gap between the improvement opportunities and the actual improvements being made by the operating units. The emphasis of this program was on improvement rates rather than the absolute value of improvements. He stated that while the Senior Management spotlight was

[5]We have chosen to refer to each person by functional responsibility to preserve anonymity.

focused on improvement rate and shipping performance, qualaity improved. One of his conclusions was that when the Senior Managers turned their attention to other pressing problems the improvements disappeared. This "story of the events" (condensed for this paper) is mapped in Figure 4.

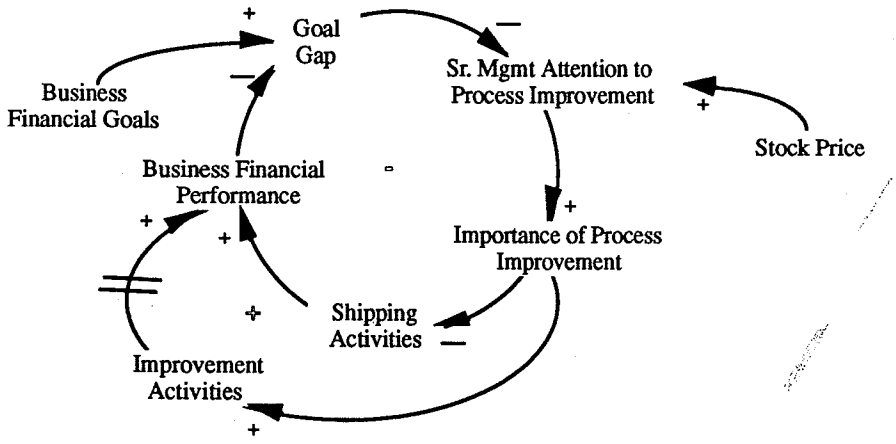


Figure 4. Dimming the Spotlight. If senior management puts the spotlight on improvement activities, they get done. Otherwise, the tendency is to carry out the "normal" activities, such as shipping.

In this story, improvement activities are moderated by the level of attention that senior management devotes to improvement activities versus day to day activities, such as shipping. When management attention to process improvement is high, it leads to a growing sense of importance of process improvements which drives improvement activities and improves business performance. This reduces the business goal gap and reinforces management's attention. But, the benefits of improvement activities usually takes time to bear fruit so there is also the possibility that shipping activities take precedence whenever management's attention is diverted. In this company's case, a sharp drop in the company's stock price diverted attention away and activity shifted from the positive loop to the negative loop leading to an abandonment of improvement activities.

Other mini-stories included "Resistance to Change", "Realistic Goal Setting", "Productivity Dilemma, "Ship or Measure, " Capital Crunch," and "Train the Troops." All these mini-stories are then integrated into a single causal loop diagram. The diagram in Figure 5 contains three of the mini-stories (Train the Troops, Dimming the Spotlight, and Ship or Measure).

Integrated Map

The integrated diagram presents a richer map of the pattern of events which still preserves each mini-story without losing the details. In the absence of senior management attention on improvement performance, the response to a shipping backlog (caused by a sudden increase in orders) results in man-hours being applied to shipping activities in lieu of improvement activities. This also reduces training hours. Once this sequence of events is put into motion, the importance of process improvement erodes, leading to a decline in improvement activities. Over a period of time, the improvement rate deteriorated and performance returned to its historical level.

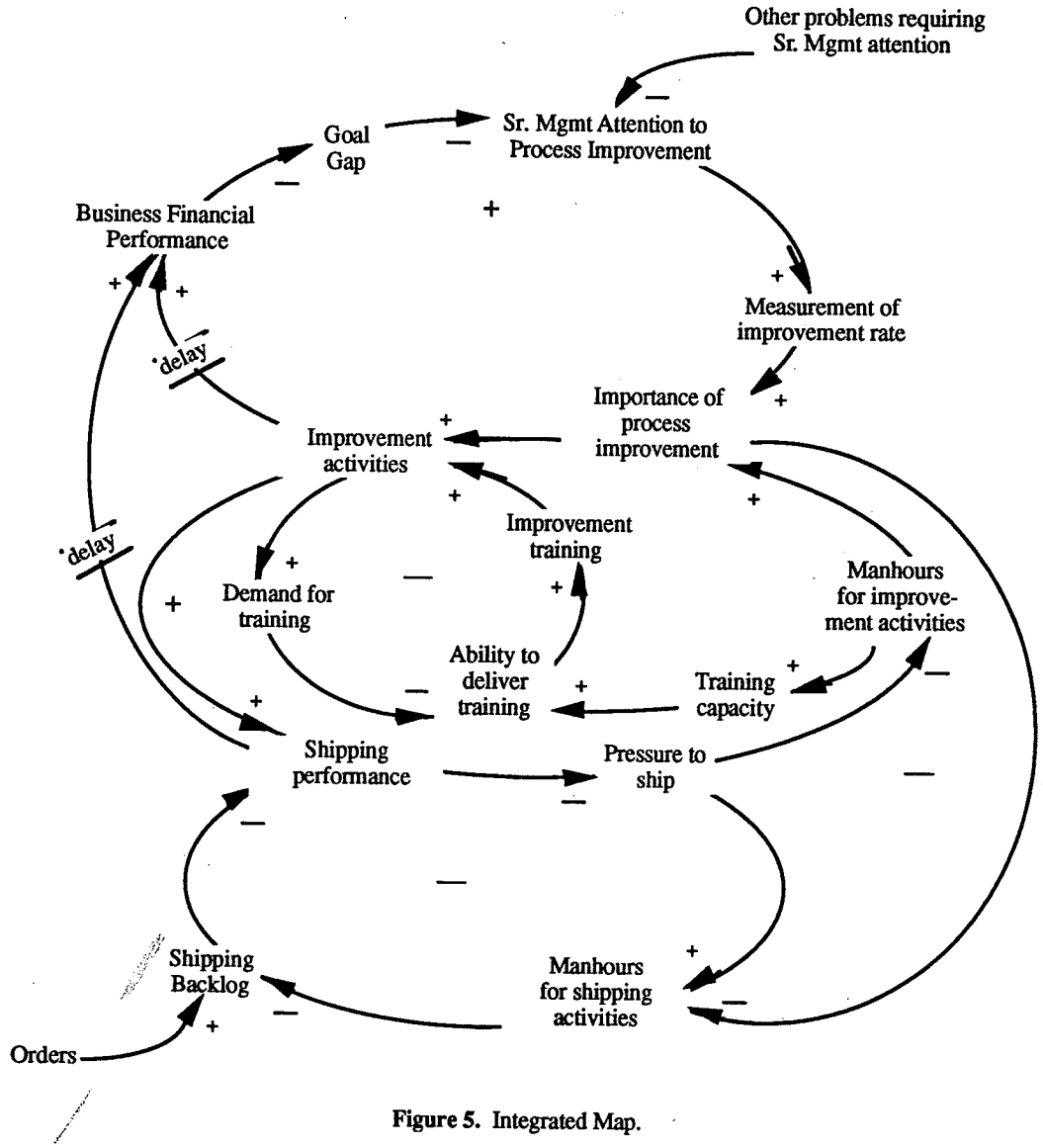


Figure 5. Integrated Map.

The integrated map, while extremely useful for diagnosis, can be difficult to comprehend let alone communicate. We found it useful to simplify our integrated maps by applying the concept of abstraction. Abstracting upwards means finding larger "chunks" of stories embedded in the integrated map that can be captured in terms of archetypes. Figure 6 contains one such example where a Limits to Growth archetype has been abstracted from the larger integrated map. By abstracting several of these from the integrated map, one can construct a simpler summary map which is composed of a set of interconnected archetypes. The final abstracted version captures the richness of all the stories told in the interviews, but in a way that can be easily understood and remembered.

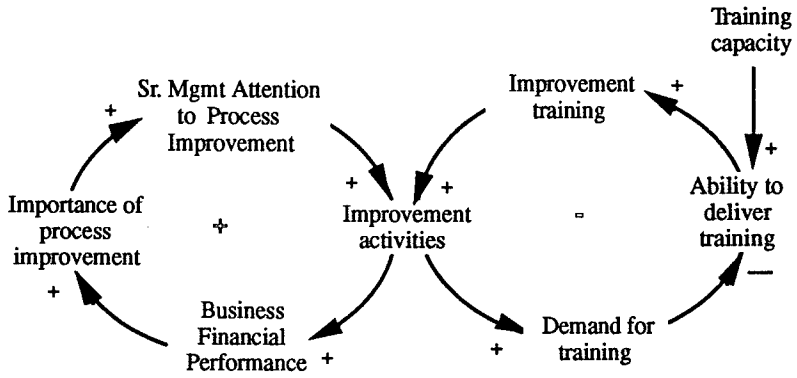


Figure 6. Abstracted "Limits to Growth" Systems Archetype from Integrated Map.

Next Steps

In order to build a typology of how different implementation false starts played out dynamically, we need to replicate this study with about a dozen more field sites. The results of this initial two-company study suggests that there are some common patterns that companies can fall into (such as the Limits to Growth structure shown in Figure 6). Having such a typology can help companies understand how their implementation plans went awry so that that they can design ways not to fall into the same traps. Perhaps more importantly, new companies venturing into a TQM implementation can learn from the experience of others.

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