# Frameworks for Integration of Systems Thinking with The Quality Management Practices

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**Abstract**

Total Quality Management (TQM) has been experiencing great deal of attention. It has become the competitive strategy of choice. However, a seeming lack of a unifying framework, TQM appears to be fragmented into isolated approaches. For an organization to achieve business success, various quality initiatives should be mutually reinforcing. Implication is that managing relationship among several TQM component programs is at least as important as the implementation of the individual programs. In contrast to many other tools, system dynamics tools facilitate management of relationships in a proactive way. The focus of this paper is to advance this role of the system dynamics. Several relevant processes and critical initiatives generally confronted by an organization engaged in phasing in quality management are captured in distinct casual frameworks. The paper also explores how and when system dynamics tools can be leveraged with commonly known quality management tools by quality professionals.

# Frameworks for Integration of Systems Thinking with The Quality Managemer Practices

Declining competitiveness and rapidly changing technological environment created the commonplac problems that threaten well-being and survival of many organizations. Organizations that could get awa with being reasonably unhealthy and those pinched by these pressures have embraced quality manageme principles and practices. Improving health of an organization requires holistic approach and means takir time out to examine basic operating assumptions and replace those that are dysfunctional with mo competitive ones. Many have been spending an increasing amount of time and money in quality relate issues without making significant progress. Successes of few isolated quality initiatives remained sho lived. Many reorganized into leaner and more market responsive structures. Movements of decisic making down into hierarchy and team approaches are in vogue. Effective integration of people and busine processes in a way that taps into people's brainpower is considered to be critical. TQM offers philosophic foundation, principles of behavior, and tools, which are designed for mass consumption. Many laudab goals such as empowering individuals and teams often proved to be counterproductive because many of o human systems are complex, dynamic, and noisy at the levels of aggregation where the major long r behavior patterns are controlled. Considering the number of critical dynamic problems now facing t quality management systems, system dynamics has enormous potential for contribution.

System dynamics is the only science -- based methodology that is sufficiently logical (causal basec comprehensive, flexible and quantitative. Recent advances (Senge, 1990) in identifying recurring busine and management difficulties and situations as system archetypes and availability of personal comput based software have brought the field of system dynamics closer to larger public. Although some m question (Maloney, 1993) benefits of such advances, most would agree that causal loop diagrams, flo diagrams, policy structure diagrams and system archetypes capture much informed picture of busine situations. Kim (1990) offered a framework for viewing total quality and system dynamics complementary approaches to organizational learning. One of his major contribution was to classify vario system thinking tools in a more digestible form. An objective of this paper is to reinforce the key messa and further the cause of system dynamics.

Next section presents a framework that shows interrelationship among all critical operational level quali initiatives. This structure is similar to "The Growth and Underinvestment" archetype (Senge, 1990) a allows management to transfer the knowledge about known behaviors of this archetype to guide long-te aggregate performance of TQM initiatives. The section following this describes a causal framewo representing one of the most common processes encountered when an organization phase in quali management. Today team management has become synonymous with TQM. The framework explai group problem solving process and associated learning. The next section provides an integrated view quality management and system thinking. The final section presents a management framework t integrates PDSA (Plan, Do, Study, and Analyze) and SDCA (obtain Standards, Do, Check, and act) Deming's problems solving cycles (Shiba, Graham & Walden, 1993), a strategic value chain (Porter, 198 and LEARN (Locate, Employ system dynamics, Assess, Reflect, Nominate solutions) -- a complementa system dynamics based planning cycle.

## TQM: Manage the Interrelationship

For many people, to implement TQM means sum of capturing the voice of the customer using Qual Function Deployment (QFD) and customer surveys, designing the product using Designs of Experim (DOE), implementing Just In Time (JIT) and Statistical Process Control (SPC), empowering teams

breakthrough improvements, educating workers to use seven quality tools for continuous improvements, infusing organization with leadership training, and many more. Each of the quality initiatives has notable success, great promise and is necessary. However, business results are the consequence of the interactions of all initiatives with each other and with the social environment. That means the success depends not only on individual initiatives, but also on management of the interrelationship. Figure 1 shows the interrelationship map of key total quality issues and initiatives.

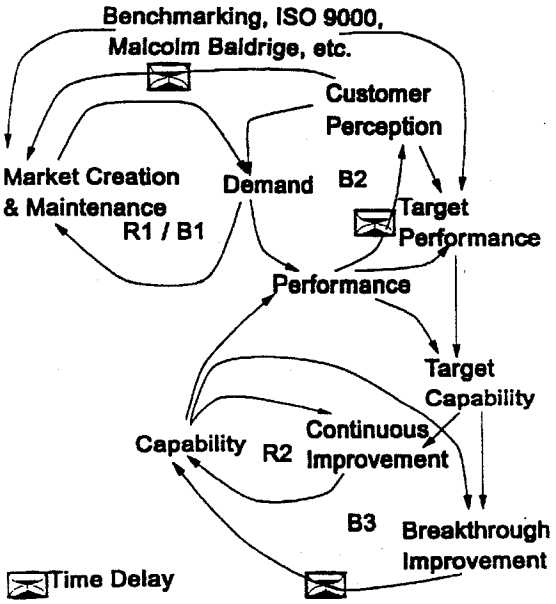


**Figure 1: A Relationship Map of Key Total Quality Management Issues**

The key variables are "capability" and "market creation and maintenance." Capability is viewed to be different from capacity and as ability to meet demand placed on it. Demand is an aggregate of amount, quality, features, delivery preferences, etc. In order for a firm to generate money now and in the future, it requires to create new market and maintain existing customer base on one side and upgrade capability through continuous improvement and breakthrough improvements. Capability would be more difficult to define. Capacity can be used as a starting point in relation to capability. However, capability can grow or shrink as a direct response to the changing market conditions, which would be reflected through customer perception and benchmarking efforts. Capability improvement can be viewed as an act of removing one or more of the constraints, which are either behavioral, managerial, logistical, technological, informational or capacity. The target capability is keyed to the target performance required to be competitive. Customer preferences and benchmarking are used to establish the target performance for the capability improvement on one side and to enhance market base on the other side. The international or national level quality programs such as ISO 9000 and application of the guidelines developed for Malcolm Baldrige award are external impetus that is to be used to establish target performance and to provide a signal about commitment to quality to market place. These initiatives are also often used without developing deep understanding and to overcome the internal resistance management may face. The diagram also shows that the capability and market creation are interrelated in time. That means the effect of today's capability improvement efforts on the market place is related in time. A skilled system thinker can easily add additional variables such as cost and profit.

This diagram was originally developed by the author to show a group of managers what system thinking all about. A laundry list of various items was generated during a group brain storming session. Aft several iterations and application of affinity diagram, the final list of variables was used to build th diagram. The emphasis of the exercise was to show that the quality initiatives are means to the busine ends and that is to protect your current or future profits. Strategic and system thinking is very critic managerial skill. If quality initiatives are considered to have any strategic significance, the syste perspective has promise.

## TQM: A Group Problem Solving Process

Many of the TQM tools (Brassard, 1989) can be viewed as means for capturing knowledge and using it wi teams to discuss and debate problems and changes. The tools offer schemes to organize informatic (diagrams, matrices, graphs, etc.). Tools affect teams when they lead to changes in group members' ment models and select a course action to alter perceived undesirable state of the system under study. Figure shows a broad view of how actions are selected to satisfy the

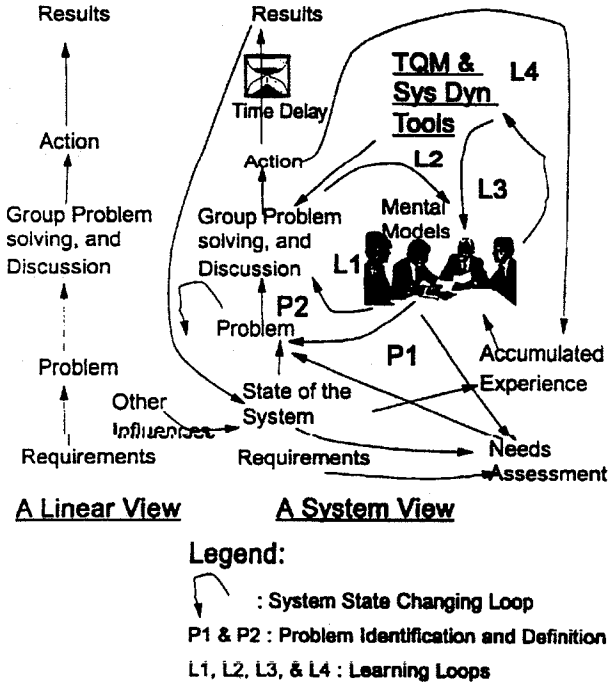


Figure 2: A Group Problem Solving Process

requirements, which is stimulus for forming a team for problem solving. The left hand side of the diagra provides a linear view often used with some variation to describe how a group problem solving proce progresses. The right hand side of the diagram offers a causal loop diagram showing how in reality th problem solving process advances. Once an action is selected the implicit assumption projected by line view is that the results alter the state of the system. The causal loop diagram explicitly connects the acti chosen by the team to the state of the system and recognizes the presence of time delay and other influenc causing the change. The shop floor applications of quality tools and principles have been successful main due to short time lag between action and results and hence, the learning that takes place is appropriate a valid. However, increasing time lag between action and results coupled with decision makers' inability

correctly perceive time delays and feedback from decisions to the environment (Sterman, 1987a, 1987b), as in the case of product and process development or technology management, the learning that is expected to take place in a team environment would be problematic. It is precisely in these cases, system thinking tools (Kim, 1990) can play a significant role. If we accept the assertion (Forrester, 1987) that only people's beliefs, that are, their mental models, will determine action, the quality of the mental models can also be viewed to influence the quality of action. If quality of action is what an organization is concerned about, the system thinking tools must be made widely available. The developments in system dynamics (Morecraft, 1992) have included team involvement to build models, the process of eliciting executive views, mis-perceptions in dynamic decision making, learning and gaming. All of these developments concern with connection between modeling and its influence on thinking and actions.

The causal loop diagram presented in Figure 2, identifies several loops that can explain the dynamics of underlying group problem solving process. Problem identification and problem definition loops include the variables: needs assessment, state of the system, group problem solving, and discussion, and mental models. There are also four learning loops. The loop L1 is interpreted as an interaction among team members. Both loops L2 and L3 include TQM & system dynamics tools and mental models. The loop L3 is viewed as learning to use the tools and be proficient and the loop L2 is looked upon as learning to leverage tools for the specific group problem solving process. The loop L4 is a relatively longer term learning in which team members will accumulate in their memory the problem and the associated action. The quality of L4 is critical from a loner term perspective. In the future problem solving situations, the team members will draw from their experience. If the time delay between action and the results is long, the quality of this learning will be deteriorated. By appropriate use of system dynamics tools, one can hope to improve this part of the learning. One such a tool is a situation specific microworld. Enhancing organizational learning by having team members freely experiment in a risk free environment of managerial microworlds (Senge and Lannon, 1990; Paich and Sterman, 1993) has great potential.

**TQM: System Dynamics LEARN Process**

LEARN is a process designed to assist individuals in working together to enhance learning and leverage their understanding through applications of system dynamics tools. The group uses the LEARN to work together through a basic learning enhancement model, which is integrated with PDSA (Plan, Do, Study, and Analyze) quality improvement model as shown in the Figure 3. The naming of the process acronym was motivated by the similar acronym used for the classroom teaching and learning improvement process (Baugher, 1993).

The steps are:

L Locate a core interest or focus for systemic evaluation
E Employ system dynamics tools for leveraging understanding
A Assess for the adequacy of the current representation
R Reflect the process and the results
N Nominate solutions and enter the PDSA cycle

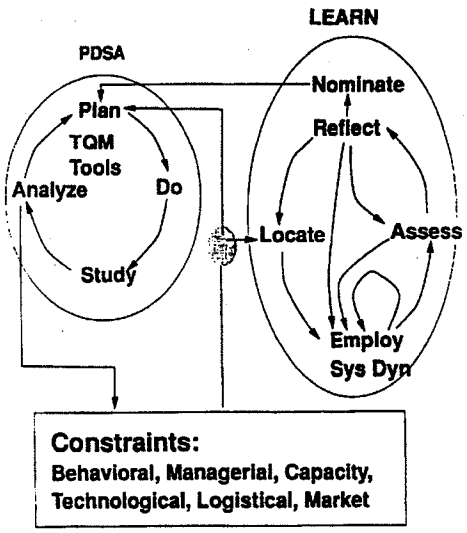


**Figure 3: TQM PDSA and System dynamics LEARN Problem Solving and Learning Cycles**

The group works through this process along the with the PDSA cycle while working on an improveme project. One less time demanding approach is to introduce the concepts of causal loop diagramming ar system archetypes as a part of TQM training.

The following step by step process has been used by the author in a classroom environment for developing causal loop diagram.

Step 1: Identify key variables and build a loop representing a core interest, a concern or a focus. Generall this step yields either a balancing (negative feedback) or a reinforcing (positive feedback) loop.

Step 2: Leverage your understanding of the core focus in the context of the story by making connection the variables in the core loop with the variables not yet included in the diagram. Continually, ask if "A affects "B," how does "B" affects "A."

Step 3: Repeat Step 2 as often as necessary.

This method generates a requisite causal loop diagram. When this method was adopted to recognize system archetype, the available library of archetype provided the end goals and helped to channel thinki process in steps 2 and 3. This process has similarity with the archetype family (Goodman and Klein 1994). The following step by step process has been used by the author and is one way to genera understanding about a business and management situation using system archetypes.

Step 1: Recognize a core focus. If it is a reinforcing cycle, go to step 2, else go to step 4.

Step 2: (Reinforcing) The next level of leveraged diagram can either be "Limits to Growth" or "Success Successful." If it is a "Success to Successful" archetype, go to the final step. If it is "Limits to Growth" ar if it is be sufficient, move to the final step. If required, go to step 3. If the reinforcing loop has symptomatic solution as well as a fundamental solution, the archetype is modified to a "Shifting t Burden" type before moving to the final step.

Step 3: (Limits to Growth) The next level of leveraged diagram can either be "Tragedy of Commons" or "Growth and Underinvestment." In either case go to the final step.

Step 4: (Balancing) If the balancing loop is due to a fix that is applied, look for any side effects, which may resurface the old problem. In this case, we have "Fixes that Fail" archetype. If the fix is symptomatic solution or external intervention and fundamental solution or internal solutions are alternatives, we have "Shifting the Burden" archetype. In either cases, go to the final step. If the fix involves lowering a goal, instead of improving the system, we have an "Eroding Goals" archetype.

Final Step: Assess, reflect and nominate solutions and/or begin leveraging the identified archetype by going back to step 1 with one of the reinforcing or balancing loop as a core focus. The resulting diagram will be a hybrid of several archetypes.

The process described here is brief and can be flushed out by inserting appropriate questions, answer to which would yield a required archetype. The LEARN process does not restrict to just development a causal loop diagram or to recognition of an archetype, but also to development of computer models. It should be noted that most problems selected for application of the TQM tools have either a reinforcing core focus or a balancing core focus.

The above method was first applied in a group problem solving session attended by managerial level people in an architectural and engineering firm. The underlying problem was lack of employee initiative and some morale problem. A questionnaire was administered and the answers to the questions were collapsed into manageable number of variables for the discussion and reflection. It was revealed that the firm had experienced growth in recent years and the size of the firm almost doubled in a four year span. Many old habits of the managerial level people of taking charge in the case of a crisis and ad-hoc planning turned out to be responsible for many of the problems the firm was having with their employees. A "Shifting the Burden" archetype was identified. It was also noted that one particular group, electrical and mechanical engineering, was bottleneck and had lowest morale. An additional causal loop diagram was developed to illustrate the relationship between the workload and the morale problem.

The method was also tried first time in a classroom environment, in which students were required to analyze cases (Clark and Wheelwright, 1993) in a group and were encouraged to identify archetypes. This has resulted into many interesting possibilities for future applications. The students were able to recognize many of the archetypes (Senge, 1990). One additional hybrid archetype (named here as "Ping-Pong") was also pinpointed whenever two autonomous but interdependent groups are trying to satisfy some external requirements and the communication is bureaucratic or through a third party. It was learned later that this is also named as "Accidental Adversaries" (Kemeney, 1994). This archetype was also noted whenever there appears to be communication problems between the staff and the line personnel and also between design and manufacturing groups. Another archetype when resources are shared was "Tragedy of Commons" (Kim, 1993). Students did find it difficult at first, but after few attempts, their ability to identify an archetype went up. Some of them no longer found a need to follow a step by step process outlined above.

**TQM: A Management Framework**

Figure 4 shows a complete management framework, which harmonizes well-accepted quality improvement processes recognized as SDCS and PDSA cycles and LEARN process with strategic value chain concept (Porter, 1985). A major objective of developing such a framework was to clearly establish a place for system dynamics.

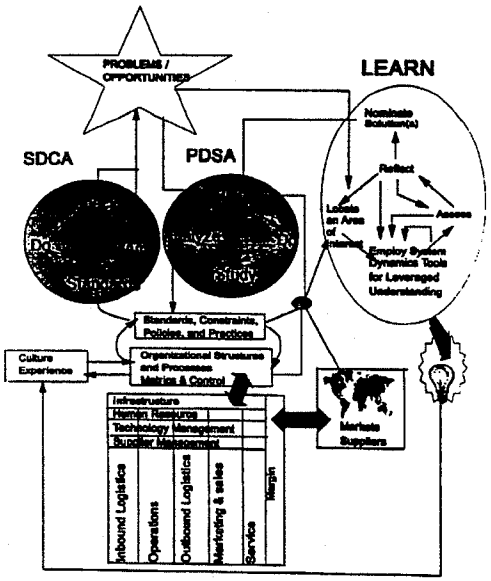


**Figure 4: A Management Framework**

## Conclusion

The objective in writing this paper was to offer an improved platform within TQM umbrella for supportin the strategic and system thinking as promoted within the field of system dynamics. It has been played u within the TQM community that Deming does offer a system framework. From the author's experience, th field of system dynamics offers superior and well proven tools and concepts for system thinking.

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