

Beyond Six Sigma: Systems Thinking and Six Sigma Shortcomings

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What is systems thinking?

Systems thinking is about examining the "structure" of the system in order to understand its behavior. "Structure" means the feedback loops in the system ... positive and negative (known as reinforcing and balancing). Unless we understand these feedbacks, we really don't know which policies to adopt or which actions to take to change the system's behavior in order to experience different "patterns of events" and "events."

Nothing grows (or declines) without a reinforcing feedback. Reinforcing feedbacks are two-edged swords; they go up or down with a vengeance.

Nothing grows forever. There's always a balancing feedback that will (eventually) limit growth.

Balancing feedbacks also provide systems stability. Long-lived systems have an overwhelming number balancing feedbacks that make the system stable ... and resist change. Even when we want to improve behavior, these balancing loops will "rise up" to oppose change. This is why "change" is so difficult. So we'd better understand the balancing loops or change initiatives will fail.

So systems thinking is about understanding the feedbacks in the system that are relevant to the problem being considered. This is the foundation of [Systems Thinking Leadership](#). It's vital for systems that problems that are dynamically complex, that is, systems with multiple feedbacks and long delays.

With systems thinking we expand the boundary of the system until we can identify structures that, internal to the system, create observed behaviors. The structure is a theory of the system for comparison against the data of reality. This is the scientific method applied to social systems. Note that "data" is more than numbers in a database; it includes our "mental models" that determine how we humans interact with and influence the system (soft data).

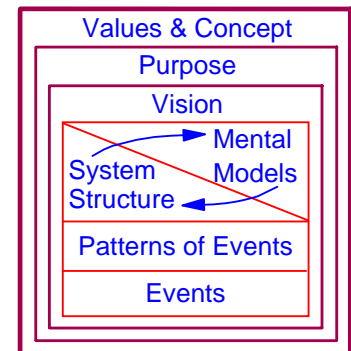
If we implement policies and actions that we believe should act on the structure to produce the desired change, and it does not, then we've either got some work to do on the theory (model) or we need to examine the validity of the data. It's just like science; it's social science. And [it's practical](#).

Organizations go through cycles of performance, faltering and even failing because we don't understand structure and how policies influence them. This makes it difficult to respond to changes, such as those accompanying growth or evolving external conditions.

Often, it's difficult to learn. We either never get the feedback that our own decisions produced the unwanted results, or the feedback is so delayed we are not able to link the causes of the results back to our own decisions. We don't realize we're suffering the consequences of our own actions. This produces great pain and loss.

A systems thinking or system dynamics approach is appropriate for problems that

- are dynamically complex ... there are feedbacks with long delays.
- are chronic ... they have existed for some time and defied corrective action.
- have well-understood reference modes of behavior ... we can draw or plot behavior over time charts.
- can be explored with those with the power to act ... to explore and share their mental models.
- are important ... because it requires an investment.
- are clearly-defined ... we don't "model the system;" we model a problem.



Both systems thinking and Six Sigma have this last in common. Jack Welch is quoted as saying that the "best [Six Sigma] projects solve customer problems."¹

Beyond Six Sigma

Is it possible to go beyond Six Sigma? Well, yes. That's because its paradigm is linear cause and effect, whereas the world operates to a large extent on circular cause and effect: feedback.

Problem Prevention

Six Sigma refers to this as "mistake proofing." Problem prevention is the essence of [Exponential Improvement](#).

This approach goes beyond preventing individual problems to preventing categories of problems. It prioritizes the categories according to which have had the most problems. We use the data to create Pareto charts. It works best when all those involved in a process track and maintain a consolidated record of what goes wrong. If only managers do it, "they learn too much from too little" ... no one can know all of what those involved in a process know.

The paper on [Exponential Improvement](#) explains that, because this is a feedback process, it produces exponential reductions in the metric being tracked and improved. This results in a straight line on a semi-log plot vs. time, where the slope of the line is the "half life." For most processes the half life is 3 to 6 months. That's powerful progress as the first half-life gives half of the improvement potential.

Addressing Special Causes

Six Sigma distinguishes "common cause" variations expected from a process in control from "special cause" variations due to process changes.

One source explains: "Special causes are often poor candidates for Six Sigma projects because of their sporadic nature. The project investment has an unsure payoff, unlike the predictable nature of common cause variation. Until the underlying root cause of variation is defined, the economic benefit of the improvement is questionable. The benefit of an improvement on a special cause depends on the underlying process condition at the root of the special cause variation.... if there is a financial burden from the special causes, it would tend to justify a proper investigation, such as a designed experiment ..., into the causes."

If this is the case, then Six Sigma is not geared to addressing an organization's most pressing problems. For these, designed experiments introduce a kind of complication that's unnecessary. There are complicated problems, but they're complicated in a different way that require systems thinking.

The Exponential Improvement process prevents "inadvertent mistakes" and "technique errors" that result from what seem to be random special causes. It addresses special causes by consolidating failures and problems into categories that can be examined to prioritize candidate root causes and actions to take to address them. This allows addressing not just individual organizational failures, but categories of failures. This makes possible the prevention of some failures that haven't even happened.

This is failure prevention, instead of crisis management. Prevention is all too rare because *we've never learned to reward people for the disasters that never happened ... that is, the disasters they prevented!* In my view, this is the major barrier to improvement. Exponential Improvement provides a way to do this.

For how groups can efficiently address process problems, causes, and actions, see [Facilitating Group Action](#).

Because of the [Primacy of the Whole](#), "we give up the assumption that there must be an individual, or individual agent, responsible. The feedback perspective suggests that *everyone shares responsibility for prob-*

¹ *six sigma DeMystified* by Paul Keller, 2005, p. 39.

lems generated by a system. That doesn't necessarily imply that everyone involved can exert equal leverage in changing the system, but it does imply that the search for scapegoats -- a particularly alluring pastime in individualistic cultures such as ours in the United States -- is a blind alley."²

"Blaming individuals instead of attributing the behavior to the system" is so prevalent that there's a name for it. Not seeing the power of systemic effects is known as the "fundamental attribution error."

We tend to look for "who screwed up," find the person, fire that person, spend a lot of time looking for the perfect replacement person for the job, and too often find that the new person screws up, too. In too many cases, the problem is that no matter who we hire, that person will be subject to process or system failures that doom that person to screw up. This is a tragedy.

Yes, people do screw up. Yes, sometimes individuals are to blame. But most often, "blaming" is a clue that systems effects are involved. Unless we look for systemic causes, we give too few people the chance to *not* screw up.

Process Improvement vs. the Quick Fix

An important emphasis in Six Sigma is to reduce non-value-added activities. One source states that³

Significant cycle time reduction is achieved through a reduction of errors requiring rework. Practices for reducing rework include standardization of procedures, mistake-proofing (using failure modes and effects analysis), and improvement of process capability. As errors requiring rework are eliminated, the non-value-added inspections and approvals currently necessary may be reduced or eliminated.

Systems thinking helps us become aware of how difficult process improvement really is. Many improvement initiatives fail (Six Sigma, TQM, lean) as a result more of our psychology than the specific technique. This is because we fall into a Process Improvement Trap: We blame people instead of realizing the system is responsible for the failures. Blaming people becomes a "self-confirming attribution": the belief that people are to blame leads them to actually become the problem.

For process improvement we have two basic choices. We can either Work Harder to improve the gap between actual and standard performance. Or we can Work Smarter by improving the process. Both of these form balancing loops that work to keep us at the performance standard.

Now everyone knows it's better to work smarter, because that lets us do more in the same amount of time at work. But we get trapped by the interaction between these two loops. When we get in a time crunch, there's more pressure to get work done. That prompts us to spend less time improving the process in order to spend more time working. So, while we know improvement is important, we feel trapped by feeling that improvements help in the long run, but if we don't survive today there will be no "long run." That's powerful incentive to put off improvement until "tomorrow." And, too often, we do.

This interaction is made even worse by the attribution that people are the problem. This arises because, with all the pressure, we tend to notice when people aren't working (taking a break) ... and when they make mistakes, which they make more of when under schedule and performance pressure. So when we see workers as the problem, it's deemed particularly important to apply more pressure ... to Crack the Whip.

More gets done, but that means less time improving process. It gets even worse when the increased pressure to get work done encourages doing whatever it takes to get production out, such as untested process changes that result in more process failures that erode process capability and decrease performance. We also resort to expediting product shipments, which disrupts normal production. Untested process changes and expediting are quick fixes, but ...

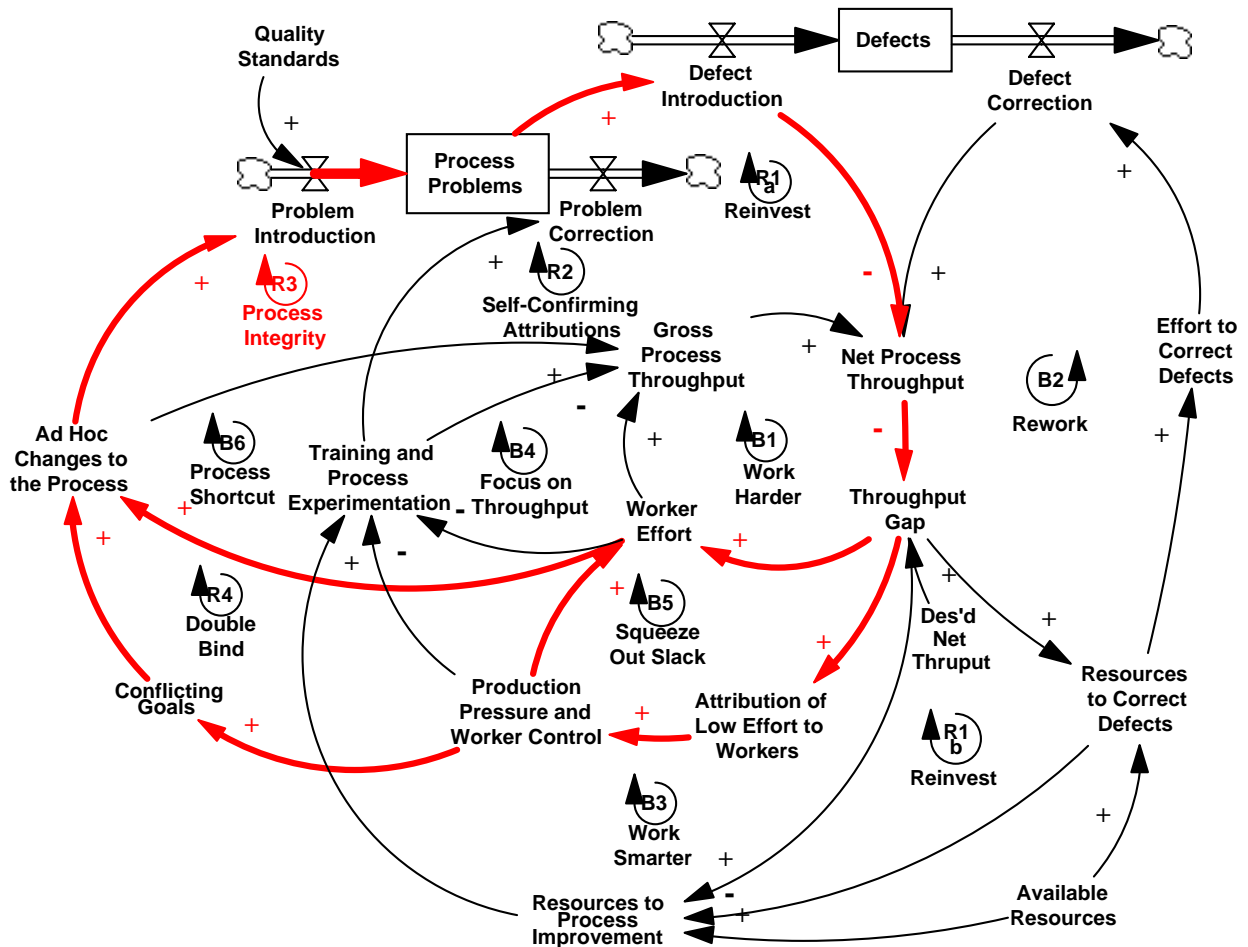
² *The Fifth Discipline* by Peter Senge, p. 78.

³ *six sigma DeMystified* by Paul Keller, 2005, p. 109.

The degradation in process capability caused by quick fixes doesn't happen immediately. The delay allows us to perceive (falsely) that they're a net benefit. We don't make the mental connection between our actions and the delayed negative impacts. These negative effects form reinforcing feedback loops that create a downward spiral of performance. See [The Process Improvement Trap](#).

"Systems thinkers" have dubbed this often-observed combination of a balancing loop and a slower-acting, but more powerful, reinforcing loop a systems thinking archetype called "Fixes That Fail." It's the core of the problem humans have with addiction ... it's the "quick fix" ... our never-ending quest to "feel better fast." There are many ways to "feel better fast," but look out for the hangover — the delayed negative consequences.

See the papers on [Addiction and The Crisis Syndrome](#) describing the generic structures that trap us in short-term, instead of long-term, thinking, how to move from the short-term quick fix to long term improvement, and specific approaches for individuals and organizations to move to a long term focus.



The diagram above illustrates in red the feedback loop I call "The Road to Hell."⁴

"If your organization is caught in the capability trap and suffers from the dynamics of self-confirming attributions, then the merits of your next improvement initiative matter little. Its chances of succeeding are

⁴ From Nelson P. Repenning and John D. Sterman, "Getting Quality the Old-Fashioned Way: Self-Confirming Attributions in the Dynamics of Process Improvement", 1997. <http://web.mit.edu/jsterman/www/>.

slim. In this situation, your organization would be better served by examining its internal dynamics."⁵

We have a choice. We can employ quick fixes, which are often prompted by a belief that individuals are the problem or we can delay gratification and improve the process instead.

Scott Peck defines delayed gratification as "the process of scheduling the pain and pleasure of life in such a way as to enhance the pleasure by meeting and experiencing the pain first and getting it over with. It is the only decent way to live." What a good idea.

Barriers to Improvement

The [Barriers to Long-term Improvement](#), are vitally important.

I reviewed these and other barriers in a session with the Colorado Springs Chapter of the American Society for Quality. The structures on which the barriers are based and the Pareto ranking of the barriers are included in the report on the session (available at the link).

The ASQ participants used proportional voting to arrive at the ranking in the table. **Firefighting / crisis issues are in red. Systems thinking issues are in purple.** Most of these issues are related to organizational dynamics and our mental models.

These barriers will block Six Sigma and any other improvement efforts.

Rank	Barrier Description
1	Lack of Management Investment in Training
2	More Reward & Recognition for Firefighting than Prevention
3	Excess Short Term Pressure from Wall Street
4	Reactive Maintenance vs. Preventive Maintenance
5	Ad hoc Changes to Processes
6	Excess Focus on Correcting Defects
7	Job Insecurity Due to Fear of Blame
8	High Organizational Complexity
9	Attribution that People Are the Problem
10	Excess Scope of Initiatives

Rolled Throughput Yield Functions vs. Rolled Throughput Cost-Yield Functions

It's often-noted "that the cost of quality tends to increase as errors in a product or service move downstream." The usual observation is that it costs \$1 to correct a problem at the design stage, \$10 in manufacturing, and \$100 after delivery to the customer. A similar effect can be very important within a process.

While the multiplication of the step-yields for processes with multiple steps is an improvement over simple first-pass yields, cost is what should really be considered. The total cost is the sum of the number of parts at each step times the cost at each step.

As parts fall out through a process, the cost at later stages is applied to fewer and fewer parts. The idea then is, if there are to be perhaps unavoidable losses,⁶ to recognize earlier in the process the parts that will be rejected in later in the process. This becomes more important when later process steps are more costly.

When parts that will eventually be rejected are rejected earlier, process cost can be considerably reduced even though the process rolled throughput yield remains the same. I made major cost reductions in a thermal print wafer process by doing this, in addition to reducing fallout in the early process steps.

⁵ After Repenning & Sterman, "Nobody Ever Gets Credit for Fixing Problems that Never Happened: Creating and Sustaining Process Improvement," 2000, <http://web.mit.edu>

⁶ Obviously, it's better to eliminate the cause of the rejects.

Flow Down Functions vs. Factor Thinking: A Learning Disability and a Weakness of Six Sigma

What are described as flow-down functions define metrics in terms of other variables as in

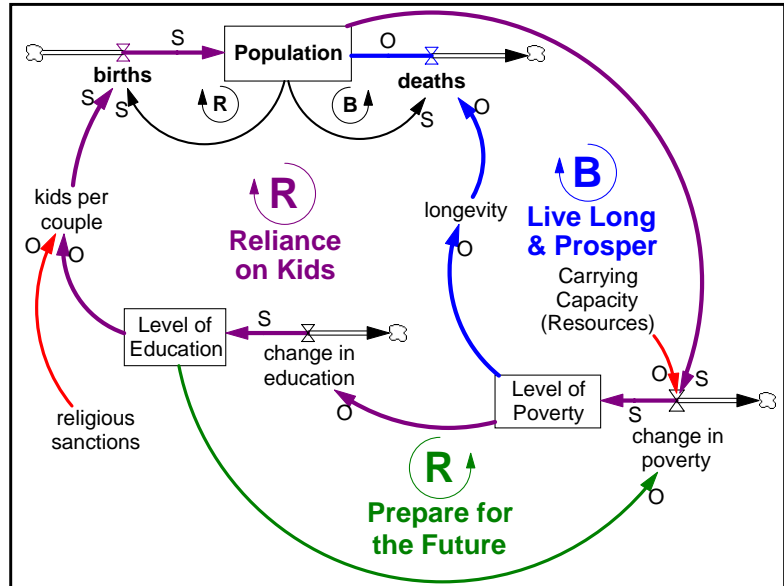
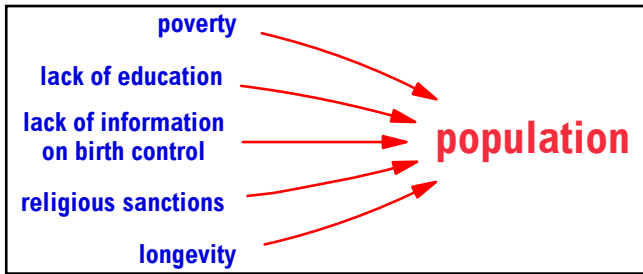
$$Y = f \{y_1, y_2, \dots, y_n\}.$$

Often best fit curves are created to show how Y depends on what are considered to be the independent y_n variables.

One source notes that such functions "are defined at each level of the organization: the business level, the operations level, and the process level."

Unfortunately, at the business and operations levels the world is more complicated than this because the causality is not one way. Instead of being independent, variable dependencies form feedback loops. This can be considered as one of the [Fundamental Sources of Conflict](#): the tendency to use "factor thinking" in situations where we need "operational thinking." See the difference in the two diagrams.

Operational thinking is a necessary [skill for learning](#) in dynamically complex situations such as customer satisfaction and service quality.



Benchmarking

Benchmarking is "a means to evaluate the best in class for particular industries, processes, or even process types" according to one source.⁷ But excessive reliance on benchmarking can be a problem.

The danger is that it can feed an addictive process called "The Process of the External Referent." For addictive persons this means developing a concept of self through external referents; that is, through what "other people think" of us. We learn to "give up our awareness of the messages inside ourselves that tell us what we feel and think."⁸

The parallel for organizations is: "None of the competition is doing this, so why should we?" "When all firms suffer similar quality erosion none serve as a role model to demonstrate the potential leverage of increased adjuster capacity. Entire industries can thus experience eroding quality standards ..."⁹ Entire industries can be screwed up.

I personally experienced this as manager of ASIC Product Engineering. Our group realized that we could improve design speed by approximately 11% by taking into account "input delays" in addition to "output de-

⁷ *six sigma DeMystified* by Paul Keller, 2005, p. 141.

⁸ *The Addictive Organization* by Schaeff & Fassel, 1988 describes syndromes, characteristics and processes of addiction. See the short papers on [Addiction and The Crisis Syndrome](#) on my website.

⁹ Senge, P. M. and Sterman, J. D., "Systems Thinking and Organizational Learning: Acting Locally and Thinking Globally in the Organization of the Future." In Morecroft, J. D. W., & Sterman, J. D., (eds.) *Modeling for Learning Organizations*. Portland, OR: Productivity Press, Inc., 1994. See [Service Quality Erosion](#): based on work at MIT, describes the structure that can drive entire industries into a vicious cycle of declining service quality.

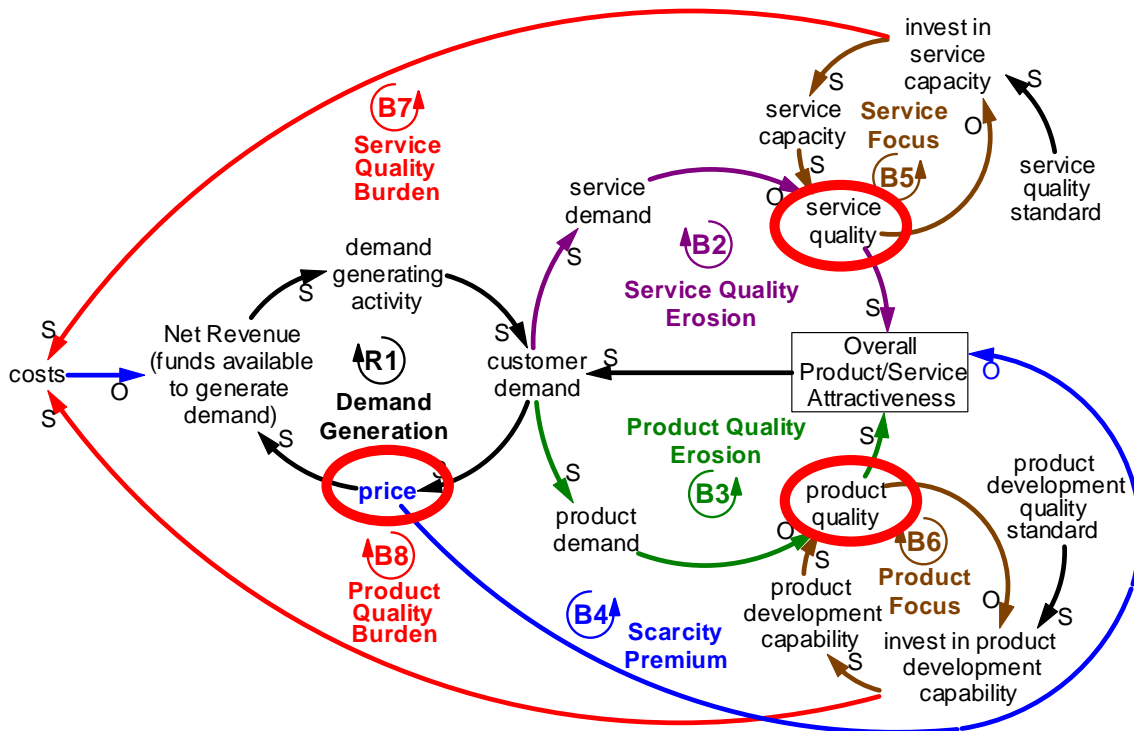
lays." The design manager opposed this because "No one else is doing this for 1.2 micron designs." So it didn't happen. Years later I learned that the organization was "dusting off" my group's work on this to increase performance to meet the competition. Had this been done years earlier, the organization could have led the competition instead of lagging it.

Six Sigma Metrics and "The Attractiveness Principle"

"Six Sigma metrics focus on one or more of the three critical factors: cost, quality, and schedule." or critical to cost (CTC), critical to quality (CTQ) and critical to schedule (CTS).¹⁰ The problem with this is that these three factors are usually highly interrelated when dealing with problems that are dynamically complex. Dynamically complex problems are actually better described as "messes," that is, problems so interrelated that we cannot do just one thing. It's like pushing on a balloon; when we push on one spot, it bulges elsewhere.

A prime example of this is "The Attractiveness Principle." The structure is shown below with three key variables circled in red: price, service quality, and product quality.

No business can be best at all three. This is why the business literature stresses that it's important that each business must have a unique "value proposition." If a business attempts to be more attractive on all dimensions, it will be overwhelmed on at least one of the dimensions.¹¹ There are trade-offs. The interdependence of CTC, CTQ and CTS must particularly be recognized at the business level.



On the other hand, at the operations and process level there are often what's known as "trade-ons." For ASICs, for example, we found that the three could all be improved using [Exponential Improvement](#). See this paper on how we improved all three at the operations and process levels.

¹⁰ *six sigma DeMystified* by Paul Keller, 2005, p. 85.

¹¹ Note: attractive doesn't mean "prettier"; it means the net composite of features that attract.