TPS versus Lean and the Law of Unintended Consequences

Every couple of years I am fortunate enough to visit a former colleague at plant of Toyota Motor Corporation's and to tour their facility. This year I was able to visit an engine plant in West Virginia for an eventful day of observation. The premise for the visit was to say goodbye to a former colleague, for whom I briefly worked for Toyota in Japan during the late 1980's and early 1990's. After four years of advising and directing all production operations in the 1,000 employee producer of over a half million small engines and transmissions annually, he was returning home to Nagoya.

During and after the visit I could not help but reflect upon what I observed at this particular Toyota facility versus what I experience on typical visits to other plants in North American attempting a lean transformation. The West Virginia plant has won the Harbor award for most efficient engine operations in the United States and nearly meets or exceeds the performance of its sister plants in Japan. It has no late deliveries and has less than one day of inventory between it and the customer. Scrap is minimal and customer defects were in the 50 ppm range. Real productivity was up 10% over the last year and more improvements were in the works. The plant is technically a cost center but it contributes to the healthy bottom line of the company with its overall efficiency. With this performance level, anyone who visits this stellar facility should come away duly impressed. But many people walk away from trips to places like this one and similar Toyota facilities with a mix of awe and utter confusion. The awe is self-explanatory. The confusion comes from the fact that the facility looks nothing really like the stereotypical image of lean that is often fostered in the U.S. by various well intending parties.

For starters, the plant staff includes no dedicated change agents or black belts; there were no value stream maps posted anywhere, nor were there value stream managers; no small U-shaped work cells; only a small portion of the plant contained actual standardized work charts; and many of the daily tracking systems were highly computerized. On top of all this, there were several automatic guided vehicles, and many robots that had been installed to replace human operators. A typical reaction is, "Isn't this the antithesis of what we've been told to think is Lean manufacturing? Surely if they have added robots and automated tracking systems but don't have a value stream map for every manufacturing line or a standardized work chart on every single machine then this Toyota plant is not Lean. Has Toyota fallen off its lofty pedestal?"

The answer, to put it bluntly, is "No". Real TPS is not just about "flow" or "pull production" or "cellular manufacturing" or any of the other catchy phrases or tools you may frequently hear. For over fifty years TPS in Toyota has been primarily concerned with making a profit, and satisfying the customer with the highest possible quality at the lowest cost in the shortest lead-time, while developing the talents and skills of its workforce through rigorous improvement routines and problem solving disciplines. In every piece of TPS literature from Toyota, this stated aim is mixed in with the twin production principles of Just in Time (make and deliver the right part, in the right amount, at the right time), and Jidoka (build in quality at the process), as well as the notion of continuous improvement by standardization and elimination of

waste in all operations to improve quality, cost, productivity, lead-time, safety, morale and other metrics as needed. This clear objective has not substantially changed since the first internal TPS training manual was drafted over thirty years ago.

Despite this consistent message on the part of Toyota, the lines have become crossed in many Lean plants. In the U.S., becoming Lean appears to have gone down a path of *implementing tools* such as "one piece flow", "value stream mapping", "standardized work", or "kaizen events", but results have not always followed. Toyota, by way of contrast, has stayed focused on its *principles* and a disciplined emphasis on *process improvement to obtain results* such as "making a profit", "reducing lead-time", "improving productivity", "achieving built in quality", as well as "respecting human dignity of employees" etc. The difference may sound trivial, but it is actually significant. In fact, it is likely the main reason why Toyota has continued to see success on so many dimensions, where others struggle. This mishap has not occurred intentionally. As the title of this article indicates, it is something like the 'law of unintended consequences' at work. If we are to *be like Toyota* in terms of results, and *not just look and sound like Toyota in word*, then several things need to change in Lean implementation.

There are several important aspects upon which we should reflect. To a large extent, the points outlined below contribute the reasons many have struggled so mightily in their efforts to become Lean, but have failed to actually become like Toyota

(Price – Cost) x Volume = Profit

Rarely does anyone at a Lean conference or in a Lean article discuss in any detail the notion of profits and improvement. It is almost as if profit is not a proper topic for public discussion, and should be left for accountants to contemplate behind the scenes. Instead people, articles, and books opining that lean is all about flow, value, and customer satisfaction are the norm. Maybe Lean is about these things, but TPS is not that simple.

Among the first slides I was shown at Toyota during my employee orientation was the simple equation: Profit = (Price – Cost) x Volume. In the highly mature, competitive automotive industry, Toyota believes they cannot dictate price, and the market decides how many units will sell in the long run. Hence, the only lever they have to control is cost, so all effort is made to manufacture in such a way as to reduce cost; otherwise the company will go out of business and not earn the right to grow and provide higher wages etc. to employees. The basic, critical assumption behind every aspect of TPS is to continuously reduce cost. Inventory, scrap and rework, extra people and resources, downtime, etc… all cost money - and all of these must be eliminated or minimized. In other words, waste elimination has a specific *purpose,* and it not just seven neat categories to be quoted during work or training.

This point was continually drilled into my head at work until it became second nature. Toyota is a very cost conscious company that is very good at designing, producing, and delivering quality products that meet the needs of its customers. While other individuals have commented on the need in Lean to have "problem awareness" or "kaizen consciousness", the

phrase I remember most from my superiors at Toyota was to have "cost consciousness" and to never waste a dime. Time and time again, the Japanese proverb "you must wring water out of a stone if necessary" was repeated in budget meetings and project review sessions. Unfortunately, these internal processes that make up the culture of the company, are invisible from the outside. External consultants and academics cannot see this, and do not write about it as a result.

Regardless of your job in Toyota, though, the cost structure is tightly controlled and subject to harsh review and continual improvement pressure. This point was very clear to me during my visit to West Virginia where my colleague explained all the benchmarks between this plant and a similar engine plant we launched years ago, and in comparison how fewer support resources were available to him now. Despite the vastly reduced support levels, he had produced a superior facility. Somehow this same results emphasis and cost focus needs to be put into all Lean efforts if American companies are to succeed in the long run. Anyone who tries to tell you that TPS is all about "flow" and not about making a profit is sadly mistaken.

TPS Tools Are Just Ways to See Problems – They Are Not Solutions

A disturbing trend in many Lean Manufacturing efforts I observe pertains to the instruction given to plants by the head of the company's lean program or change agents. The nature of the advice tends to be along the lines of draw value stream maps, establish supermarkets, create one piece flow, post standardized work charts on every machine, create U-shaped work cells, implement kanban, and walk the plant floor to conduct lean audits every day. These are examples of Lean phrases recited almost daily and the list does not end here. While these and similar key phrases from each company's lean journey can often be heard in U.S. plants, rarely if ever will you hear then uttered in this fashion at Toyota.

The inherent problem in all of the above statements is the following: *practitioners have not been required to first determine what the exact problem is before being instructed to use the tool in question.* When people are told what to do, they are absolved from the critical responsibility of thinking for themselves and determining why they need to do it, what is the nature of the actual situation at hand, and deciding how to best proceed. TPS is not a set of rigid guidelines proscribing what to do in exact detail in every situation. In fact the T in TPS has often been said to stand for "Thinking", and not just Toyota. The system was developed over the years by trial and error focusing in on specific problems, making people challenge the conventional wisdom behind situations, identifying the root causes of issues and then solving problems in some unique, and often spectacular, manner. When the countermeasure developed worked particularly well, or proved to be a very good analytical aid, it became a standard tool in the Toyota arsenal, and was taught to other people so it could be used wherever it was applicable. If TPS is reduced to just applying tools without equally understanding the problem at hand, it will not produce as much in the way of significant results.

Examples of Tool Development in TPS

Sample problem statement	Historical root cause	Analysis tool or countermeasures developed
Poor work motion and material flow in line layouts	Insufficient detail in layout planning or line conversions	Value stream mapping and work motion analysis.
Right stamped parts not available when needed despite much inventory	Long change over time	SMED. Analyze and separate internal from external work.
Right parts not delivered to downstream when needed	No physical or accurate signal. Push style of production.	Pull system and kanban cards to signal replenishment.
High level of scrap and defects	Low process capability	Build in quality at the process. Not through inspection.
Low labor productivity in man machine combination areas	One man one machine layout and work assignment	Separate man from machine. Create standardized work. Promote a multi-skilled work force with job instruction.

The Figure above is representative of how lean practitioners should think about implementation. The goal of TPS is not to implement a tool such as standardized work or kanban. The tools are merely methods techniques for analyzing and improving situations in a systematic context. It is critical to have a specific objective in mind when setting out to make improvements in Lean. In all cases, the current condition surrounding the situation must be thoroughly grasped and the actual problem defined. Then the probable root causes must be isolated, a specific action plan developed, improvement goals set, and a validation method established. If using an existing Lean tool helps you to diagnose or accomplish this, so much the better, but goal is improvement and not mere use of the tool. Failure to follow this path in Lean implementation diverts the message from "*solve the root cause of major problem X*" to "*apply tool Y in some other area*". Lots of activity might take place but minimal results will be realized. Mr. Taiichi Ohno remarked that TPS is very much like the scientific method of experimentation. When this is not kept in mind, the result is "push" style Lean (Do as you are told), rather than "pull" Lean implementation (What is the biggest problem?) People naturally rebel at the former approach, but will embrace and take ownership of the latter. The leader or consultant who properly grasps this principle can be highly effective and will be much more likely to get results.

Don't Confuse Local Tools in TPS with Universal Solutions.

I have a further nagging uneasiness with the prominence of certain lean tools as they are typically used in the U.S. Chief among them are value stream mapping, standardized work, kaizen, etc. The problem is not with any of the tools, per se, as they can be powerful improvement devices. My concern is with *how* the tools tend to be misused. Value stream mapping, for instance, is perhaps the most widely used tool in lean programs today. The prevailing assumption in virtually every plant is that a value stream map must be drawn for each product family, a value stream manager anointed, and that it will somehow magically reveal all of the plant's problems. This practice has become a sort of litmus test for Lean. If there is no value stream map and an associated tracking center, then the company is not pursuing true Lean manufacturing. But there were no value steam maps in the Toyota facility in West Virginia, nor are there value stream managers. And this is hardly because Toyota employees are so smart they all carry the value stream maps around in their heads.

The reason there are no value stream maps in most Toyota plants is very simple in hindsight. It was a tool developed primarily as an analytical aid to look at *material and information flow problems* in certain processes. In fact, the actual name of the tool at Toyota is "material and information flow analysis" - not value stream mapping. A third dimension, human motion, is often added to the mix for consideration as well at Toyota. As TPS evolved internally and was rolled out to supplier companies externally a consistent problem was insufficient investigation into the details of material flow, information flow, and human motion in the process. A typical layout drawing, for example, simply does not emphasize these aspects clearly enough to bring problems to the surface. Once production starts, it is too late or costly to fix some of these items.

In response a creative countermeasure was developed that became a requirement for engineers and others in charge of manufacturing processes and line conversion work at suppliers. The emphasis was to draw both detailed standardized work charts depicting operator motion, and flow charts depicting material storage locations, scheduling points, and operator work sequence before the start of production. In other cases, this tool was used externally to find ways to convert lines to more efficient ones. The key point is that the tool was created to analyze and solve a specific category of problems Toyota faced in new production lines and in helping suppliers implement lean.

From this fairly specific local origin in Toyota, the tool was slightly modified (the human motion emphasis was reduced) and popularized in the U.S. by my good friend and former Toyota colleague John Shook, and his co-author Mike Rother, in their insightful, best selling workbook "*Learning to See*". The title of the work I think is important. Originally the authors had considered titling the workbook "*Material and Information Flow Analysis for Lead-Time Improvement and Work Flow Kaizen*". This name, which would have been truer to the original intent of the material, was changed for marketing reasons to "*Learning To See*". The workbook

went on to sell over 125,000 copies, and has affected the direction of lean efforts in the U.S. more than any single publication.

Unfortunately the object of *what* the workbook urges the reader to see is not as clearly communicated in the catchier title – and here is where the law of unintended consequences kicks in. The book is about learning to see what is primarily a material and information flow problem, or essentially elements of the JIT pillar of Toyota's production system (flow, takt time, level, and pull production). By design it doesn't even attempt to address the topic of Jidoka for example which Toyota considers an equally if not more important support pillar than JIT or equipment stability. The technique used in the workbook simply measures the overall manufacturing lead-time versus production value add time. Everything non-value adding (i.e. the waste) is to be eliminated and answering seven specific questions outlined in the workbook will help you accomplish some of this goal. Overall, however, when the 4M's of manufacturing (man, machine, material, and method) are considered you'll realize that this tool mainly considers the material (and information) flow component. The other 3M's are much less emphasized and one other important M – metrics - is expressed chiefly in terms of lead-time and value-add time. This is fine for Toyota. Internally they well know the limits of the tool and understood that the it was never intended as the best way to see and analyze every waste or every problem related to quality, downtime, personnel development, cross training related issues, capacity bottlenecks, or anything to do with profits, safety, metrics or morale, etc. No one tool can do all of that. For surfacing these issues other tools are much more widely and effectively used.

Unfortunately, the average user of the workbook tends to copy the pattern expressed in value stream mapping regardless of the nature of their manufacturing problems. The unintended consequence of the success of the method has been to convince many people that it is a universal tool for identifying all problems in manufacturing operations. Marketing hype helps reinforce this notion. "Just draw a value stream map and it will show you all your problems to work on" is a popular refrain that I hear quoted in companies attempting lean. This guidance however biases companies with major quality, downtime, or factor productivity problems to deemphasize them since those items are not surfaced well using the method and questions outlined in value stream mapping. The tool just does not frame these problems well by design. Couple this effect with the fact that most lean efforts already have a disproportionate bias towards the concept of "flow", and there is a recipe for inherent danger. For example instead of learning to see what is truly broken in their processes companies wind up typically focusing on a particular subset of operational problems chiefly that of flow and lead-time related issues.

There are a host of similar problematic examples I could mention with other tools, such as standardized work, U-shaped cells, kanban, etc. They are all good tools but have inherent limitations and specific applications in Toyota. Companies struggle when they take any of these tools that have a specific and local purpose in TPS and attempt to apply it as a more universal tool or solution for their respective situation. Inevitably this conveniently ignores other, often more serious, manufacturing problems and fails to deliver the desired results.

The Importance of Developing People

Another critical difference between Toyota plants and other 'Lean' plants is skills development. Despite common knowledge of its importance, this topic is typically relegated to the HR department or someone else in training and development. Implementing lean requires a specific set of skills and experiences. Most companies go to great lengths to hire or create special change agents, responsible for directing and facilitating lean program implementation. On the surface, this practice seems to make sense. There is, after all, a small, elite group of specialists in Toyota filling similar roles, although there are perhaps only 50 of them world wide in a company of over 200,000 employees, and they are very senior experts in TPS for the most part.

The area of skills development that I am most concerned with, however, is not that of the change agent specialist, but that of the natural operations work team leader. Although less prestigious than the TPS specialists, development of work team supervisors in Toyota is considered an equally, if not more important, topic merely because there are tens of thousands of these individuals. Specifically, it is these manufacturing leaders that are the main focus of training efforts in Toyota since they lead the daily work areas, and they directly and dramatically affect quality, cost, productivity, safety, and morale of the team environment. In most companies implementing Lean the reverse set of priorities is true. Emphasis is put on developing the specialist, while the supervisor skill level is expected to somehow develop over time on its own.

Focusing development efforts on the supervisor goes all the way back to Toyota's early days, when they introduced several management training programs in the company known collectively as Training Within Industry (TWI). These programs focused on the development of the production supervisor and his or her ability to instruct, improve, and lead their work team. Three specific courses known as Job Instruction, Job Relations, and Job Methods were used to provide supervisors with skills needed to develop their teams and solve problems in the work area they managed. To a very large degree, these programs are still the back bone of the supervisor development program in Toyota, and a big part of why the company is so successful.

The contents of these courses are still highly relevant to the success of Lean or TPS today. Everyone managing people at Toyota is expected to not only have knowledge and proficiency of their job, but to teach, improve, and solve work team related issues in a standard and expedient manner, as well. These skills are not trivial. There are 10 hour training courses for each of these areas, as well as in other topics in Toyota. Space limitations in this article preclude describing Toyota's entire supervisor training program, but it is important to understand the fundamental point that, while having trained specialists in staff roles, can be helpful, Lean success is more directly related to a company's ability to elevate the Lean skills of operations managers and supervisors. Within Toyota, the internal focus is on achieving results through natural work teams and not via the efforts of change agents around them.

Final Advice

If there is just one simple piece of advice that I would give those implementing Lean manufacturing today it is the following; put a stop to the dogmatic routine of using any single tool (value stream maps, kaizen events, or any other) and expecting that it will highlight or solve all the problems in the facility. The reality concerning actual TPS could not be further from the truth. While value stream mapping for example can be a great high level analysis tool that can show many problems in flow, lead-time, where inventory piles up in the factory, and what might be causing on-time delivery problems in production, these may or not be the main problems facing your operations. Certainly these are not the only problems facing a facility. Therefore, different and better ways to *see problems and to solve them* are required. In other words customers, executives and shareholders care more than just about the flow of product through the plant. They care about profits, quality, downtime, productivity, safety, and many other key metrics. These should be the concerns of everyone implementing Lean, as well.

From my own years of experience and discussions with numerous Toyota managers, I have learned the hard way that the only proper approach to implementing TPS is to reflect long and hard on Mr. Taiichi Ohno's original advice. Ask what the greatest point of need for improvement is and start from there. If it is quality then figure out where the majority of the defects are occurring, why they are occurring, fix them and prevent recurrence immediately. If the problem is low productivity, then analyze jobs for non value added versus value added time, figure out the points of the greatest amount of waste and eliminate it. If the problem is on-time delivery, then figure out what products are late, why they are late and fix the root cause. If there is too much inventory and poor flow in the plant, then by all means, draw a value stream map and get about fixing the associated points in the process! Over course TPS is a comprehensive system, and basic problem solving alone will not make the company Lean. If Lean is implemented without a rigorous problem solving focus, however, then I guarantee that you will not achieve lasting results.

If the law of unintended consequence runs true to form, then someone who reads this article may run out and throw away some or all the Lean tools in their corporate toolkit. Of course, nothing like this should happen. TPS is a complete production system, comprised of many methods and techniques, and not limited to mere problem solving tips. What I have hoped to emphasize however is the following two items. First you need to learn to use the right tool for the right problem or you will struggle. Secondly, in all implementation efforts the concepts of TPS and discipline of problem solving cannot be separated if you aim to generate any real success. Toyota did not even bother to name its production system for over 20 years after its initial pilot line experimentation or write down the tools in a handbook. Instead they focused on making real, quantitative improvements in line with the core principles and metrics, and the tools were deployed or invented along the way. Everyone should keep that order in mind during their own implementation journey.

In conclusion I would like to echo a couple of comments that senior Toyota executives in Toyota are fond of making. First, no one ever said that the business of making improvements is easy. It is strenuous, time consuming work and requires dogged persistent if you want to be any

good at it in the long run. If the situation were otherwise, then other companies would have caught up to Toyota by now. Also, executives frequently point out that the T in TPS actually should stand for "Thinking", and this too requires hard work in order to achieve any substantial process improvement. This is, in fact, the very essence of the 'Toyota Way'. In other words, do not simply put opinions on the table or throw a universal tool at your problems and then accept whatever happens. Instead, demand that problems be brought to the surface, challenge all of the conventional notions of manufacturing wisdom, and assure that root causes are promptly corrected. Anything less is just another type of waste in your factory and will not lead to improved profits, added value, or enhanced customer satisfaction.