The Thinking Production System

Working Paper n°5, Projet Lean Entreprise

Michael Ballé, ESG Consultants & Associate Researcher, Télécom Paris[1],
Dept. of Economics and Social Science
Godefroy Beauvallet, Associate Professor,
Dept. of Economics and Social Science
Art Smalley, Art of Lean, Inc.
Durward K. Sobek, II, Associate Professor, Montana State University[2]
Dept. of Mechanical and Industrial Engineering

[1] Télécom Paris, 46 rue Barrault, 75634 PARIS Cedex 13, France.
[2] Bozeman, MT 59717-3800, USA.

Toyota Motor Corporation no longer needs an introduction. The spectacular success of Toyota in the last few years, combined with the no less spectacular problems of western automakers, has propelled Toyota from an isolated curiosity within one industry to a model of world-class design, development and manufacturing. Much of its success is attributed to its now fabled Toyota Production System (TPS), dubbed *lean manufacturing* (or simply, "lean") in Womack, Jones and Roos' ground-breaking book, *The Machine that Changed the World*[3]. Since that time, TPS has been extensively studied with dozens of books and articles describing the system and its tools and techniques, and promising significant gains in efficiency, quality and on-time delivery. Numerous authors have described successful lean transformations[4]. Toyota itself has contributed significantly to the diffusion of its model, because they need their local suppliers to perform at the same high level if they want to reproduce their success outside of Japan. Indeed, lean is now being applied across broad sectors of the economy, from logistics to healthcare[5] to building construction[6] to services[7].

And yet, though many corporate players have endeavored to "go lean," few have succeeded beyond reaping the low-hanging fruits. Hajime Ohba, head of the Toyota Supplier Support Center, recently commented, "Many firms have doubled productivity in the short run, but few have been able to evolve by continuing to apply the principles of TPS."[8] Similarly, in the authors' experience, despite the increasing armies of internal and independent consultants en route to turning lean consultancy and training into an industry of its own, truly lean enterprises as defined by Womack and Jones[9] are rare.

---

[3] J. Womack, D. Jones & D. Roos (1990) *The Machine That Changed the World*, Rawson Associates.
[4] J. Womack & D. Jones (1996) *Lean Thinking*, Simon & Schuster; J. K. Liker (ed.) (1998) *Becoming Lean*, Productivity Press.
[5] S. Spear (2005) "Fixing Healthcare from the Inside, Today", *Harvard Business Review*, September.
[6] L. Koskela, G. Howell, G. Ballard & I. Tommelein (2003) "The Foundations of Lean Construction", in: R. Best & G. de Valence (eds.) *Design and Construction: Building in Value*, Butterworth-Heinemann
[7] C. Swank (2003) "The Lean Service Machine", *Harvard Business Review*, October.
[8] H. Ohba (2002) Communication to the "Making Things 21C" Conference, Nagoya, March, 7th.
[9] J. Womack & D. Jones (1994) "From Lean Production to the Lean Enterprise", *Harvard Business Review*, March-April.

In today's environment of global competition and intense cost pressures, the low rate of successful lean transformation is worth investigation. At first, explanations about the difficulties of implementing lean in western companies were about culture. But, as Toyota transplants have shown that TPS can perform equally well in the US or Europe as it does in Japan, the culturalist argument gave way to a "lack of leadership" thesis. But even that is not very satisfying as, clearly, companies in the automotive industry and elsewhere have taken lean very seriously. They've created lean-VPs, invested in lean offices staffed with lean officers, and driven their lean programs hard. Thus, the failure to realize the full promise of lean does not seem to be due to lack of initiative or effort – something else is at work.

We believe deep frames pervade TPS that fundamentally alter how the system is understood and therefore how to proceed with implementation. "Frames," or "frameworks" are the mental constructs through which we see, interpret and act on the world. Furthermore, we argue that if lean tools (such as kanban, SMED, 5S, TPM, poka-yoke, etc.) are applied without "frame control," the results will be disappointing beyond gathering the obvious low-hanging fruit. If managers and program leaders fail to understand the frameworks underlying TPS, they consequently miss the point of the tools and therefore fail to achieve the expected results. The fact is, TPS masters continually harp on issues of frame control (making sure the tools are applied in the right perspective), but few seem to pay much heed. The good news, though, is frame control can be taught, and thereby significantly improve the effectiveness of lean programs. Indeed, the implementation implications of better understanding the framing of TPS are significant, and open the way for another approach to lean implementation.

FRAMING THE TOYOTA PRODUCTION SYSTEM

Framing is a well-studied concept in social science. It can be described as implicitly selecting some aspects of perceived reality as more salient than others, thus orienting problem definition, causal interpretation, moral evaluation and eventually action

recommendation. Framing, then, explains why the same events can be interpreted very differently depending on the observer's framework. Framing can be though of as, literally, looking at as situation through a picture frame and focusing on some aspects, while completely missing others.

The lean movement has been successful in changing some frames in the industrial world. For instance, inventories are now generally accepted sources or symptoms of waste, and large batches to fulfill "economic order quantities" are increasingly unacceptable. Indeed, for many years, "productive inventory management" was the main framework for new ideas in manufacturing processes, with MRP systems, automated guided vehicles and automated warehousing, all promising the next level of productivity gains in manufacturing until Toyota changed the frame by demonstrating that the real issue was reduction of inventory, rather than the management of it. For instance, an expensive showcase Texas Instrument (now Raytheon) automated warehouse was scrapped before reaching full production when it was realized that the real issue was to reduce inventories rather than on the need to build ever-more efficient warehouses[10] In this case, reframing has led TI executives to focus on the causes of stock and ways to reduce inventories rather than on the need to build ever-more efficient warehouses. Nonetheless, regardless of successes in changing some frames locally, little more has been achieved than getting at the low-hanging fruit—sustained continuous improvement often remains far out of reach.

Most western efforts at implementing lean are about, in one way or another, *applying lean tools to every process* in the company. This would seem logical enough to most western thinkers. But Toyota's own TPS masters have a different take. As TPS veteran Teruyuki Minoura[11] explains, the "T" in TPS stands for "Thinking." To him, TPS as about creating "an environment where people have to think [which] brings with it wisdom, and this wisdom brings with it kaizen (continuous improvement)."

[10] NCMS Projet (2000) *Product Development Process, Performance Measures & Methodology*, Final Report of NCMS Project n°130120.
[11] T. Minoura (2003) Communication at the "2003 Automotive Parts System Solution Fair", Tokyo, June, 18th.

Nampachi Hayashi[12], a Toyota Executive Advisory Engineer and disciple of the legendary Taiichi Ohno, opined that the essence of TPS is developing within each employee a "kaizen consciousness." TPS master Hajime Ohba, quoted earlier, attributes the difficulties of transferring lean to a failure to apply TPS as a "system of training." In other words, TPS masters view lean transformation from a different frame: *changing the thought processes of every employee*.

Going lean, then, is less about "leaning out" every business process or applying finely tuned tools to achieve a certain lean aesthetic, and more about improving organizational performance, seeing problems, solving them the "right" way, and in doing so continually increasing the intellectual capacity and skill of all members of the organization. Why is this important? As we explain in the following pages, the "apply lean tools to every process" frame is inherently limited, but tapping and evolving the creativity of every employee, if properly cultivated and directed, has unlimited potential. We expose this fundamental difference in perspectives by exploring four deep frames that pervade the TPS: *performance mindset*, *problem awareness*, *solving problems the "right" way*, and *developing people through problem-solving*.

IMPROVING PERFORMANCE: COST AND LEAD-TIME REDUCTION

Improving performance is the first goal of TPS, not implementing tools for the tools' sake. Improving performance is explicitly framed as:

- *Customer service by reducing lead-time*: how can I please my customers by delivering to them exactly what they want, exactly when they want it, in the right quantity at the highest quality and the lowest cost?
- *Cost reduction through waste elimination*: anything other than the minimum amount of equipment, materials, parts and working time absolutely essential to production are merely surpluses that only raise cost.
- *Quality improvement through Jidoka*: building in quality at the process rather than inspecting it in later.

[12] N. Hayashi (2002) Communication to the "Making Things 21C" Conference, Nagoya, March, 7th.

Missing the deep "performance improvement" frame can lead to unhappy confusions. For instance, one of the authors, who worked several years for Toyota in Japan and was trained in the plant where Taiichi Ohno initially tested many of the TPS tools, agreed to help a U.S. based company with the implementation of TPS principles in low volume, high mix machine intensive shop where others were having no real luck. After discussion and analysis it was decided with management that improving on-time delivery, reducing inventory, and improving productivity were key goals that mattered over the next year. Furthermore, from his observations and discussions, he determined that on-time delivery problems were due to an incorrect mix of components coming from the critical pacemaker machining processes. Over the following weeks and months, the author guided the plant personnel in improving set-up times, reducing batch sizes, and reducing lost production time on specific machines through cross-training among other improvements. Under his guidance, plant employees discovered the main problems in each the key areas, devised countermeasures, and implemented them on a trial basis as necessary. A year later, the most problematic plant in the division was now shipping almost 100% on-time with one third less inventory, and labor productivity was up 15% or more. As a result of the improved shipping performance, organic growth, and other key improvement activities, sales were increased and profits as measured by return on sales were up nearly 50% from a year earlier.

The division managers and plant staff expected to receive internal accolades for their improved performance. Sadly, however, they were in for a rude awakening. An audit by the corporate lean group scored the plant among the lowest performers in the entire company. The reasons cited were that the value stream maps and tracking center did not follow the internal standard, all machines did not have standardized work charts, and the way visual control was implemented also was not the method the central function wanted, etc. Clearly, the corporate auditors had a very different frame than that of the plant and our author-consultant. Despite the tremendous improvement in performance, their "apply lean tools to every process" frame lead

them to view the plant's lean progress as not up to snuff and deserving of a dressing down - which it painfully received.

PROBLEM AWARENESS: DEVELOPING A KAIZEN CONSCIOUSNESS

The second deep frame of TPS is problem awareness or, in the words of already quoted Nampachi Hayashi: "the biggest problem is thinking you are okay." A general, and understandable, tendency is to blame circumstances when we run into difficulties. The explicit deep frame of TPS here is to take responsibility, challenge assumptions and ask "Why? Why? Why?" For example, Steven Spear and H. Kent Bowen describe[13] a harrowing session when a TPS master asked a group working on tool change reduction why they had not achieved the five-minute goal they had originally established – although they had reduced the changeover time by 50%. The group offered explanations to do with machine complexity, technical difficulties and equipment upgrade cost. The TPS sensei responded to these replies with more questions, and pushed the group members to challenge their assumptions on the smallest details. Spear and Bowen assert that the sensei was not suggesting the team had failed, but that he was trying to get them to realize that they had not fully explored all their improvement opportunities because they had not questioned their assumptions deeply enough. They thought they were okay because they had achieved the "easy" 50% reduction.

People tend to naturally try to "go around" problems, which means find a quick fix so as to continue to work, rather than try and sort out the fundamental issue. But confronting problems is strongly built into the TPS. The notion of "stopping at the first defect," finding an immediate countermeasure, and doing a root cause analysis to solve the problem completely is one example. In early Toyota training documents the supervisor who never stops the line is suspected of hiding problems, but one who stops the line twice for the same problem is also considered not very good, because he has not been able to fix the root of the concern. "No problem is a problem" is a very

[13] S. Spear & H. K. Bowen (1999) "Decoding the DNA of the Toyota Production System", *Harvard Business Review*, September-October.

strong TPS frame which is constantly conveyed by TPS masters in their attitudes: the pat on the back is quick, and the further questioning on "why didn't you think further on this" long. This is often interpreted as a personal personality bias of the *senseis*, when it is in fact a core element of the method.

For example, one of the authors recently toured a Toyota engine plant in West Virginia, a 1,000 person facility which manufactures over a half million small engines and transmissions annually. The plant was impressive on a number of aspects. The overall layout as well as the minutest detail of the plant was well thought out. The workforce was bright, multi functional, and highly engaged. Inventory, scrap, defects, downtime, and safety problems are always minimal and they indeed do seem to have less of everything – they *are* lean. The plant has won the prestigious Harbor award for four years running in North America as the most efficient engine plant in the U.S. It also matches, and in some cases exceeds, the operating metrics of its sister plants in Japan.

But the most striking thing was the attitude on the shop floor. Despite arguably being the best Toyota engine plant in the world, you would think the place was about to shut down when considering the mindset of the management. On each production line, the person in charge was explaining with precise detail the top five quality problems, the top ten downtime machines in terms of frequency and intensity, the most likely potential causes for accidents in their area, or the two top reasons for some real or perceived minor decline in worker morale. Mind you, these terrible "problems" are performance levels that most companies would love to have on their best day – 50 ppm defects or less in precision machining operations with tolerances as tight as three microns, 85-90% true operational availability on virtually every automated machining line, minimal scrap, annual productivity improvements of over 10%, no late delivery incidents to the customer, and very short internal lead-times in production. And oh yes, not to mention that the place is of course clean, very well organized, and contributes substantially to the company's bottom line.

Thirdly, TPS also conveys a deep-frame for problem-solving. As Ohno once said[14], "in a production plant operation, data are highly regarded – but I consider facts to be even more important." Facts, in TPS contexts, are events that you have yourself witnessed at the real place, with the real parts and the real people. In other words, the questions are to be put in reality, not in thought experiments on paper. This is a very strong constraint that explains a wide difference between the "go and try" typical response of the TPS masters, and the in-the-room paper analyses of many a "lean" study group. The question is therefore not to be put abstractly, but in real conditions. The way to put questions is to conduct simple experiments where the question can be answered in practice and not in theory. In TPS "getting your hands dirty" has a very literal meaning, because, ultimately, the way to "put a question" is to run a shop floor experiment, which will highlight the problem. Some of these experiments have been codified in "workshops" such as SMED, flow-and-layout and so on, and consequently, many mistake them for "tools", ways to obtain a result. In reality, these "tools" are nothing but observation practices that permit a hands-on understanding of the issues, and therefore a concrete resolution. "Solving" the problem by getting a result without having rigorously explained the situation will not get good marks from a TPS master.

Effective resolution will be derived not so much from deep, clever thinking, but from many iterations of problem-solving at the same spot. One of us had an eye opening experience early in his career as an engineering trainee at Toyota. A particular grinding process was producing between 2-3% scrap, which was ten times the current "acceptable" amount for that type of machine. After all morning studying various data at his desk, and arriving at no insights as to the cause of the problem, his supervisor ordered the trainee to go stand in front of the machine for an hour and then report back. Upon doing so the trainee felt no closer to solving the problem than he had in the morning. On a flip chart the supervisor made him draw out the grinding

[14] T. Ohno (1988) *Toyota Production System: Beyond Large-Scale Production*, Productivity Press

process in excruciating detail and then list all the potential things that could be affecting the quality of the part. After about 15 things were listed and accepted as potential causes, the trainee was told to devise a test for each of them, carry them out only one at a time, and report back his findings after each one. The tests involved grinding wheel speed changes, wheel in-feed changes, dressing wheel changes, clamping changes, cycle time changes, coolant amount, and other variables that each took a couple hours to ready and involved much begging of help from either the operator or maintenance.

The first eight experiments took two days to complete and did not resolve the problem but did importantly clarify cause and effect of certain items in the trainee's mind. The ninth experiment on the morning of the third day finally yielded a breakthrough. The machine's coolant tank was badly contaminated with bacteria of some sort and fouling the concentricity of the solution. This minor issue was enough to cause the majority of the scrap problem on the machine. The question focus then turned to first why had the coolant not been checked on a proper interval as specified and how had this machine been missed. Furthermore what had contaminated the coolant and how had this occurred needed to be further probed.

The trainee's experience serves to illustrate several key points relating to Toyota's frame about problem-solving. First, problem solving can not be done alone sitting at a desk analyzing data. The problem must be understood in its context, and the data turned into facts (i.e., given contextualized meaning). Second, wherever possible it is best to learn by doing through quick experiments to test potential causes of a problem. For experiments to be meaningful, however, requires a rigorous protocol where hypotheses are made, then results checked to confirm or refute the hypotheses. That's why the TPS mentor had the trainee report the result of each experiment—he wanted to make sure no corners were cut. In fact, Toyota has a number of lesser known tools to rigorously check results at various levels, such as standardized work procedures and problem-solving follow-up sheets at the cell level, or A3 reports at the line manager level.

Finally, Toyota's frame strongly emphasizes that the problem solving does not end with a solution to the immediate problem at hand (i.e., the quality problem in this case). The thinking process must often shift to another realm (in this case the method and interval for checking coolant contamination) to prevent recurrence prevention and produce systematic improvement.

DEVELOPING PEOPLE BEFORE MAKING PARTS

After resolving the high scrap rate problem in the grinding problem above, the trainee asked his supervisor how quickly he would have isolated the cause of the problem. The supervisor's reply: about ten minutes. He had solved a similar problem years ago and could tell the contamination by smell. When asked why he did not share this insight up front and saved the trainee several days of work, he remarked, "This way you learned one thing for sure that worked and eight other things that did not work. If I had told you the answer up front you would have learned eight things less." The trainee's focus had been in fixing a quality problem. The Toyota master's goal was to teach the Toyota way of thinking while solving an actual problem, reflecting one of the deeper, essential frames of TPS, that of developing people as the starting point for making things.

Recalling his days as an Ohno disciple, Teruyuki Minoura muses, "I don't think he was interested in my answer at all. I think he was just putting me through some kind of training to get me to learn how to think." Hajime Ohba depicts TPS as fundamentally a system of training where everyone solves problems under the guidance of a mentor. Kenji Miura, head of Toyota's Operations Management Consulting Division, on recent visit to a European plant chided the plant management, "Don't have kaizen-men and observers." This was a strong way of saying that developing a "kaizen consciousness" was the responsibility of the management, not of staff "experts."

In fact, the TPS frames every manager's job very strongly as:

- Build the performance mindset
- Establish the standard method
- Track actual performance (make problems or abnormalities visible)
- Teach a basic way for analyzing work
- Develop employees through solving problems or improvement tasks

This difference in framing is extremely significant for lean implementation because the goal post is not likely to be the same. The endgame of a traditional lean program is a plant that "looks lean," where the tools in the manual are being used and obvious wastes cannot be seen. In contrast, the goal post of the true TPS form is a shop floor where production cells perform at a very high level, but also where every production worker routinely identifies problems in their work routines and actively works on solving them; where supervisors and team leaders coach their direct reports in problem-solving, but are also aware of the most important problems plaguing their work area and are working hard at resolving problems of their own, again under the close guidance of a coach; where line stoppages and gaps between performance and goals are commonplace.

Certainly solving the problem at hand is important. But just as important, perhaps more so, is the learning and skill development that takes place. In this sense, problem resolution is the test or confirmation of the learning. Thus, TPS mentors ask tough questions that force the trainee to a higher level:

- Why did you chose to work on this problem when there where more important problems elsewhere?
- What is the specific goal of your activity?
- How do you know this is the root cause of the problem?
- By what method did you conduct your analysis?
- Why did you choose this particular solution?

- Did you test any other possible solutions?
- What effect has this solution had so far versus the previous method?
- How were operators involved in the process?
- Are you certain there are no other factors you should consider?
- What remains to be addressed to achieve your goal?
- How will you train everyone to the new method?

In TPS a problem or any deviation from a standard requires immediate attention. For a supervisor or manager, however, it is not only a matter of solving the problem; it is a matter of training and development as well. A true measure of a manager is said to be when he hands over duties to a subordinate. If performance stays on track after the hand off, the manager has done his job correctly. If performance falls, the manager is viewed by everyone as having done a poor job in terms of employee development.

THE ROLE OF THE TOOLS

All of this talk of frames is not to say that the principles and tools of TPS are unimportant. They have a key role to play in frame-control. Lean principles function to orient the thinker in the right direction, such as the Just-in-time principle to reduce or eliminate the stagnation of material and information, or the Jidoka principle to build quality into the product by "stopping at the first defect." The lean principles tell us which performance metrics are important (performance mindset frame control), help us see problems that beforehand might have been overlooked (problem awareness frame control), provide direction in the kinds countermeasures implemented so that we move the operation forward along the right vectors (problem-solving frame control), and indicate what concepts must be mastered and internalized as part of one's skill development (developing people frame control). Thus lean principles are important, but do not supplant the primary frame. Rather, they guide organizational behaviors and priorities in ways that deepen the basic frame.

The lean tools take on a whole new dimension from this new perspective. They become much more than just mechanisms to implement the lean ideals, as important as that is. They also become vehicles by which the deep frames are instilled. For instance, from the typical frame, 5S is often seen as a straightforward housekeeping tool or practice ("everything has a place and everything in its place," etc.). However, with the new frame in mind, what was a tool or practice for cleaner working environments becomes a way to develop an operator's knowledge and responsibility about their work cell. 5S becomes an ongoing practice to help people think about how their workstation is laid out and arranged, and for them to act on all the small things that can make it better, safer, more ergonomic, and easier to work in. Companies that do not share this frame will hire external consultants or appoint a "5S manager" to make sure that the shop floor is clean all the time, not recognizing that the teams must take ownership for their cells, by applying the tool themselves! Management in these companies understands the part about cleaner environments, but they completely miss the "developing people" frame. Not surprisingly, like a fad diet without change in the fundamental behavior of the person, these "5S" drives fail time and time again. The tool is important, but must be applied with the proper frame in mind.

Value stream mapping is another useful tool for companies on the road to lean. From the typical frame, the VSM helps the plant (or value stream) manager envision what the overall material and information flow in the lean system should look like, identify the true value-adding activities, and determine the potential for production lead-time improvement. However, from the new frame, VSM highlights specific kinds of problems (i.e., those related to stagnation of material and information flow), and where to focus their people's problem-solving efforts to have the biggest impact on performance measures of significance to overall plant performance. From the traditional frame, VSM is useful; from the TPS frame, it is powerful.

A third example is Toyota's approach to inventory management and production control. Stocks are placed back at "the right place", which means their point of origin or producing process. Nothing can be moved forward until there is a confirmed signal

from downstream that it is time to move and the following process is ready to pull. Each latter step in the operation is viewed as the customer. Eventually the finished goods storage location or final point in the system becomes a distribution center, with containers already organized into outgoing trucks. Containers that won't be shipped because customers change their mind at the last minute go into a specially managed "pool" area. Finished goods which cannot be attributed to a specific customer shipment will remain at their place of production in a "shop stock." Materials on hand to produce at any process will be no more than what is needed for the up coming production hour or so, and all purchased materials are kept in a central market, which delivers via frequent deliver across the factory on a regular basis (thirty minutes for example). Purchased parts are picked up daily from suppliers, so the parts and materials which are not ready to be consumed in the coming day remain at their point of origin at the supplier and so on. What is the point of keeping different stocks separate? For leaner flow and minimizing overproduction, yes, but more importantly so that problems of delivery and production mismatch can be identified immediately and readily isolated from other problems for more effective and speedy resolution. During a plant tour with Alain Prioul, Faurecia's Production System Vice-President, who was trained by Nampachi Hayashi, two of the authors were able to witness vividly the difference in frames. As plant management was showing the various stock types they kept, Prioul asked: "what happens when you have to take a container from the safety stock?" Management's reply was that the safety stock was there to cover for irregularities in the production flow and that it allowed them to know where to take the missing product from. Prioul corrected them, pointing out that the main purpose of the separate stock was to trigger immediate and in-depth analysis whenever the flow was disrupted, and not simply to smooth out irregularities - a task any finished goods inventory could easily perform.

Frame control via using the tools with the right frame is a learned skill. In practice it means applying a set of rigorous questions to make sure that we are in the right TPS frame when attempting a shop floor action:

- Is the issue fundamental in terms of service, quality or cost?
- How do we frame the problem in terms of a TPS principle?
- How will we get to a root cause and prevent recurrence?
- Who do we want to develop?
- Which tools will help clarify the situation and jump start problem solving?
- How do we rigorously measure performance to verify progress?

Certainly, workshops (or "kaizen events") such as flow-and-layout manpower, Single Minute Exchange of Die for lowering tool change-over time, or Quick Response Quality Control are invaluable tools to kick-start the thinking process in any plant. But to gain sustained improvement over time, these efforts must be conducted with the right frame – to uncover problems, challenge assumptions, resolve problems, and ultimately help shop floor staff learn how to best use their existing equipment to produce better parts, when and as their clients want them.

MANAGEMENT IMPLICATIONS

The framing debate has considerable managerial implications, both at the levels of day-to-day management and for the deployment of "lean" programs. Firstly, frame control becomes essential, that is, the ability to keep the frame of reference focused on the right things: performance improvement, problem awareness, solving problems the right way, and developing people. This, in itself, is a major challenge for any manager, whose days are typically consumed by fighting one fire after another. Making sure that managers and supervisors surface problems rather than go around them, and then treat them as development opportunities for employees requires a deep commitment to continuous improvement, and rigor in day-to-day applications. Truly,

many TPS tools properly applied will help, as their main purpose is to make problems appear at the right place, and the right time.

Moreover, "frame control" also applies to the way programs for lean transformation are conceived and deployed, on four main points:

1. Track implementation progress using customer focused metrics that gauge performance improvement, not simply tool deployment or tool evaluation.
2. Find out what is really limiting performance, and where specifically. Focus on the vital few first and not the trivial many.
3. Identify problems one-at-a-time, as they arise in the areas limiting performance, and address them with the "right"' methods and principles.
4. Since each new problem is an opportunity to develop someone as well as improving performance, ask people to solve problems rather than apply specific solutions.
5. Establish a system of training in which every manager has a coach, works on problem solving and coaches his own people in turn[15]; similarly, every front line employee works on problem solving with the guidance of a coach.

How can we possibly touch *every* employee? From a corporate staff perspective, this is an impossible task. However, in Toyota, implementing TPS is not just a staff issue but a line role, starting with the plant manager. Indeed, within Toyota establishing work standards and fostering kaizen is a key supervisory role; and supervisors, not engineers, are accountable for both work instructions and line performance in terms of productivity and quality. Consequently, deploying TPS through a firm is not about how many areas have been "kaizened" but how many plant managers, and then supervisors and team leaders, have been trained by a sensei and can start training people on their own.

[15] S. Spear (2004) "Learning to Lead at Toyota", *Harvard Business Review*, May.

Isao Kato is a now retired manager from Toyota's training and development department in Japan. Internally for many years he was famous as Toyota's internal master of standardized work, among other topics. Toyota did not attempt to train every employee in the company in standardized work, as there are over 200,000 employees in the company. Instead, for each plant around the world, Mr. Kato would develop ten or so standardized work trainers who were acknowledged as good supervisors and competent instructors. The ten people selected attended a two week special course on how to teach standardized work. Upon successful completion of the course, they would return to their home plant and teach the ten hours (five days by two hours) course under the supervision of Mr. Kato. Once certified as competent instructors, they were responsible to teach all their fellow supervisors standardized work as the need arose in the future. Mr. Kato worked with production managers to make sure they followed up on the courses and made sure the lessons were applied. Beyond this level, however, standardized work was now a plant management responsibility – not a staff or training department issue. Virtually all off the job training is handled in this cascaded fashion[16] in Toyota. This is not an easy challenge and Toyota itself is suffering from a dearth of experienced masters like Mr. Kato (and many others on different topics) as it grows faster than its capacity to develop "masters." Still, compared to traditional companies where management continues to manage by the numbers and firefight, and a few staff people are given the impossible mission to "apply lean" in all processes, engaging the creative potential off every organizational asset seems a better recipe for sustained success.

Incidentally, this does not mean that there is not place for the lean office. In fact, Toyota has a small centralized staff of TPS masters to lend expertise throughout the corporation. However, the role of the lean office changes. No longer is their charge to deploy the tools company or plant-wide. They now "coach the coaches" in lean principles and problem-solving while occasionally lending technical expertise in

[16] The origins of the cascading training model can be traced back to the "Training Within Industry" program in the US, as exported to Japan by McArthur's Occupation Authority. For further information, see: J. Huntzinger (2002) "The Roots of Lean", *Target*, 18(1); and D. Dinero (2005) *Training Within Industry: the Foundation of Lean*, Productivity Press.

applying a specific tool. Additionally, many companies are looking for sensei's to help guide their lean effort. Rather than seeking out a someone who can help design and implement U-shaped work cells or kanban supermarkets, companies should seek out sensei's that can teach them problem-solving methods and frameworks of lean.

How people frame problems has real consequences. Until this fundamental truth is acknowledged, and lean converts face up to the need of developing frame control in applying the tools and techniques developed by Toyota, lean transformation will continue to be slow, frustrating and ultimately unrewarding. If your frame is "apply lean tools and principles to every process," you will certainly gather the low hanging fruit, but the potential for your lean transformation will remain limited. On the other hand, if you frame lean transformation as "change the thought processes of every employee to develop kaizen consciousness," the potential is unbounded. In the present industrial context, the framing issue is not just of academic interest as a manner of explaining why paradigm shifts are so slow and painful. It is of critical importance for firms investing resources, time and efforts in a lean transformation and who need to radically improve their performance if they want to compete with low cost providers, who, incidentally, are also improving their own operations at an incredible pace. The TPS masters, the true lean experts and originators of lean, realize they're not in the same framework as the people they're trying to coach, but, conversely, the frame of their audience is so strong, their message is not heard! TPS is a practice, not a philosophy. Lean is not a codified body of knowledge. It's the cumulative behavior and experience of the people who practice lean. And although its practice is demanding and difficult because it does not come naturally to our organizations nor our mentalities, TPS, the Thinking Production System is also profoundly empowering. In the words of Michikazu Tanaka, a former managing director of Daihatsu Kogyo who was trained by Taiichi Ohno: "In terms of results, [TPS] involves reducing work-in-process, raising productivity and lowering costs. But the real aim is to bring out the capabilities of each individual. The ultimate aim is to draw out people's motivation."[17]

[17] S. Hino (2006) *Inside the Mind of Toyota*, Productivity Press.