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The model area in successful lean transformation and scale modeling

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Abstract

The True Lean System Program at the University of Kentucky was created in 1994 to study how the development of the Toyota Production System (TPS) contributes to Toyota's success. This increased understanding of Toyota's experience would provide useful guidance to Western companies taking on the challenges of replicating Toyota's success within their own organizations. The common struggle point shared by the companies who come to us is their inability to establish sustainable TPS-based Lean transformations throughout their organizations. Our work with these companies along with our study of Toyota's own experience in bringing TPS to its own American operations has led to a belief that a major obstacle to adopting and implementing TPS into Western organizations is a lack of understanding of the essential motivational mechanisms embodied in TPS. It was these motivational factors that originally triggered the creativity and innovation of Toyota's workforce in the context of Japanese culture. In bringing TPS to America, Fujio Cho recognized the need to pay attention to these same motivational factors with an American workforce, particularly in light of the fundamental cultural differences between Toyota's Japanese workforce and their Western counterparts. This TPS-cultural difference needs to be clearly understood to enable Western companies to successfully transform into TPS-driven organizations. TPS is based on a learning-by-doing methodology which has lent itself to a transformative process in which organizations apply the principles of TPS and kaizen in a limited model area before spreading to the entire organization. The result of this application produces a series of incremental (often small) improvements which may be explained with the help of scale modeling principles and methodology. This paper is our first attempt to show the direct applicability of scale modeling concepts/methodology to the model area approach for successful TPS transformation, including the role of standardization and problem solving in Kaizen. i.e. continuous improvement. Our new findings show promising first steps for organizations and TPS/Lean researchers facing the twin challenges of establishing sustainable TPS/Lean models and subsequently scaling them up along a pathway defined by the needs to achieve full scale TPS/Lean organizational transformations.

Keywords

Kufu, Hitozukuri, Inductive and deductive, Lean production system

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The model area in successful lean transformation and scale modeling

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Abstract

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TPS is based on a learning-by-doing methodology which has lent itself to a transformative process in which organizations apply the principles of TPS and *kaizen* in a limited model area before spreading to the entire organization. The result of this application produces a series of incremental (often small) improvements which may be explained with the help of scale modeling principles and methodology. This paper is our first attempt to show the direct applicability of scale modeling concepts/methodology to the model area approach for successful TPS transformation, including the role of standardization and problem solving in *Kaizen*. i.e. continuous improvement. Our new findings show promising first steps for organizations and TPS/Lean researchers facing the twin challenges of establishing sustainable TPS/Lean models and subsequently scaling them up along a pathway defined by the needs to achieve full scale TPS/Lean organizational transformations.

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Introduction

The University of Kentucky's Institute of Research for Technology Development (IR4TD), Lean Systems Program traces its roots to the seeds of a challenge first issued in 1994 by Fujio Cho, then president of Toyota Motor Manufacturing (TMM) in Kentucky, Toyota's first wholly owned North American automobile manufacturing operation in Georgetown, Kentucky. Cho's vision, voiced in a letter addressed to Kozo Saito stated his desire to "…begin to reciprocate for the generosity that, I feel, Japan has been shown by the state of Kentucky and the United States…" [1]. In the letter, Cho proposed a partnership between Toyota and the University of Kentucky to teach Kentucky's industries, and ultimately other business and

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community organizations, about TPS [2]. Cho identified a significant gap between the progress in technological development made possible by the Industrial Revolution and the progress in understanding the role of people in manufacturing. Cho learned TPS directly from Taiichi Ohno [3], the pioneer of TPS, and witnessed the evolution of TPS over time as countermeasures to identified problems in the pursuit of *Kaizen,* or step-wise continuous improvement through the elimination of waste. These countermeasures eventually became important tools of TPS [3] or "lean manufacturing" [4]. Cho described TPS simply as "a technology…of how to effectively utilize three basic elements for production: "Man, Machines and Material" [5]. He also recognized a crucial distinction between these elements, especially "Man" (people), with regard to their relative importance as determinants of sustained organizational success, stating that, "… the key factor that makes the difference among plants is the workers," and stressed emphatically in a lecture [5], "…to satisfy our customers, it is essential that we motivate our workforce".

This placement of people's motivation squarely at the heart of determining an organization's success led Cho to an appreciation of the value of an understanding of the culture that exists in an organization's workforce and the sources of their motivation. He tested the validity of this assessment through his leadership in sharing and aligning the underlying philosophy and values of TPS with the cultural values of a Kentucky workforce. Having experienced his own engagement with the principles of TPS within the cultural context of Toyota in Japan, Cho was keenly aware of the implications of the cultural differences between East and West as he sought to transplant the thinking, principles, and practices of TPS into the new soil of an American workforce and operational management team. The challenge of bringing TPS to Toyota Motor Manufacturing Kentucky, (TMMK), was met by Cho and his team through a collaborative learning process characterized by its active demonstration of respect for people and the pursuit of continuous improvement. This approach reflected a belief that the key lay in finding the underlying motivational common ground for people and that commonalities in their motivational needs can and should be met in the course of performing their daily jobs. This resulted in an overarching concern that failure to meet these needs would cause people to lose interest in their jobs. No organization could afford to lose respect for, and ultimately waste, the valuable ability of their people to think, reason, and learn, i.e solve problems. To this end, he identified four motivational pitfalls to be avoided [5]. People lose their motivation when:

1. they are not involved and cannot participate in decision-making,
2. they are not informed of relevant information,
3. they are not given any responsibility or authority, and
4. their work or contribution is not recognized.

Seeking to avoid these pitfalls, Cho outlined a two-part approach to help ensure that people, or "team members", remain motivated. The first part addressed respect for people directly through human resource policies clearly defining the expected behaviors and attitudes needed from both managers and front-line employees. The second part described an indirect approach of "…various motivating elements…scattered throughout our production methods and on the actual plant floor" [5], which was more critical due to the bulk of workers' time being spent on the plant floor in the performance of their jobs. He clearly recognized the threat posed by both motivational and psychological hazards to worker's well-being in the workplace resulting from meaningless or wasteful tasks that disregard their dignity as human beings. Furthermore, he recognized that motivational challenges would continue to grow more complex in the increasingly mechanized and multicultural workplaces of the modern world. Closing the manufacturing research gap on the role and motivation of people was, and still is, critical to ensuring the effective utilization of people, an organization's most important resource, and the achievement of an ultimate goal; the cultivation of mutual trust to engage not just the hands and minds of the workforce, but their hearts as well, in contributing to the success and well-being of the organization, the surrounding communities to which they belong, and society beyond [6].

Closing the manufacturing "software" research gap: a "scale modeling" approach

Fujio Cho's sense of urgency in addressing this research gap stemmed from two significant concerns. The first was evident in his discussion of the effects of the Industrial Revolution on people, stemming from the evolution of manufacturing away from craft production toward mass production [5]. Cho believed, the prevalence of the four motivational pitfalls, described above, in many modern plants was a dangerous unintended consequence of the division of labor and development of machinery that emerged during the Industrial Revolution. These technologically powerful concepts provided great boosts to productivity but also brought with them motivational risks associated with the changing relationships between people and machines. In many cases, people in mass production environments perceived their roles had shifted from being the users of machines and equipment to being used by machines. Common laments, heard then and still heard across production organizations of all types today are "…they just want to turn us into robots," or worse yet, "they're replacing us with machines." Cho foresaw the potential for mass production environments to have devastating motivational side effects on individuals, their families, and the communities to which they belonged. Current events in the United States and across most of the developed world bear witness to the validity of his concern.

The second concern focused on the source of the identified research gap and why the time had arrived to address that gap. Although the success of TPS, both in Japan and the U.S. was becoming widely recognized and documented through anecdotal evidence and professional management literature, an academically sound theoretical basis for the manufacturing "know-how" of TPS [5] was still virtually non-existent. Toyota's American operations and their partnered suppliers had established an empirical track record for manufacturing success through the application of TPS in western cultures, but Cho saw a greater need to grow and improve the scientific understanding of TPS to enable its benefits to be shared beyond the manufacturing floor. With its close proximity to TMMK, Cho believed that the University of Kentucky was uniquely positioned to undertake this worthy task.

Applied methodology

Fujio Cho encouraged the University of Kentucky to begin in the same way that Toyota had when they were first developing TPS, through the inductive process of "learning by doing" [2]. This methodology has been carried out in partnership with Toyota and a variety of American and other western organizations and their workforces. The starting point for non-Toyota organizations was recommended by Ken Kreafle, the Lean Systems program's first Toyota "Executive in Residence" [2]. He encouraged the adoption of a mindset; "What was Toyota doing before they had TPS?" [7]. Having this thinking in place, the goal became to help participants in our programs understand what a truly TPS-based operational environment and work culture looks like and how the people in it behave. Their next step was to assess their current operational environment and the existing culture of both their leadership and workforce. With this understanding, gaps between their current work processes and culture and those of a TPS-based work environment could be identified. Participants were then coached on the creation of a strategy and plan to close these gaps by engaging their leadership and workforce in identifying "prioritized problems" that were recognized as needs for change by both groups. Then, using a systematic team-based, problem solving process, they were able to develop true countermeasures to eliminate the root cause of each problem to keep them from returning [7]. Employing this approach, we and our partner organizations have learned to think and pursue the step-wise continuous improvements of *Kaizen* in response to specific operational needs, just as Ohno, Cho, and their team members at Toyota did. The results of this process have included the development of need-based versions of many of the same TPS tools and practices originally discovered at Toyota. More importantly, following this process has provided participants with opportunities to experience the power of learning through collective struggle and the shared motivational energy of working together with other team members to improve their own daily thinking and behaviors as problem solvers for whatever process challenges they are facing.

Scale modeling: bridging the gap between inductive TPS and scientific research

The "learning by doing" approach described above has resulted in a significant amount of shared learning to date between the University of Kentucky, Toyota, and the many companies we have worked with. It is important to note however that this learning has still been predominantly acquired in the same inductive manner, through numerous iterations of trial and struggle, as that attained by Toyota during its own discovery and development of TPS. A great deal of anecdotal groundwork has been lain, but the fact remains that the scientific research gap on the "software" of manufacturing pointed out by Cho [5] is still largely unaddressed. Here, we investigate the use of the concepts and methods of scale modeling to contribute to the closing of this gap.

One of the key learnings that has been acquired through our work with companies has been that a crucial element of a successful strategy is the creation of a model area. A small model area provides a safer environment to facilitate the initial introduction and establishment of TPS/Lean operational thinking and cultural behaviors, followed by the subsequent incremental growth toward full scale TPS/Lean organizational transformation. This approach is well served by a basic understanding and application of the principles of scale modeling. Of particular interest is the concept of *Kufu* [8–10], rooted in the teachings of Zen Buddhism [8], which helped shape Japanese culture and particularly craftsmanship. *Kufu* stresses struggle as the necessary step to attain breakthrough or enlightenment and helps cultivate our mind to capture the essence of things by direct observation and inductive learning; this approach largely differs from traditional western logical thinking [2, 8–9]. Japanese culture rests on two important philosophical bases: Buddhism and Confucianism, both of which came to Japan around the 6th century. The Japanese people obviously saw the unique values in these philosophies, adopted them, and most importantly, modified them into the form that could best help to shape their own culture. This entire transformation process, consisting of recognition, appreciation, adoption, modification, and implementation of the final form into their day-to-

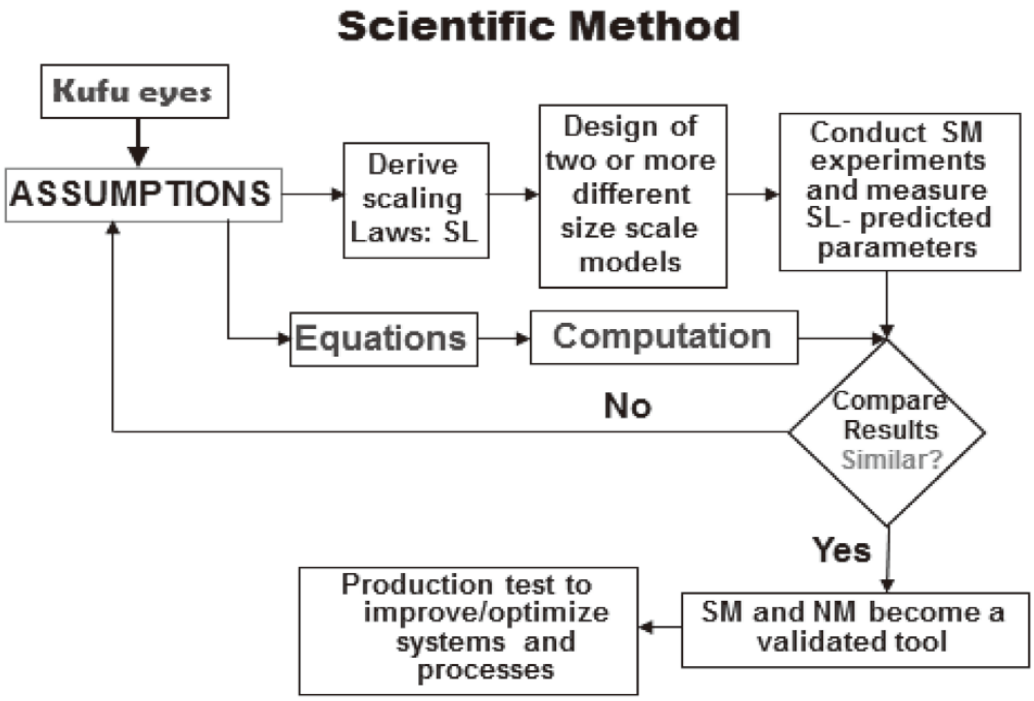

Fig. 1. The role of Kufu eyes in developing scale modeling assumptions [11].

day living, is the heart of Japanese culture. Importantly the final day-to-day living is not the end product, but rather a living experiment of learning by doing, connecting their findings and experience with recognition and appreciation for new values, bringing that back to the beginning of this cycle and going through again for improvement. This cyclical improvement process simulates the PDCA cycle in TPS.

Saito first introduced the concept of *Kufu* to scale modeling in the Preface to *Scale Modeling in Engineering* [10]. Later, Saito and Williams [11] elaborated on their description of *Kufu* to include the more specific term, *Kufu eyes*, as an essential element in developing the good assumptions that are required for all scientific methods: theory, experiments and numerical and scale modeling. The *Kufu eyes* concept also simulates the *Kaizen eyes* concept stressed by both Ohno and Cho as important attributes to possess in order to recognize waste in TPS. A central issue and challenge faced by the Lean Systems Program is helping companies enable their workers to develop their own *Kaizen eyes* as part of the ongoing process of “transplanting” the values and principles of TPS throughout organizations and their workforces in the U.S.

Beyond its importance to inductive learning, Saito and Williams [11] have also described *Kufu’s* potentially valuable contribution to scale modeling in formulating Reasonably Good Assumptions, (RGA’s), which are useful inputs to a successful first step in both scale modeling and numerical simulation. These RGA’s play a crucial role in bridging the gap between the Eastern, inductive, learning domain of Japan in which TPS was founded and the Western, analytical, learning domain of Scale Modeling and the Scientific Method as shown in Fig. 1. Reflection on the efforts of the University of Kentucky’s Lean Systems Program with our numerous industrial partners suggests that we too have benefited from our own *Kufu* – infused processes of learning. Through ongoing iterations of working with non-Toyota organizations wrestling with the challenges of transforming their own operations and culture, we have collaboratively begun to develop our own *Kufu eyes* for observing and discerning the emerging inductive lessons. These resultant learnings have contributed to potential RGA’s involving the presence of standardization and an accompanying systematic problem solving methodology as major factors in the establishment of an effectively working and sustainable TPS/Lean Model area, and buy using a scale model characterized by team member behaviors focused on culturally motivated problem solving with collective goals of continuous improvement and respect for people.

Results and discussion

A key element for any organization hoping to adapt and implement TPS/True Lean principles to transform their organizational culture is the development of a vision, strategy and master plan for the transformation. An image of a proposed overall implementation strategy is shown in Fig. 2.

A common struggle point has been shared by most organizations we have worked with. Broad-based

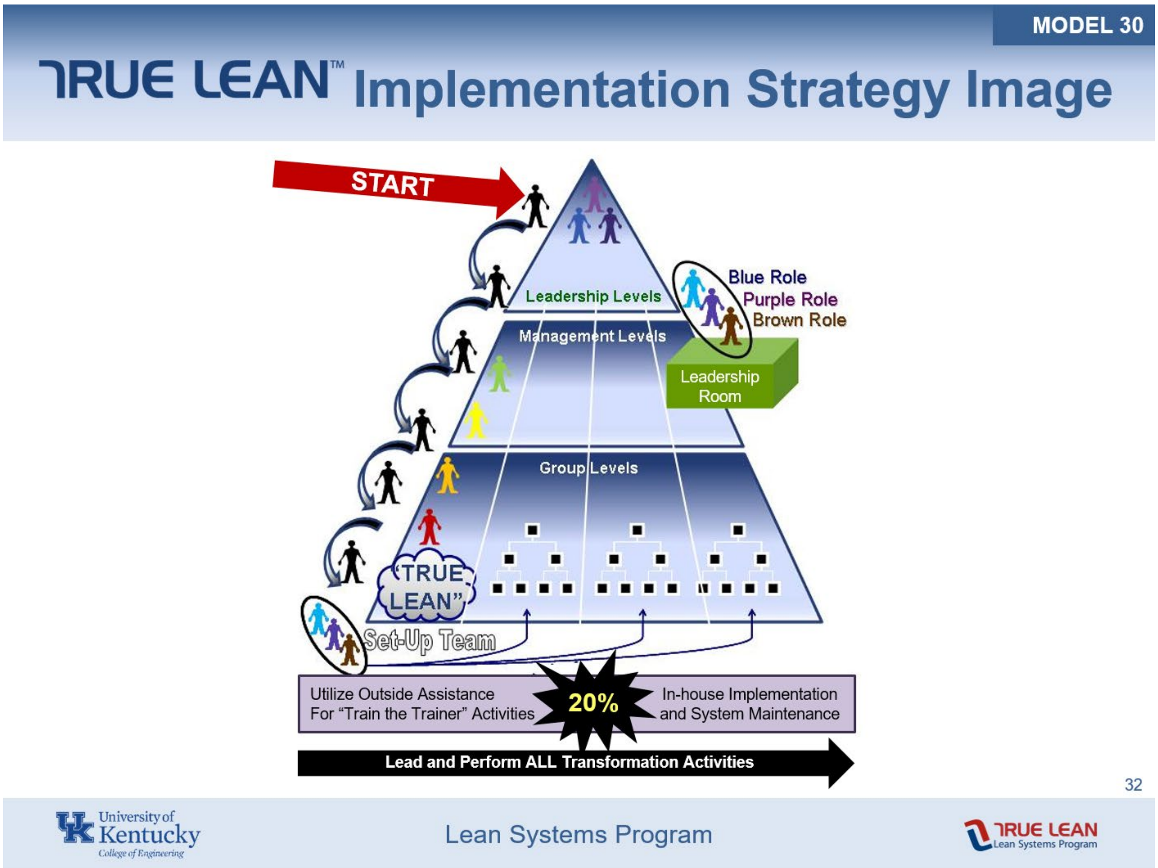

Fig. 2. True Lean Implementation Strategy [12]. © *Copyright University of Kentucky 1994-2017.*

attempts to "roll out" the training and implementation of TPS/Lean concepts and practices across the board have led to inconsistently established and isolated pockets of success [12]. Such efforts ultimately have not been sustainable, with the existing organizational culture and behaviors reverting back to "business as usual." This common "derailing mechanism" observed in TPS/Lean transformation attempts has led to an empirically-based assumption that the identification and establishment of an appropriately scaled model area in which the concepts and practices of TPS/True Lean can be initially learned, adapted, practiced and sustained is an absolutely essential component to any transformation plan.

Having assumed this need, our thinking has evolved toward identifying key major factors which must be present and working together in any model area. These factors should be sufficiently present to enable the initial establishment of a successful model area. Subsequently, they should be present at a level capable of sustaining the original model area and supporting larger model areas once the organization is ready to expand the scope of transformation toward full scale implementation. A better understanding of these sufficiency levels will emerge as the ability to quantify these factors and the interactive relationships between them are developed through future application of the Scaling Laws approach. A schematic of our current understanding of the key elements of a True Lean Model Area is shown in Fig. 3.

The inclusion of these seven identified elements in a model area is the result of both logical reflection on the purpose and needs of a model area and the inductive learning garnered from the experience of organizations with which we have worked. While their inclusion here indicates that they should be present in any model area, it would be premature to assume that they are all necessarily major factors. Some may in fact result from other elements in the list which truly are major factors or from other major factors that have yet to be identified. The criteria for identifying major factors should include their measurable impact on both the initial success of a TPS/Lean model area implementation and on the spread and sustainment of Lean behaviors and culture as the organization begins to scale up from the initial model. Fujio Cho's concerns about the changing role of people and the attendant threat to their healthy motivational needs in modern manufacturing environments suggest that the classification of an element as a major factor should be based on its contribution to the engagement and development of highly motivated people at all levels of an organization. Evidence of this contribution should be manifested in demonstrated improvement activities

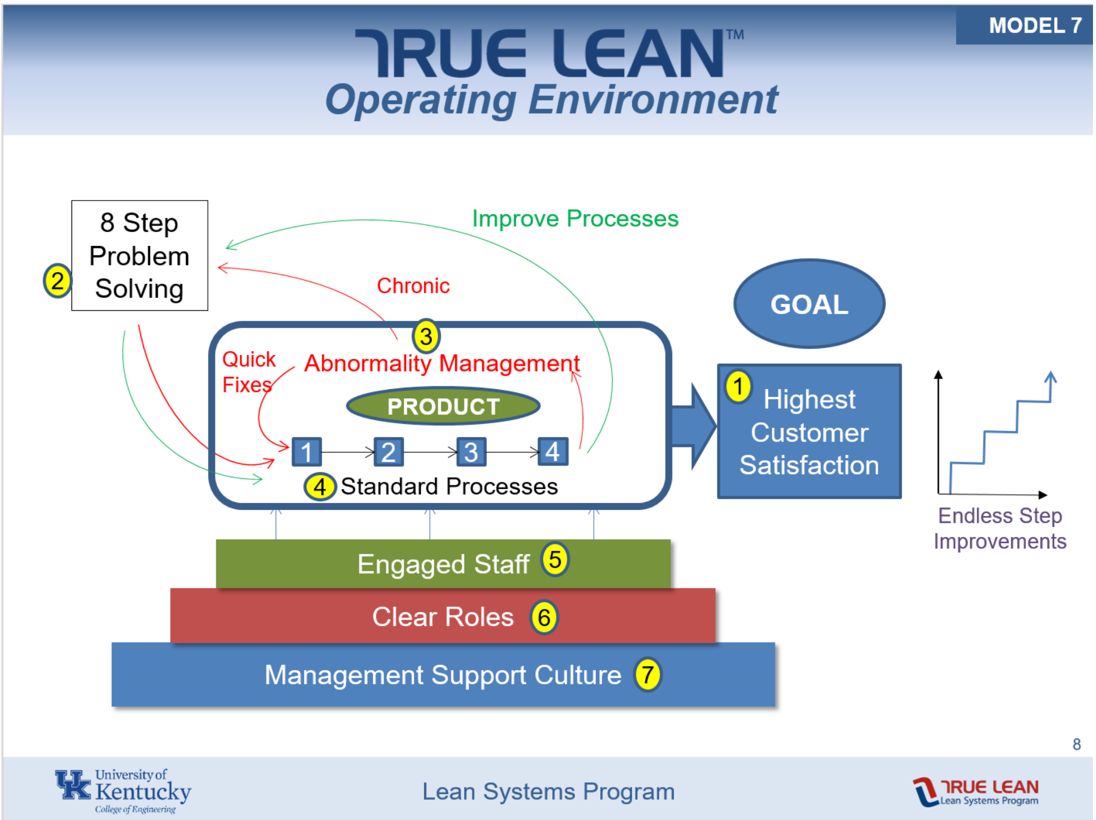

Fig. 3. True Lean Operating Environment [13]. © *Copyright University of Kentucky 1994-2017.*

by people who see themselves not just as individuals, but as members of a team working together to improve their current daily work processes and also their problem solving skills and flexibility to meet an increasing array of requirements. The level of active participation by team members at all levels of the organization in pursuit of the continuous improvement of the work that they do can be a quantitative indicator for assessing the presence of TPS/Lean culture in a workforce. Care must be taken though to discern whether the observed problem solving behaviors are truly motivated by the existence of TPS/Lean culture.

Several organizations, eager to train and establish good problem solving skills and behaviors early in their transformation strategies, have attempted to train and direct their people into problem solving activity. They have quickly discovered that their people have struggled with the first step of problem solving; identifying and clarifying the extent of a problem [14]. This struggle stems from the fact that to be addressed, a problem must first be clearly and easily recognizable. Problems in a TPS/Lean culture are defined as a departure or gap from a normal or "non-problem" condition. Normal conditions should be defined by a current standard for all work processes and conditions. Engagement of people in problem solving is therefore dependent on the presence of these standard processes as shown in Fig. 3. The foundational role of standardization was also discovered and asserted by Ohno [3] in the original development of TPS and is illustrated in the "Toyota House" shown in Fig. 4.

Experienced TPS practitioners have continued to work with and coach organizations such as these to adjust their transformation strategies by going back and focusing on stabilizing and standardizing their existing work processes, roles, and conditions. By doing this, problems once hidden in daily variations, begin to surface as abnormalities and become evident to the workforce. As problems are recognized, team members can see the need for countermeasures to address them and keep them from coming back. Organizations who have followed this adjusted strategy in their model areas have now begun to have more success with engaging their members in problem solving, pointing to standardization as a strong candidate for being a major factor to be established in a TPS/Lean model area. Ongoing quantitative research has, and continues to support the significant impact of standardization on the abilities and motivation of people to engage in problem solving. Two of these studies are summarized here.

Kufu and the formulation of reasonably good assumptions, (RGA's), with regard to major factors for a true TPS/Lean scale model

According to Suzuki [8], *Kufu* generally means 'to seek a way out of a dilemma' or 'to struggle to pass

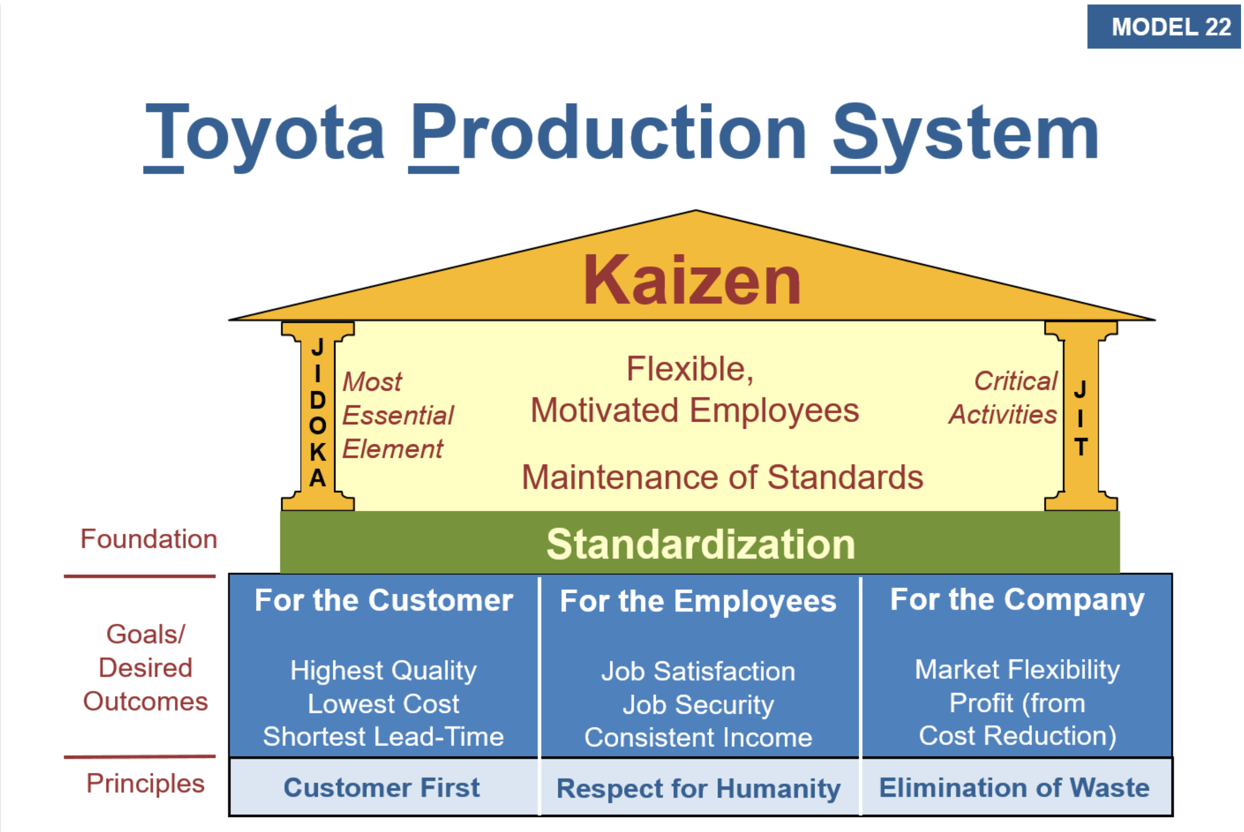

Fig. 4. Schematic of "Toyota Production System House" [14]. © *Copyright University of Kentucky 1994-2017.*

through a blind alley'. It represents a point 'where the intellect can go no further..., but an inner urge still pushes one to somehow to go beyond.' (pg. 109). The essence of this thinking can be found in Toyota's core principle of Continuous Improvement, encompassing the spirit of *Challenge, Improvement, and Genchi Genbutsu* (go and see).

The desire to bring the power of *kufu* from its eastern inductive origins to a western, scientific approach to learning raises two important research questions: 1) What provides the fundamental motivation of individuals to relentlessly seek out waste (i.e. problems) in how their work is performed, and 2) how can companies nurture and support the ability of team members to struggle with and develop new ways to eliminate waste and improve their work inside the organization?

One aspect of question 2 is to understand how learning occurs and is supported. Initial research conducted by Maginnis of the Lean Systems program [15], exploring the impact of standardization on learning, can provide some insight. Fig. 5 shows a typical learning curve which can be described as consisting of a rapid 'induced learning' stage and an 'autonomous learning' stage based on the cycle time, (CT), for data measured over hundreds of cycles. The two stages are separated by the sharp change in learning rate. Induced learning typically occurs as new situations are encountered and workers struggle to figure out how to resolve them, resulting in rapid change in cycle time over relatively few cycles of work, i.e. indicating rapid learning; this typically occurs when 'new' work is introduced. Autonomous learning primarily involves improved motor learning, i.e. repetition refines motor skills, resulting in small incremental improvement in cycle time over a large number of cycles. The dotted line represents 'Induced Autonomous Learning', describing a condition where a relatively rapid learning rate occurs even after the initial Induced Learning ends.

Maginnis devised an experimental set-up to test this hypothesis. The experiment consisted of four teams of two operators (OP A, in assembly/QC, and Op B, in disassembly and part staging) per team, where each team produced 1024 pneumatic cylinders under four run conditions called R1, R2, R3 & R4 consisting of 256 cycles each; the cycle times were measured for each cycle. All four teams started at identical set-ups and training levels, then ran under the same conditions for R1 and R2. Operators A & B rotated after the first 128 cycles of each run. Beginning with R3, the two treated teams were coached to create standardized work based on their experiences in R1 & R2 and apply Toyota's 8-Step Problem Solving (PS) method. In R3 treated team operators applied PS to eliminate obstacles preventing them from following standard work and in R4 they also

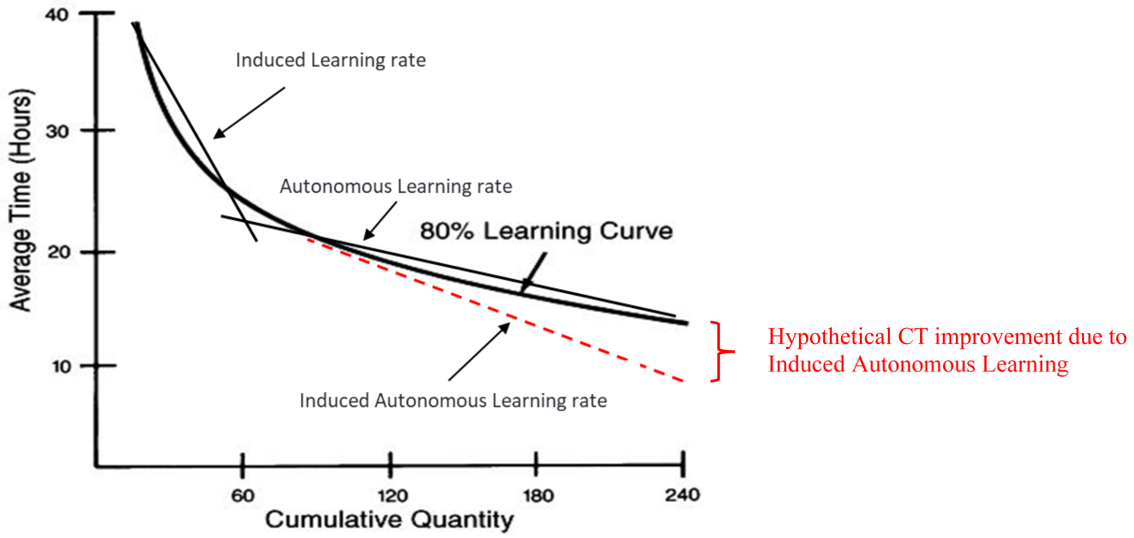

Fig. 5. Illustration of a *learning curve* showing Induced and Autonomous learning regions along with the hypothesized Induced Autonomous learning region [15].

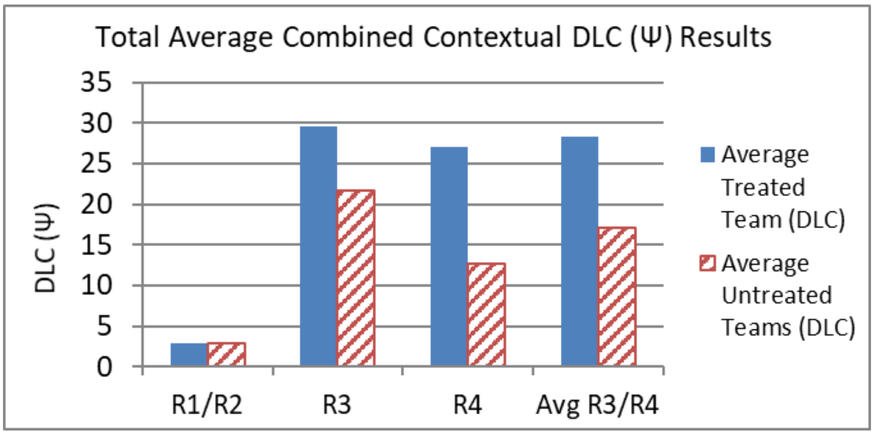

Fig. 6. The total average combined contextual DLC results for R1/R2, R3 and R4 [15].

identified and removed observed waste, also based on PS method. The two untreated teams were allowed to perform their work whichever way they thought was best but were continually encouraged to improve. The work experimentally demonstrated that team members experienced greater rates of Induced Autonomous Learning under standardized work conditions in which systematic problem solving was occurring, compared to team members working under individualistic, non-standard, work and problem solving conditions.

One measure used in the study is called the 'Demonstrated Learning Coefficient", or DLC, which measures the learning rate calculated from Learning Curves derived from recorded cycle time measurements for each team and run. A larger DLC value indicates a faster learning rate, and consequently, greater improvement. Fig. 6 shows the experimental results in terms of average DLCs for each run and shows a distinct difference in treated team learning rates compared to their untreated counterparts.

This result can also be seen by calculating the absolute learning ratio (average DLC of treated teams divided by the average DLC of untreated teams) shown in Fig. 7 below. The graph indicates team members working under standard conditions, performing systematic problem solving (8-Step PS), on the work they do exhibited twice the learning rate as their untreated counterparts. These results support the hypothetical concept of Induced Autonomous Learning illustrated in Fig. 5.

The results indicate standardization and organizational factors supporting it could preferentially support *Kufu* by increasing TMs ability to recognize abnormalities more quickly and by creating a more stable environment that allows TMs to more effectively run alternate mental and experimental scenarios as they search for improvement

Table 1. Types of training methods [20].

Training Method	Key Points
On-the-job Training (OJT)	The trainee learns by doing the job
Apprenticeship Training	Trainee becomes skilled through a combination of classroom instruction and OJT
Informal Learning	The trainee learns through informal means of performing the job daily
Job Instruction Training (JIT)	Providing the trainee step-by-step training of job tasks, key points, and reasons
Programmed Learning	Present facts, allow the trainee to respond, and provide immediate feedback
Literacy Training	Testing trainees' current skills and setup programs around desired skills
Audiovisual-based Training	Training using audio/video tapes to expose trainees to situations not easily demonstrated in lecture
Simulated Training	Training use off-the-job equipment, computer based training, electronic performance support systems or learning portals

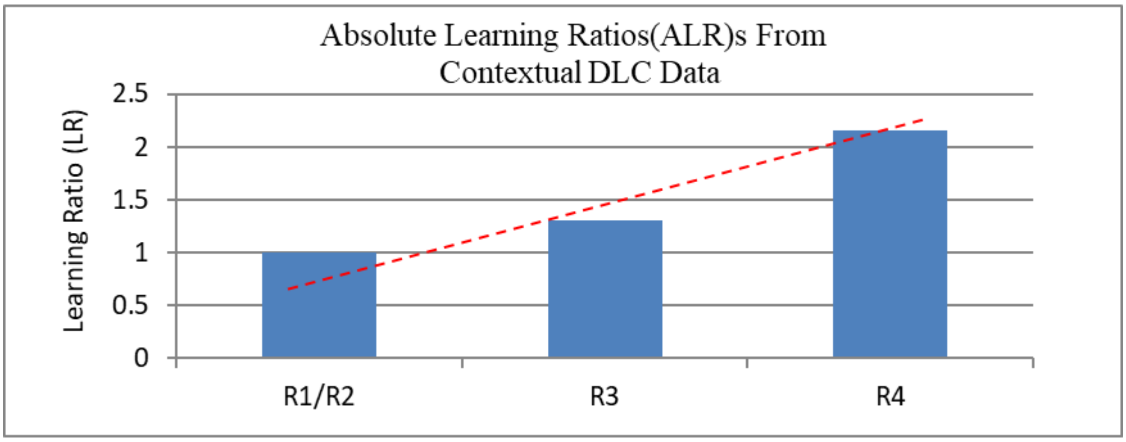

Fig. 7. Absolute learning ratios of (treated/untreated) DLC data [15].

opportunities. This is similar to the difference in trying to hit a stationary target versus a moving one.

Achieving process consistency: the impact of job training methods in equipping and motivating people to consistently follow standardized work processes

Maginnis' findings support an assumption that standardization must be in place for teams to successfully apply problem solving to eliminate waste. The experience of many organizations demonstrates however, that while the presence of some form of standardized work is necessary, it is not sufficient to ensure that people will be enabled and motivated to follow standardized work and identify problems. A need still exists to understand what factors impact the ability of teams to consistently follow their standardized work. Observation and coaching with organizations who have struggled even after having put standardized work processes in place has suggested that a lack of an effective standard training methodology negatively impacts team member's ability and motivation to follow standardized work. If so, this in turn would limit the ability of that team to make improvements through problem solving. Trained employees are a crucial input to process consistency.

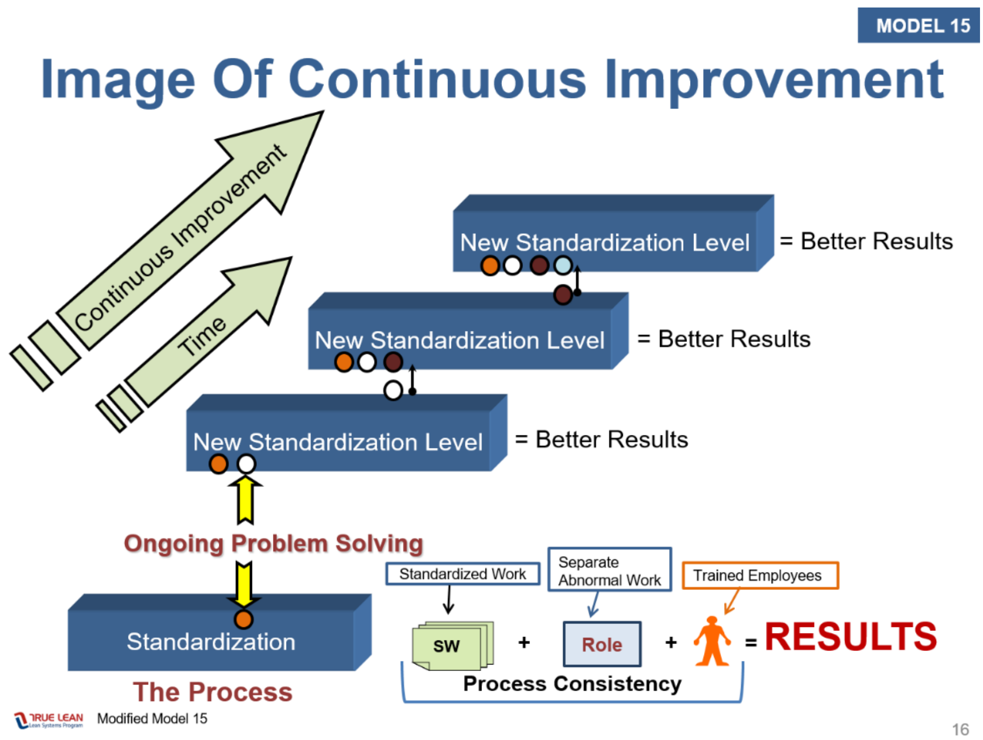

Fig. 8. Standardization and continuous improvement [16]. © *Copyright University of Kentucky 1994-2017.*

This connection between process consistency and problem solving can be seen in Fig. 8.

Ongoing research being conducted by Parsley of the Lean Systems Program examined the impact of training as an important factor when implementing standardization. Research has shown that to make successful changes to production systems the organizations must focus on training their employees beforehand for any change [17, 18]. For this study, training is defined as "an organization's planned effort to facilitate employees' learning of job related competencies" [19]. Parsley hypothesized that companies who have a standardized training process in place would have better success in creating a problem solving environment. A variety of training methods are used within various organizations and work settings to provide employees with the skills needed to carry out their work assignments. Dessler highlighted eight different types of training methodologies that are commonly used within organizations [20]; these are shown in Table 1. One of these methods, Job Instruction Training, (JIT) was first developed and used in the United States as part of a program called Training Within Industry, (TWI), that trained replacement workers in American factories during World War 2 [21]. At the conclusion of the war, this method was shared with Japanese industries to help with reconstruction efforts and was a method adapted then by Toyota to train their new workforce members. Toyota continues to use a version of JIT today, which typifies the historical context within which research played a of job training in the development of TPS. This research did not, however, attempt to focus on a specific training method.

The data set of Parsley consisted of two hundred and fifty survey results from a variety of organizations who either have or who are continuing to attempt to achieve a TPS/Lean transformation. The analysis is currently using data mining techniques, i.e. "the process of discovering useful patterns and trends in large data sets" [22], to understand if job training is a major factor in the successful implementation of standardization within those organizations. Using data mining approaches should make it easier to apply mathematical models to large data sets and uncover more in-depth relationships and patterns that exist.

Implications for future research

Ongoing research would benefit if it utilized *Kufu eyes* to study and identify RGA's. The focus should be on clarifying, and where appropriate, quantifying the relationships between standardization, job training, and other elements of TPS/Lean model areas to provide a clearer understanding of which, if any of these, are truly major factors which can serve as independent control variables in a scale modeling approach.

Both Cho and Saito have previously discussed that, in addition to *Kufu and Kufu eyes*, the closely related eastern concepts of *Monozukuri* and *Hitozukuri* played important roles in the original development of TPS and its pursuit of Kaizen [23, 24]. It seems likely that a RGA can be made that one or both of these concepts are potentially major factors in initiating and sustaining TPS/Lean transformation efforts. The relationships between all of these potential factors and their effects on the engagement and motivation of workforce team members should continue to be explored. A better understanding of the correlations between these potential factors and problem solving, motivation, engagement, *kaizen,* or other possible transformation indicators is essential to enabling the development of their basic functional relationships and useful scaling laws. These laws would represent the fundamental roadmap to more accurately predict the levels, precedence, and combinations of factors necessary for successively increasing the scope of TPS/Lean implementations from small scale model areas to full scale, sustainable, organization-wide transformations.

In the spirit of *Kufu*, our intent has been to reflect on known natural laws to guide our thinking. One potential example is the use of the first and second laws of thermodynamics as the basis of the Law approach to scale modeling with the goal of revealing organizational (systems) behavior during a TPS/Lean transformation. Assumptions and the emergent models represent a foundation for Cho's and Saito's desired bridge between the existing inductive sphere of TPS/Lean transformation and the theoretical sphere with its opportunities for applying the approaches and techniques of Scale Modeling. Much is yet to be learned, but there is promise in this approach. We hope to continue contributing to the achievement of the worthy and challenging goal of bringing the learning and predictive potential of a scale modeling approach to bear as an effective catalyst and scientific complement to the heretofore mostly inductive struggles of transforming the existing cultures of western organizations into TPS/Lean based cultures. Success will be measured in terms of truly changed organizational cultures and workplace environments characterized by the core TPS philosophy of respect for people and an everyday desire for continuous learning and improvement.

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