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Fujio Cho Legacy Lecture Notes

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Foreword

Toyota developed the Toyota Production System in the 1950s by integrating Sakichi Toyoda's Jidoka concepts from automated looms with his son Kiichiro's Just in Time (JIT) manufacturing methods. Taiichi Ohno led these efforts in the 1950s and 1960s through trial and error on the shop floor. This was all learned by doing. Fujio Cho is one of Ohno's trusted students. Since joining Toyota in the 1960s, Cho learned TPS directly from Ohno and others. He is one of the very few Toyota leaders Ohno developed himself.

In the 1980s, Mr. Cho helped bring TPS to Kentucky at TMMK. To this day, 30 years later, he is deeply revered and cherished by his former students in Kentucky that he inspired to learn, live, and share TPS. Mr. Cho eagerly supported methods to study and share TPS beyond Toyota by helping establish the Lean System Program at the University of Kentucky. He asked UK to both study TPS from an academic, external perspective through rigorous academic research and develop undergraduate curriculum and programs to integrate TPS thinking in engineering courses. University of Kentucky is one of the first industry-academic collaboration Toyota started in the U.S. He also established a Toyota non-profit subsidiary, the Toyota Production System Support Center, in 1992 to share TPS outside Toyota by helping organization build the TPS culture to strengthen employment in North America.

Mr. Cho returned to Japan after his tenure at TMMK and progressed in his career to become Toyota's global Chairman in June of 2006. As Toyota grew in the 1990s and 2000s a recurring challenge was to learn how to build the TPS culture in new and expanding operations around the world. Mr. Cho was integral in those efforts.

Through these notes Mr. Cho shares his experiences, keen insights, passion, and most importantly his wisdom from 50 years learning and applying TPS throughout Toyota and the world.

July 2020

Takashi Horinouchi

President, Toyota Production System Support Center, Inc.
Vice President Operations Management and Development Division
Toyota Motor North America

Preface

Toyota opened its first North American automotive manufacturing plant in Georgetown, Kentucky in 1986. That is the same year I joined the University of Kentucky as a faculty member of mechanical engineering. In May 1986, prior to moving to Lexington Kentucky, my newlywed wife Mary and I visited my doctoral thesis advisor, the late Professor Ichiro Emori at Seikei University, my alma mater. Professor Emori once served as a technical advisor to Toyota Motor Corporation and was a well-respected figure among Toyota executives in Japan. He introduced me to the late Toyota president, Mr. Eiji Toyoda to discuss a future research sponsorship opportunity. Mary and I took a bullet train from Tokyo to Nagoya to visit President Toyoda at his head office in Toyota-shi, about a 40-minute local train ride from Nagoya station.

We had a wonderful lunch with Mr. Toyoda, but our conversation never touched on the research sponsorship. However, he promised me a meeting with Mr. Fujio Cho when I returned to Lexington. That meeting took place on January 1, 1987 during the Japan Kentucky Association's New Year gathering in Lexington Kentucky. Mr. Cho kindly introduced himself to me and requested a follow up meeting. Based on this first personal meeting, Toyota managers/engineers and UK faculty members started visiting each other; UK faculty gained understanding of the automobile manufacturing process, while Toyota personnel gained understanding of UK's academic and research activities. Mr. Cho himself also gave three different lectures to UK mechanical engineering students. This relationship building and enhancing of mutual understanding continued until 1994, when Toyota decided to fund two different projects: production engineering and lean manufacturing to establish a win-win long term relationship between Toyota and UK to serve the Commonwealth of Kentucky and beyond.

Initially, the Lean program was housed in the UK's Center for Robotics and Manufacturing Systems (CRMS), a research center of the College of Engineering, and I coordinated automotive painting technology research in the mechanical engineering department. Following Mr. Cho's long-term vision, I also have played an ambassador's role between Toyota and UK to maintain and further develop our mutually beneficial relationship. Meanwhile, Mr. Cho returned to Japan to become president of Toyota Motor Corporation (the global Toyota headquarters in Japan) and then chairman of the board. I have kept contact with him for updating progress and Mr. Cho continues to give his support to this day.

This successful partnership was further expanded in 2007, by creating a new UK Institute of Research for Technology Development (IR4TD) with Toyota's \$1M gift and the Commonwealth of Kentucky's \$1M matching research competitive trust fund to expand our research mission to non-automobile companies. In 2010, these two Toyota-sponsored programs, which had taken two different routes, united under the newly created IR4TD. Meanwhile, it became necessary to distinguish our program from others which also were using the term Lean. We needed to make clear that our program was built upon the unique Toyota-University of Kentucky partnership designed to explore, study and teach Toyota Production System (TPS) to UK students while performing academic research on TPS. Accordingly, our program was renamed True Lean System's Program.

In 2012, Akinori Saito (Toyota) and myself jointly edited a book: Seeds of Collaboration, Seeking the Essence of the Toyota Production System to capture the true essence of TPS. The book was dedicated in honor of Mr. Fujio Cho, Master Teacher. To celebrate this book and share the wisdom of TPS, known as Goroku, the Fujio Cho Legacy lecture was initiated in 2013, and is now part of the

IR4TD/True Lean System's Certification course. This Certification offering, created in 2000, has become an example of success serving a total of more than 200 people annually reflecting Mr. Cho's emphasis on Hitozukuri, the human side of the Toyota Production System.

Overall, our True Lean System's program has served more than 30,000 people in 18 countries and throughout the United States, and our reach is expanding every year. In 2019, the Toyota-UK partnership celebrated its 25th Anniversary. Toyota, UK, and government leaders gathered to mark the success of this longstanding partnership which created the UK IR4TD/True Lean System's program.

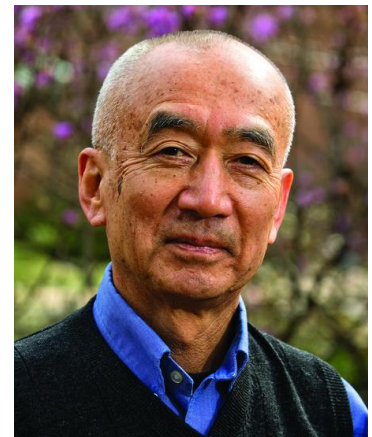
During my writing of these Cho Lecture Notes, IR4TD members reviewed the manuscript and offered their Toyota knowledge, experience, views and comments. I found them very helpful in understanding TPS, so I obtained permission from them to keep their unique views and opinion under the notes, where each individual's name who made the note is shown. Terry Horinouchi, an active Toyota North American vice President in the Operations Management and Development division agreed to write foreword and Glenn Uminger, a senior member of our True Lean program offered his epilogue with his unique Toyota knowledge and experience.

July 2020

Kozo Saito
Lexington, Kentucky



Fujio Cho



Kozo Saito

I. Introduction

The aim of the Fujio Cho Legacy lecture is to share the meaning of Goroku, which is the wisdom of TPS left by three individuals, Taiichi Ohno, Kikuo Suzumura and Fujio Cho. Each made unique and significant contributions to the development of TPS. Ohno created the basic TPS structure, Suzumura applied TPS to assembly lines and shop floors by developing specific tools and methods, and Cho theorized TPS for a general audience, according to Iwatsuki (2010), a student of Ohno. So, when a collection of these Goroku is interpreted correctly, not only the Lean Certificate attendees but also general readers who are interested in TPS may be able to see and feel these TPS pioneers' thoughts, struggles, and passion toward building the current version of TPS.

There are however, a total of more than 150 Goroku, and it is not possible to introduce all of them in a one-hour long Fujio Cho legacy lecture. The decision was made to address a few Cho Goroku, selected from among this lengthy list, and provide interpretations based on eastern philosophy (Buddhism, Daoism, and Confucianism), geography, sociology and Japanese culture. We also sought to clarify the meaning of Goroku and its significance within Japan's culture through its connection to existentialism and world religion. Any misinterpretation or misunderstanding created in this process will fall to the responsibility of one of the co-authors, Saito.

These Fujio Cho lecture notes were written as supplemental reading material to the Fujio Cho legacy lecture given to the UK's IR4TD/True Lean Certificate attendees, but they also may be read by readers who are interested in TPS and familiar with the concepts of Hitozukuri and Monozukuri, two supporting pillars of TPS, and Japanese Monozukuri culture. These lecture notes are written to create a thinking room (or a puzzle) for readers to fill with their own thinking, experience, and interpretations. In that sense, these notes are not reader friendly but intended to stimulate readers who are interested in challenging themselves to decipher the mystery of the Toyota Production System.

It is important to point out in relation to TPS that the Japanese education system in large inherits a long history of traditional Buddhist training, where a Zen master trains students with non-verbal and non-linear training. The history of this educational philosophy dates back to eleventh century Japan, where two different types of Zen Buddhism training were developed. One was by Dogen, for pure meditation (sitting silently with eyes half closed without any instruction or teaching). The other was created by Eisai for conversational Kouan (in which the Zen master asks questions, and a student is required to provide a simple satisfactory answer by skipping lengthy explanations). Dogen's Zen is called the Soto sect and Eisai's Zen is the Rinzai sect. These two methods are different in style, but share the same principles of learning, cultivating the learner's mind by external stimulus; for Dogen's Zen, it is silence, and for Eisai's Zen, it is Zen Mondo, a highly nonlinear question and answer process. When a third person hears Zen Mondo between a Zen master and a student, it may not make sense to her or him, since there seems to be no obvious connection between them, a big puzzle per se. For example, you can hear two hands clap, but what will happen if one hand claps? Until a student can answer this type of question, she/he can't get certification.

It is called non-linear training and learning because a gap is intentionally created between the teacher's question and the student's thinking. An appreciation of this non-linear training/learning tradition may help readers to better understand the underlying philosophy of TPS training, learn by doing. Taiichi Ohno is known for his unique and rigorous teaching methods in developing Toyota workers (Iwatsuki 2010). When he assigned tasks to one of his disciples, he never gave any detailed

instruction of how to do things and intentionally left him, but he always returned to follow-up and see how the disciple was progressing. His disciple must go through a tremendous degree of struggles to accomplish tasks, because Mr. Ohno believed that struggles made his disciples creative and innovative to learn the essence of TPS (Iwatsuki 2010). Since the role of struggles is important in learning TPS, we will revisit this topic in the later section.

The structure of Fujio Cho Legacy Lecture Notes consists of ten different chapters; each chapter has an independent theme, which are interconnected to achieve a large theme, the human side of the Toyota Production System, Hitozukuri. The following summarizes the title of ten chapters: Chapter I. Introduction; Chapter II. Toyota Production System and Goroku; Chapter III. TPS and Wisdom; Chapter IV. TPS and Empathetic Listening; Chapter V. TPS as Unique Product of Japanese Culture; Chapter VI. Deductive Science and Inductive TPS; Chapter VII. Top-Down Power-Driven System vs. Bottom-up Kaizen System; Chapter VIII. Cho Goroku on Service; Chapter IX. Eastern Philosophy, Mother Teresa, and TPS; Chapter X. Finally, the West and the East came to the same Principle.

II. Toyota Production System トヨタ生産方式 (TPS) and Goroku 語録 (Quotes)

Fujio Cho's Win-Win Philosophy

Grateful to the local communities for their support to return the favor, Toyota supports UK (U. of Kentucky) conducting a systematic study of TPS. This is the creation of UK's True Lean Program in 1994

Fujio Cho constantly advocates his win-win philosophy in relationship building. In this case, win for Toyota and win for UK. When former Kentucky Governor Martha Layne Collins brought Toyota to the Commonwealth of Kentucky, she offered a generous package to Toyota including a tax break, new infrastructure, and 1,300 acres of land to build Toyota's manufacturing plant. This investment was recovered within two years after the plant began operation. Toyota initially employed over 2,000 Kentuckians and brought over 100 suppliers to the Commonwealth, plus all different types of service industries were developed (Milward, 1986,1992 and 1998).

Cho believed that the best way to pay back to the Commonwealth was to help Kentucky industries and UK education with TPS. Both have had long-term positive impacts to economic development in Kentucky. Cho gave advice to Saito when UK started its lean program in 1994, "Do not seek a big splash like impressive big fireworks (shakudama in Japanese), which can only last a few seconds however impressive it might be. Instead, seek a long lasting, less impressive one (senkou hanabi)."

Note by Rich Alloo (former Toyota executive and member of UK IR4TD/True Lean Systems' Program): *Mr. Cho's win-win is reflected in his personal as well as business relationship building. In his earliest speeches upon coming to the United States he reflected on the value of understanding the differences between the thinking ways of Japanese and United States people.*

By sincerely questioning our own motivations and understanding and seeking to understand others', we find ways to build relationships across distinctly different cultures. From this, Mr. Cho's leadership at TMM was guided by what he referred to as "the major challenge of Toyota Motor Manufacturing

(TMM) - to integrate the best features of the American and the Toyota system giving us the best of both worlds" (from Georgetown College Speech, October 6, 1987)

He spoke of his interactions with Alex Warren (original VP of Administration at TMM) through which he learned a great deal about the motivations and values of Americans.

"Every day, after work, I was always asking Alex WHY? Why do you do things this way, or why do this or that customs exist? Each time, Alex would give me his thoughtful answers gained from his long experience.

One day, Alex came to me and said, with a wide grin, thank you. 'Alex, why are you thanking me?' He said, you are always asking me things about America. In answering your questions, I realized there were many things I had taken for granted and never thought about before. Because of your questions, I have learned things about my own country. That is why I said Thank You. We are both learning and growing together." (from Toyota and the Two-way Street, ACCJ Luncheon, April 21, 2000).

Note by Tony Chamblin (former Toyota group leader and member of UK IR4TD/True Lean Systems' program): *Mr. Cho was told that he must succeed, there could be no failure and they must produce cars within two years. He had to go to the previous enemy and figure out how to make this work. He believed that the only way was to capture the heart of the people.*

When Dr. Saito met Mr. Cho officially for the first time, Mr. Cho told him, "Let's do something together". After that conversation Dr. Saito and Mr. Cho spent a couple of years trying to understand each other. In fact, many at the University felt that Mr. Cho wasn't serious, but he was very serious! Mr. Cho was illustrating the habit of Hitozukuri (the development of people).

Cho Goroku on Legacy

I was fortunate to learn TPS from pioneers of TPS. In appreciation, I want to pass my learned lessons to young workers.

What is Goroku? Goroku is the collection of wisdom. Wisdom is the soundness of an action or decision with regard to the application of knowledge, experience and sound judgement.

Cho is passing on two points with his message: First, I am not the expert of TPS, I am a student of my great teachers, Taiichi Ohno and Kikuo Suzumura, who educated me to learn TPS, through a typical Japanese style apprenticeship training rather than classroom textbook teaching. The root of this apprenticeship training can be traced back to eleventh century Zen Buddhism, where a highly non-linear learning method, known as Kouan in Rinzai Zen and Shikan-Taza in Soto Zen, were developed as explained in the Introduction. The former uses a Zen master asking questions and students answering them, while the later uses meditation to quench the thinking and wondering of the mind. These two methods are different, but both seek highly non-linear learning to attain enlightenment ("Aha" moment in the west). Further explanation on this non-linear learning is available in chapter VIII: Struggles Make You Creative, Learning is to Steal the Spirit of Art (Suzuki, 1973).

His second point refers to a way to pay back to teachers for their lessons. Once Cho explained to me, "My teachers are all gone and they are better off somewhere, so they do not need to receive my

payback. I will share TPS lessons that I received from my teachers with the next generation of Toyota personnel. This is my way of respecting my teachers and paying back to them.”

Note by Rich Alloo: *When we are truly committed to True Lean™®, we come to realize that it is a constant series of challenges to overcome. We learn certain techniques to achieve results but more importantly we learn how to learn. This is a gift we receive from our teachers who give it in the hope that we will also give it to those we teach.*

For those of us who received this gift from Mr. Cho, we continue working to learn more about the true essence of the TPS and to pass on what we have learned to a next generation. Through this, we constantly work to repay our debts.

Note by Tony Chamblin: *Dr. Saito visited Mr. Cho a few years ago when he was the Chairman of the Board for Toyota and Mr. Cho said that he was still learning! Passing knowledge on is not about the head (mind), it is about the heart. Giving back to carry on. We should all ask ourselves how we can keep this learning going after we are gone.*

III. TPS and Wisdom 智慧

How does wisdom relate to TPS?

Wisdom is defined in chapter II as the application of knowledge, experience and sound judgement to make a sound action or decision. What is knowledge? Knowledge is facts, information and skills gained by a person through education or experience: the theoretical and practical understanding of a subject. What is experience? Experience is practical contact with, and observation of, facts or events (the definitions of wisdom, knowledge and experience were adopted from Wikipedia).

What is sound judgement? Sound judgement is not as well defined as knowledge and experience. So, I offer my original thinking and explanation. Sound judgement requires common sense, which is an ability to see the entire forest before individual trees. This is a holistic view. The holistic view won't be gained by logical thinking; therefore, we must rely on a different method. This is not easy in American society where logical thinking dominates and the external world view influences our life – our success is measured by the external values, wealth, power, social status, etc. The more we succeed, the more we will be drawn to our own self-interest and away from the holistic view. (Saito, 1996).

What is the holistic view? A holistic view comes from a desire-less mind. If we stick to our own interest and desire, we are not able to see things as they are. Our view is distorted by our desire and interest, i.e., our mind will create our comfortable self-satisfactory condition: we only hear what we want to hear. If we want to obtain an unbiased objective view, we need to be away from this comfortable self-asserting view. This unbiased objective view is necessary to make sound judgement. Why? See the following Lao Tzu's message.

Desire-less Mind is to become One with Nature

Lao Tzu 老子 (500 BCE) offered his famous message, “Ever desireless, one can see the mystery. Ever desiring, one can see the manifestations.” (Lao Tzu 500 BCE; Tao Te Ching 2012). When we are looking at the same phenomenon; some see mystery and others see manifestations. Why? Because humans tend to see what we want to see based on our desire. If we have no desire, we are able to see things as they are.

How can we attain a desireless mind? That is not easy in American society, where our open market system is based on human desire, and the Bill of Rights protects our desire to pursue happiness. Confucius offers his evolutionary life development path, eventually reaching a state of desire-less mind.

Confucius 孔子 (500 BCE) attained his desire-less mind at 70, by becoming one with nature, i.e., his desire became nature’s desire, which is desire-less. Then his judgment is no longer his own, it is nature’s. When this happens, the concept of a mistake disappears, since there is no mistake in nature. This is: see things as God sees, which is “see things as they are.” Accepting things as they are by following nature’s way is sound judgement. We do not judge what we see based on our own interest; simply give up that interest and follow nature’s way (see the following Confucius’s life).

What is going to happen when people attain a desire-less mind? An integral being knows without looking, sees without going, accomplishes without doing (Chopra, 1994). Another example is Charles Dickens. When he wrote his classic novel, Christmas Carol, he experienced, “...that my pen moved automatically without my will in completing this novel.” (Covey, 1989).

Confucius’s life: Independent to Interdependent to Harmony

“At 15, I decided to study

at 30, I became independent

at 40, I focused

at 50, I realized my mission in my life

at 60, I became able to listen to people without bias and prejudice

at 70, my thinking and ideas are in harmony with nature.”

(Confucius, 551-479 BCE; Kanaya 1982)

Confucius’s independent age (15 - 40) focus is to establish his career. His Interdependent age (50 - 60) focus shifted from his career development to serve others. He attained *Einfuehlung* (empathetic listening) at 60. One of TPS leadership requirements explained by Mr. Cho.

Harmony with nature was attained at his last age 70. This state of mind shares the desireless mind described by Lao Tzu. Confucius attained his desireless mind when he became one with nature. Prajñā (transcendent wisdom) in Buddhism is the key element to attain spirituality which eventually helps us to understand the meaning of life (see chapter IV). Thomas Merton offers meditation as an effective method to find true self which will help us attain the meaning of life.

Here is a Thomas Merton quote from Contemplation.

“Contemplation is the highest expression of man’s intellectual and spiritual life. It is that life itself, fully awake, fully active, fully aware that it is alive. It is spiritual wonder. It is spontaneous awe at the sacredness of life, of being. It is gratitude for life, for awareness, and for being. It is the vivid realization of the fact that life and being in us proceeds from an invisible, transcendent and infinitely abandoned Source. Contemplation is, above all, awareness of the reality of that Source.” (Thomas Merton).

Thomas Merton identifies the “infinitely abandoned Source” in us, which supports the Hitozukuri principle and respect for people (see chapter VIII on Hitozukuri).

Note by Rich Alloo: *Knowledge and skill can be taught. We build experience by applying our knowledge and skill in different conditions. By repeating the application and constantly questioning our own decisions, we can make better decisions when faced with unfamiliar conditions. This process of questioning and acting leads to sound judgement.*

Mr. Cho described his experience as follows: “Working with Mr. Ohno, we went through the barrage of why, why, why.... For example, I would report to Mr. Ohno that such problem occurred. Mr. Ohno would ask why. I would give him a reason I could think of. Mr. Ohno would again ask why. I would give him the next level reason. Then came another why. Normally Mr. Ohno would ask 5 to 6 whys in a row. As this happened many times, I caught on. So I began to ask why, why, why on my own. When I followed this process of asking many whys, I began to have a real grasp of the situation. It became easy for me to find the real situation. I also began to find the answers on my own. When I found the true answer, I didn’t need to ask Mr. Ohno his opinions or suggestions anymore. All I needed to do was to report to Mr. Ohno such problem occurred, and because of these reasoning, we fixed the problem this way.” (from TMC Managers Forum, March 8, 2000)

The simple question “Why?”, if we take time to ask it, opens our minds to deeply explore the conditions around us and inform our decisions with that understanding.

Note by Tony Chamblin: *TPS is not magic! In TPS we are describing the process for building the car. Takt time is 60 seconds, there are over 10,000 parts on a vehicle. But there is more to this than just building a car. We should also ask how building the vehicle will make society better. What can our product do for society?*

- *Our vehicles allow parents to take their children to school on time and in safety.*
- *We provide dependable vehicles that people can count on to be safe and have a high threshold of quality.*

This is important for all levels of the organization to consider. I was working with a major banking organization and we were helping them to understand the material and information flow of the organization. So, we worked at all levels. There were these two older ladies who were in a mail room in the basement of the organization. There were no windows, only fluorescent bulbs. It was a rather dreary workspace and they were surrounded by bags of mail that they sorted and sent to the correct departments. When we asked them what they did, they said in a very monotone manner, "I just sort the mail." My heart broke for them. Can you imagine how depressing that would be? And they had been doing it for several years.

As we mapped the process, we kept coming back to those ladies and showing them how they were connected to this bigger picture. How what they did actually initiated a lot of the other work that was being done in the organization. The change in their demeanor was amazing! We did ask to put in softer bulbs and brighten the work area, but the biggest change was that they started seeing their contribution to the bigger picture. When you asked them what their job was after that they would say in a cheerful voice, "I help people provide a home for their family, or safe transportation or education or...." I think that you get the picture. They understood how they are contributing to society

TPS is Leadership in action. If we reflect on the product at the University of Kentucky what would you say it was? The student of course!

Sound Judgement and Swordsmanship: Miyamoto Musashi (宮本武蔵) and his Faraway Mountain View (遠山の目付) (Miyamoto Musashi, 1974)

An interesting story about sound judgement attained by the master swordsman, Miyamoto Musashi; Miyamoto Musashi is the Japanese master swordsman who lived in seventeenth century Japan. In the battle of a Samurai sword match, losing it often meant a death. So, the swordsman's life depends on win or loss in each battle. To overcome fear and psychological pressure associated with this life-death condition, Musashi has developed his unique philosophy, A Book of Five Rings (Miyamoto Musashi, 1974), to attain his calm mind during the battle. One of them is "faraway mountain view" to face his opponent. When faced with his opponent, he tried to see a faraway mountain and did not stare at his opponent's face. This faraway mountain view helped him see the opponent's move but not his face. When that happened, Musashi was able to effectively block the opponent's sword movement, and make his own lightning speed offensive movement, with precision accuracy, followed. His opponent had no chance to escape his sword and lost the battle.

This sounds simple but it is difficult to do. Why? Because it requires a fearless mind, which is, again, a desireless mind, not attached to winning or losing. See the following Chuang Tzu's story.

Chuang Tzu 莊子 (BC 369-286) gave us a powerful example on how the mind can influence the performance of an archer in his story: The need to win.

When an archer is shooting for nothing, he has all his skill.

If he shoots for a brass buckle, he is already nervous.

If he shoots for a prize of gold, he goes blind or sees two targets - he is out of his mind.

His skill has not changed, but the prize divides him.

He cares, he thinks more of winning than of shooting.

And the need to win drains him of power.”

(Thomas Merton, *The Way of Chuang Tzu*, 1969)

In relation to the desireless mind, the following Dalai Lama’s message, to live in the present, is interesting. With a desireless mind, we are not attached to win or lose, simply desireless. This desireless mind does not mean that our energy level is low, instead it means that we can use all our energy at the present moment, which is opposite to the archer’s situation of the need to win that drained him of power.

Dalai Lama (2016) once answered the question of what surprises him most about humanity by saying, “Man ... because he sacrifices his health in order to make money. Then he sacrifices money to recuperate his health. And then he is so anxious about the future that he does not enjoy the present, the result being that he does not live in the present or the future; he lives as if he is never going to die, and then he dies having never really lived.”

Note by Rich Alloo: *Our True Lean model is based in systematic problem solving. The problem-solving system is much more than simply the mechanism to change conditions and achieve desired results. It is a way of thinking that includes disciplined reflection. Reflection on what we did, how we did it and why it was important to us unlocks our spirit to challenge ourselves and grow as human beings.*

IV. TPS and Empathetic Listening

What is the difference between empathetic listening and harmony with nature? The former requires a service-centered mind (separating from an ego-centered mind), while the latter requires integration with nature which requires a desireless mind (Lao Tzu 500 BCE; Tao Te Ching 2012).

TPS leaders are required to develop empathetic listening skills and capabilities which are different from just listening without empathy. The former is patterned after *Einfuehlung* in German; the word did not exist in America until 18th century. Fujio Cho emphasizes *Einfuehlung* as the foundation of Hitozukuri (A. Saito and K. Saito, 2012).

If companies are interested in Hitozukuri, Confucius’s message in evolving the stage of life can help. It requires a step-by-step development process of our own inner world; but won’t happen overnight, since it is not a skill. Mother Teresa shares her journey of developing the inner world: silence → prayer → faith → love → service → inner peace. Her last two stages share Confucius’s last two stages (see Chapter IX).

This Confucius message tells us that people in every level have something to offer society. It is unthinkable not to respect Confucius at age 70 who attained wisdom to be used for the greater

good, while he was no longer on the active front line. How about our American society? Bill Cooper and Ownie McBride offers comments.

Note by Bill Cooper (senior member of UK IR4TD/True Lean Systems program) on the second paragraph in this chapter, "TPS leaders are required to develop empathetic listening skills and capabilities," how is this connected to Hitozukuri? If they stay as a mere technique, then they are not driven by the Hitozukuri principle. Saito's reply: Hitozukuri is not a technique but a philosophy. Hitozukuri philosophy can be attained by practicing Einfuehlung. At the beginning, Einfuehlung may be just a mere standard practice and technique. By continuing the practice with Kaizen mind, this technique can carry you to enter into the world of philosophy. If we only stay at the technical level, we may not be able to attain the philosophy of Hitozukuri.

Note by Pete Gritton (Toyota's 9th North American (NA) manufacturing hire, retired as VP HR for NA) and **Ownie McBride** (facilitator and coach of UK IR4TD/True Lean Systems' Program People Side of Lean): In many organizations the front-line worker is not the most respected and does not matter most in the culture, except for their productivity numbers. In those organizations the leaders and powerful think they matter most. At Toyota, in TPS, the team member is respected not only for getting the product out the door, but also for thinking and participating in finding and solving problems. The others serve in the role of support functions to remove barriers for team members. Through our True Lean sharing of Toyota & TPS knowledge & experience, we are trying to pass on the wisdom of respect for the front-line team member, respect for people, respect for humanity, and how the organization benefits from full team member engagement.

Toyota Production System (Cho 1988; 1995; 2005)

Toyota Production System is a highly effective and efficient method to produce high quality products in an honest, steadfast and uncompromising manner. It focuses on customer satisfaction by developing people who practice teamwork to conduct kaizen.

The key to the Toyota Way and what makes Toyota stand out is not any of the individual elements, but what is important is having all the elements together as a system. It must be practiced every day in a very consistent manner, not in spurts. (Taiichi Ohno, see Saito and Saito 2012).

So, TPS may be said to be a highly non-linear system to integrate Hitozukuri, Monozukuri and Kazien, where system integration plays an important role in TPS, according to the above Ohno Goroku. To understand the non-linear aspect of integration of the Toyota Production System, the following may help readers. "Suppose you understand each element of TPS: Hitozukuri, Monozukuri, Kaizen, then you may think you understand Hitozukuri and Monozukuri and Kaizen. But how about 'and'?" This "and" is a non-linear operator to make TPS a unique product of system integration (Saito 1996).

Under the current Corona virus crisis, the following Cho Goroku may hep us. **It is the best time for kaizen when the economy is slow like now. There is plenty of time and it is easier than usual to try out something new. The result of this kaizen will show up when the economy becomes strong enough to increase our production volume. There are unlimited opportunities and possibilities for kaizen; so success lies in our willingness.** (Saito and Saito 2012).

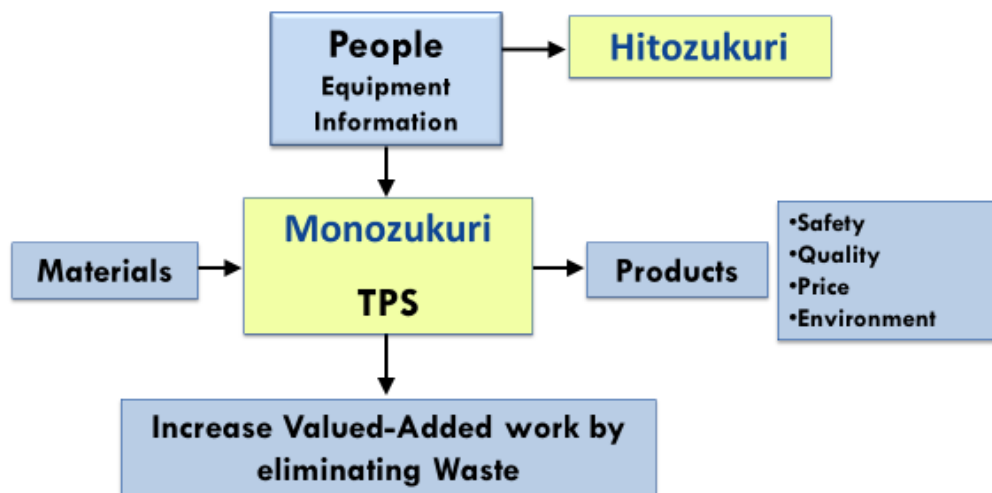
Who are the customers? People who make the vehicles, buy the vehicles, drive the vehicles, the environment, and the society at large.

Two pillars of TPS are Monozukuri and Hitozukuri (Cho 2005), which refer to a centuries-old philosophy deeply rooted in Japanese culture. Figure 1 shows a diagram of TPS. Monozukuri refers to the art of making things with excellence, skill, spirit, zeal, pride, and more. Hitozukuri refers to the need to educate and train a person to become expert in Monozukuri. Together, Monozukuri and Hitozukuri can provide the basis for a balanced approach to using technology and enhancing human capacities, one where integration and synthesis play a more important role than specialization and analytical skills.

TPS focuses on the product making and people development processes, with a motivation focused on continuous improvement through the Kaizen principle, while traditional manufacturing and business focus on the results, normally profit. How can TPS make profit by focusing on the Kaizen process? Answer: A highly efficient and effective process can produce a high-quality product in the most economical way. Profit will follow an efficient and effective system, but not the other way around.

There are three different types of work: Value-added work (most desirable), Necessary Non-valued added work (must be done to complete the work) and Non value-added work (waste).

TPS Eastern Version



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Figure 1: Diagram of Toyota Production System.

Note by Rich Alloo: *Nearing the end of his assignment at TMMK, Mr. Cho delivered a series of lectures for the general managers at the plant. In one of these, he explained the role of management in TPS as focused on identifying and eliminating Muda. To Mr. Cho, and Mr. Ohno as expressed in his Goroku, the activities of people fall into only two categories: Work and Muda. Work is commonly known as the “value added” activity. Muda encompasses every other activity, whether “necessary” or simply waste. The Hitozukuri of TPS focuses heavily on developing the ability of our members to clearly and accurately distinguish work from Muda. If we can make that distinction, then Muda can be challenged by the total elimination of waste and constantly questioning what is necessary.*

The constant challenge of Muda is essential to demonstrating respect for humanity by assuring that the effort of our people is always utilized to provide value to our customers and themselves. This aspect of the Hitozukuri is essential to achieve maximum efficiency and build the culture of TPS.

Note by Tony Chamblin: *The fundamental important issue is the human (people).*

- *To be effective with a lean transformation everyone must understand the development of the people.*
- *The True Lean Program focuses on Hitozukuri, the making (development) of the people.*
- *Appreciate the unique talent of the individual to make the overall process strong.*
- *By focusing on the Hitozukuri, we create a culture of Kaizen (continuous improvement) for the people! Then the people will improve the overall process and product.*

V. TPS as a Unique Product of Japanese Culture

Japan can be summarized geographically as a small volcanic island chain, poor in natural resources, and sociologically as a rice-farming nation. It has been influenced by three major eastern philosophies, Buddhism, Confucianism, and Taoism and has adopted Christianity, and other religions, while their native religion is Shintoism. Japan is a melting pot of religion, since they accept them all without creating conflicts among them.

Culture is a way of life and will influence our thinking, values, behaviors, traditions, and more. Culture is the topic of study in philosophy, psychology, sociology, archeology, geography, and is also known to influence science and engineering (Emori, Saito and Sekimoto, 2000).

TPS is a unique product of Japanese culture meaning that TPS is influenced by the Japanese culture. Therefore, it is essential to study the Japanese culture to understand TPS (or Toyota culture).

Toyota has a conservative approach to ensure its financial stability to withstand economic downturns. Toyota executives' average pay does not exceed eight times higher than the average line workers' pay. The average saving rate for the Japanese household is 15 % compared to 4% for the US household. Disciplines and teamwork are necessary for Japanese to efficiently and effectively function in such a very crowded place.

The concept of Kaizen and waste elimination are developed as a necessity of survival under the geographical constraints: the size of Japan is less than the state of California and the total population of Japan 126M (as of 2020) is about 38% of the total population of US. In addition, the

habitable area is roughly 30% of the total land. There are hardly any natural resources. Japan has been constantly visited by typhoons, earthquakes, and tsunamis. The Japanese developed a habit to save food and necessities to survive these disasters.

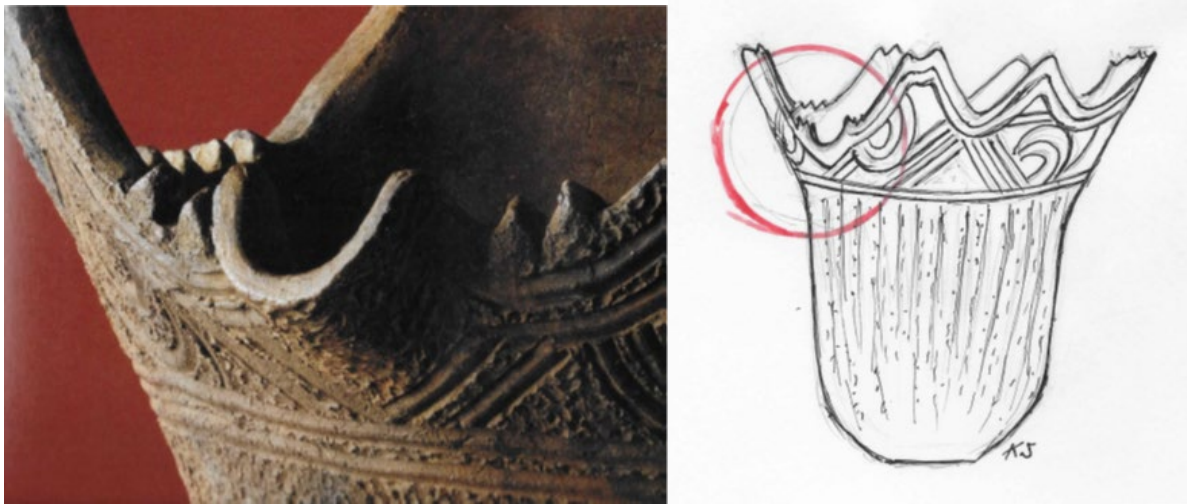


Figure 2: The left side photograph is about 5,000-year-old deep-pot pottery. The right-hand side schematic shows side-view of the pot, where the red circled part corresponds to the left side photograph.

It may be interesting to find how long the Japanese Monozukuri culture can be traced back in history. Here is an interesting story about a deep-pot pottery (whose top part section is shown in Fig. 2), made during the early Jōmon period 縄文時代 (4,000 – 3,000 BCE) which was excavated from Kode Shell Mound, Chiba prefecture near Tokyo. This earthenware is famous for its combination of a variety of rope impression on the surface of the vessel from the bottom to the edge of the mouth, and for its geometrical patterns representing many similar vessels made during the same period. A closer inspection discovered the surface decoration was made by twisting, rotating, and reorienting several different types of ropes, tightly netted possibly with native grass, exhibiting sophistication of the technique in string and rope making. It largely differs from vessels and pots made around the same period in Europe that are much simpler in design and have fewer varieties in type. (Shinagawa, 2020)

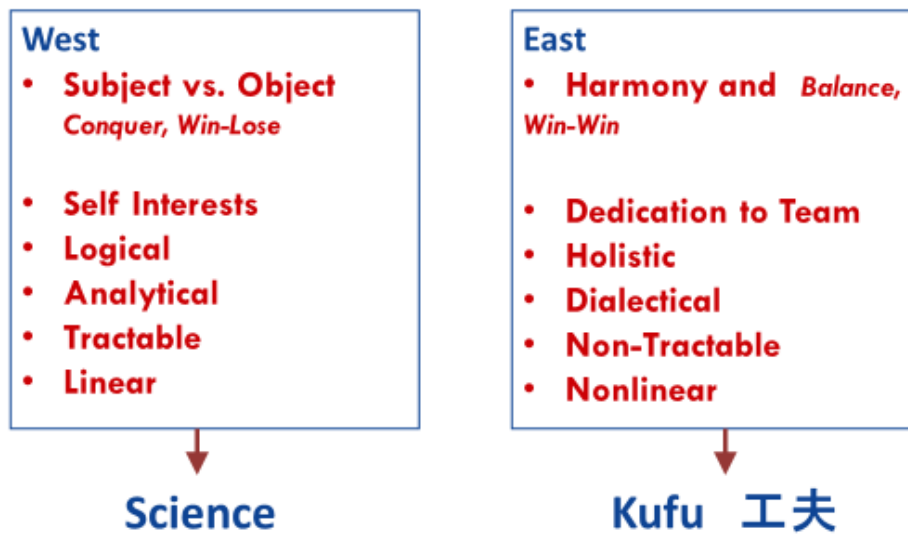
Note: Pete Gritton and Ownie McBride: explain the long-term thinking, and how it enables Toyota to ride the market fluctuations (2009 recession, Covid-19, etc.). This wise stewardship means that Toyota has cash to make improvements and build new plants while the competition is servicing their debt - in the People Side of True Lean™ we also point out that the thinking behind these principles and commitments was stressed at new team member orientation, and it was repeated throughout company communications - how these serve as to redundantly reinforce why we do what we do, and the basis for decision-making = It is long-term thinking toward sustainability. In Communications and in the People Side, we frequently refer to Taizo Ishida, Toyota's Third President, who called it, "Protect our castle."

Two Different Culture: the West and the East

Why does western culture largely differ from eastern culture? For example, eastern philosophy and religion is Apophatic, while western religion and theology is Cataphatic. Japanese technology is built based on inductive craftsmanship, while western science and technology largely use deductive scientific methods and thinking, which is rooted in Greek philosophy.

Figure 3 compares some typical differences. Science is the product of western culture and thinking, which is based on separation between the observers and what is being observed. Buddhism and Taoism both emphasize unification of human and nature as the goal. Western science is based on logical thinking to solve problems including human life, while eastern philosophy is based on meditation, a totally different way to seek the mystery of life and nature and its interaction (see Thomas Merton quote on Contemplation, Chapter III). Western logical thinking leads to science, while eastern philosophy leads to Kufu, which plays a significant role in TPS. What is *Kufu*?

Two Different Cultures



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Figure 3: Comparison between the western culture and the eastern culture.

Kufu is the fourth discipline in the scientific method to advance our understanding of nature and enhance our capability to solve problems. The four scientific methods are: experiment, theory, computation, and *Kufu* (Suzuki 1973; Saito 1995).

The Cambridge English Dictionary states that culture is, "the way of life, especially the general customs and beliefs, of a particular group of people at a particular time." Cultural lenses may make people view the same outcome of events differently. Westerners are more motivated by their

successes than their failures, while East Asians are better motivated by the avoidance of failure. Culture is important for psychologists to consider when understanding the human mental operation. (Wikipedia section on culture)

Cultural variation is not restricted only to ethnicity and nationality, but rather, extends to the specific practices within communities. In learning by observation, people learn without verbal requests for further information, or without direct instruction. Sakichi Toyoda, the father of Toyota Motor Corporation, exhibited a good example of learning by observation: "When my mother did her looming work, I sat aside all day to observe over and over how a simple looming machine worked. After a while, I was able to follow the detailed process without actually seeing it. I wanted to help my mother by freeing her to leave the loom without worrying about broken strings which would create waste. (Toyota Motor Corporation 1980)." With this experience of learning by observation, Sakichi Toyoda invented an automatic looming stop (fool proof) system that stopped the machine when a string was broken during the process.

Cho gave another interesting example between American managers and Japanese managers in their response during a regular managers' meeting at the Toyota Georgetown plant (Cho, 1995).

The hesitation to call attention to problems wasn't restricted to the shop floor. His team members and managers in the office were used to keeping their supervisors informed of their projects and activities by letting them know how well things were going. In America this is a good-news-first approach. In contrast, Japan uses a bad-news-first approach to try to identify problems.

The idea behind this approach comes from the fact that identification of the problems is the first and the most important step toward Kaizen. However, American team members thought that the identification of the problems was a reflection of their failure and could discredit their performance.

In his early days in Kentucky, Cho became very familiar with the phrase, "no problem." When they gave him reports, however, he kept asking repeatedly: what is the problem, why was it happening, what might be the real causes for the problem? They began to understand his interest was to identify the problems but not to blame people. To effectively implement this concept, TMMK established a basic agreement between American and Japanese team members. This agreement reflected new mutual learning and understanding. American leaders and managers learned that those who identified problems should be rewarded, not punished. In turn, Japanese leaders and coordinators learned that it's important to let people know when a job was well done.

It may be interesting for you to see the differences in American and Japanese approaches. Cho asked one American and one Japanese manager from our quality control department to list the strengths of the American and Japanese workers in his department. The following are the answers.

The American manager listed the strengths of American workers:

- Adherence to standards, once standards are established and accepted by individuals, they faithfully adhere to them
- Effective use of an advanced computer system
- Clear cut requirements and specifications in design drawings
- The strong desire of team members for Kaizen activity

The same American manager listed the strengths of Japanese workers:

- Effective planning and systematic approach
- Effective use of visual control
- Problem solving by teamwork
- Building quality into products through the process

The Japanese manager listed the strengths of American workers:

- Effective use of computer system
- Making it clear where responsibilities lie
- Clear cut requirements and specifications in design drawings, since they consider the drawings as a contract
- A strong desire toward Kaizen and all kinds of positive changes
- A strong willingness to face challenges, such as the challenge to become the best in the US
- Professionalism and respect for experts
- A commitment toward following the rules and standards once they are established

Note by Rich Alloo: *In an early speech delivered to the Scott County Kiwanis Club, Mr. Cho introduced the nature of Japanese to the new US home of Toyota. He began with a quote attributed to a non-Japanese professor who stated: "One Japanese is calm and quiet. Two Japanese are smiling and laughing. Three Japanese are mysterious."*

After commenting that as a Japanese person he did not find a group of three Japanese to be at all mysterious, Mr. Cho went on to explain why they may seem so to non-Japanese. First, he explained that the Japanese culture is deeply rooted in the history and geography of Japan. Because of the limited natural resources and dense population of Japan, people developed a strong reliance on group acceptance. This influences behavior in the following ways, he explained:

- *Responsibility of the group for the acts of individuals*
- *Strong preference for group decision-making*
- *Individual's identity is strongly tied to their group*

These attributes are taught in Japan from birth and so become a part of each person's behaviors. The behaviors lead to a sense of ease by Japanese people to make friendships with others in their group and maintain harmony by caring for others as a member of the group. These ingrained behaviors also lead to a sense of unease when Japanese are separated from their group, such as when called upon to make decisions or express opinions by themselves.

Americans by contrast, Mr. Cho observed, are more inclined to think by themselves, act on their own and accept responsibility for their own actions. As with the Japanese characteristics, the inherent characteristics of Americans are deeply rooted in the history and geography of North America. With relatively sparse population density and virtually unlimited natural resources, Americans needed to develop a strong self-reliance with limited dependence on others for their survival.

Mr. Cho suggested that the combination of these behaviors between Japanese and Americans could contribute to beneficial outcomes even in the Toyota environment where teamwork is a cornerstone.

He was committed to developing TPS as a new system, based upon the fundamental principles of the TPS in Japan, combining the strengths of both the Japanese and American cultures.

VI. Deductive Science and Inductive TPS

Deductive and Inductive Methods in Science and Engineering. Traditional science and engineering uses the deductive scientific method which originated in Greek philosophy to separate human observers from nature (what is observed), while Eastern philosophy seeks the ultimate goal of human and nature interaction, known as *Śūnyatā* or *Shuunyataa* (空) through the inductive method where observation and experience play an important role to develop *Kufu*.

The following quote from Einstein well summarizes the role of inductive and deductive methods in science. "Thus, the supreme task of the physicist is the discovery of the most general elementary laws from which the world-picture can be deduced logically. But there is no logical way to the discovery of these elemental laws. There is only the way of intuition, which is helped by a feeling for the order lying behind the appearance, and this *Einfuehlung* is developed by experience. Can one therefore say that any system of physics might be equally valid and possible? Theoretically, there is nothing illogical in that idea. But the history of scientific development has shown that of all thinkable theoretical structures a single one has at each stage of advance proved superior to all the others." (Albert Einstein, 1932).

East offers Inductive Approach and West offers Deductive Approach. Together they offer the dynamical exchange in philosophy and thinking that is helping us reach a deeper understanding. The following shows these two different approaches. (Capra, 1991; Saito 1995, 2005)

Deductive Scientific Approach (Greek Philosophy)

A priori → Assumptions → Apply deductive methods to obtain predictions (the observers are separated from what is being observed) → Predictions (to be validated by experiments) → If yes, validate assumptions (enhance our understanding) → Cataphatic Theology

Inductive Monozukuri Approach (Eastern Philosophy)

Posteriori → Observation/experience → Apply inductive methods to develop a holistic view (the observer and what is being observed becomes one) → Harmony (the observer and what is being observed becomes one) → *Kufu* (TPS) → Apophatic Theology

Three Different Types of Research; TPS (or Lean) Research as the Third Type

Curiosity-driven Research: This research seeks basic understanding of nature's mechanisms. Deductive scientific methods (experiment, theory, and computation) are applied to prove hypotheses. The goal of curiosity-driven research is to enhance our understanding, where the selection of a research topic plays an important role. Here is a quote from an eminent Harvard Chemist, "Many scientists owe their greatness not to their skill in solving problems, but their wisdom in choosing them." (Wilson, 1954)

Purpose-driven Research: This is the mission-oriented research to solve technical problems and develop new technology to achieve a specific goal. A good example is NASA's Apollo project. The goal of purpose-driven (or project-driven) research is a new technological development or improvement of the currently existing technology or products. Von Karman distinguishes basic sciences from engineering: "Scientists see things that exist and ask why? Engineers dream things that do not exist, and ask Why not?" Von Karman. (Saito, 2008)

Customer-driven Research: Customers demand reasonably priced high-quality products. Manufacturing these high-quality products requires research. This type of research focuses on Kaizen (continuous improvement), using practical learning by actually doing, and there are no specific goals, due to the nature of Kaizen. Therefore, this third type of research differs from the above two. Ken Krefle, a former Toyota executive and a UK Lean program practitioner explains Lean research as a means to improve the following problem-solving process. "Practitioners find problems, fix problems, and prevent the same problems from coming back." (Krefle, 2017). The first two steps are science-oriented, while the third step requires discipline rather than science.

Note: Bill Cooper, Ken Krefle (former Toyota executive in residence and a founding member of UK IR4TD/True Lean program), **Abbot Maginnis and David Parsley** (Ph.D. in mechanical engineering and members of UK IR4TD. Maginnis directs the Lean Academic Program and Parsley coordinates Lean Systems Program) have been working on Lean manufacturing research and contributed to modeling TPS, Hitozukuri and Monozukuri through the University of Kentucky's True Lean System's program (Krefle 2011 and 2017; Parsley 2018; Cooper 2020; Maginnis 2020). One of their recent interests and challenges was to define Lean research, which contains system (software), process (hardware) and their integration, which are not well described by traditional curiosity-driven and mission-driven research explained above. Therefore, customer-driven research, the third type of research has been proposed for Lean research.

Kufu 工夫 as the Spirit of Monozukuri (モノづくり) and Japanese Craftsmanship

What is *Kufu* ?

"The term *Kufu* is the most significant word used in connection with Zen and also in the fields of spiritual and mental discipline (Suzuki, 1973; Saito 1995). Generally, it means to seek a way out of a dilemma, or struggle to pass through a blind alley. A dilemma or blind alley may sound somewhat intellectual. But facts indicate that this is where the intellect can go no further, having come to its limit. Yet an inner urge still pushes somehow go beyond. As the intellect is powerless, we may enlist the aid of the will; but mere will, however pressing, is unable to break through the impasse.

The will is closer to fundamentals than the intellect. But it is still on the surface of consciousness. One must go deeper yet, but how? This how is *Kufu*. No teaching, no help from the outside is of any use. The solution must come from the inner most being. One must keep knocking at the door until all that makes one feel they are one individual being crumbles away. That is, when the ego finally surrenders itself, it finds itself. Here is a newborn baby.

Kufu is a sort of spiritual birth pang. The whole being is involved. There are physicians and psychologists who offer synthetic medicinal substances to relieve this pang. But we must remember that, while man is partially mechanic or biochemical, this does not by any means exhaust his being; he still retains something that can never be reached by medicine. This is where his spirituality lies, and it is *Kufu* that finally wakes us up to our spirituality."

Note by Rich Alloo: All human beings possess three types of capabilities: Physical, Intellectual, Emotional. When we hire them they bring all three, every day! TPS requires the use of all of these capabilities and allows people to gain full value from their participation.

Physical effort results in the creation of tangible things....the products of our labor. These things are passed on to our customers and in return provide profit that allows us to continue to produce.

Intellectual effort allows us to analyze the conditions under which we produce and eliminate inefficiencies in production. Intellectual effort works within the bounds of knowledge to improve the results of our physical effort.

The emotional capability unlocks the power of the human spirit to seek what is not known and learn it. This capability breaks the bounds of knowledge and allows us to achieve the unknowable. A Taiichi Ohno Goroku touches this point:

"All good ideas require a painful process. When people struggle in finding solutions to problems, they want to escape from this painful process, awakening their innovative and create minds. Humans have unlimited capabilities." (from Saito translation of Ohno Goroku, November 2012)

Note by Tony Chamblin: Science is Yin & Yang (陰陽); black or white. Kufu is the struggle to learn together. What you have learned, you teach to others. You must struggle when learning TPS, through the struggle we come to our own conclusions and provide the logic for why something is done a certain way. The transition to understanding TPS is uncomfortable!

VII. Top-Down Power-Driven System vs. Bottom-up Kaizen System

The concept of Kaizen did not exist in the west until James Womack et al introduced Lean Manufacturing in their pioneer classic book; *The Machine that Changed the World* (James Womack et al., 1991). In western thinking and tradition, there are always a goal and objectives to achieve. Once achieved, the mission is accomplished! There is no more work, then there is only celebration. Kaizen has no final clear goals and people must continue their work forever. The concept of Kaizen makes Americans uncomfortable due to an endless journey of continuous work. There is no point to celebrate a success or win. Figure 4 illustrates concepts of two top-down and Kaizen systems.

In Japanese culture, however, the Kaizen concept is a natural way of life, i.e., the journey itself is the focus, and the result is a secondary by-product (see Chapter VIII). The ultimate success lies in our own internal journey to find our true selves, which Thomas Merton explains in Chapter III, but does not come from external recognition and material rewards, however fancy and impressive they may be. These external matters never reach deep into our soul to give us happiness and awareness of spiritual life. This process-focused mind set over the goal-focused mind set is a key TPS element in Hitozukuri. *Kufu* is a good example of this internal challenge in problem solving. Finding a solution to problems seems important. However, when compared to developing our mind to see the true nature of ourselves through hard work, struggles, and contemplation, it will become secondary.

Confucius's six different evolving steps towards harmony with nature, which he attained at age 70, are the result of process-focused Kaizen activities. Each step plays an important role to reach the age 70 stage, which is also the beginning of a new journey in the attained desireless world, where his desire becomes nature's desire, thus he is desireless. This journey will continue forever. How far we can go is a mystery and very exciting, as Thomas Merton forcefully described in his contemplation (see the Thomas Merton quote in Chapter III). Another example can be seen in

Buddhism. The heart sutra demands hard work, critical thinking to seek why, discipline, and persistent practice to attain wisdom, which is the beginning of helping others to cross from the ego-centered life to the service-centered life, *Prajñāpāramitāh* (see Chapter IX).

Note by Tony Chamblin: *In a Top Down organization:*

- *Let me impress the boss; do extra to get a bonus or promotion.*
- *When working for the existing manager, I can improve and learn. When I get a new manager, I must start all over to meet the expectations of that new manager.*
- *We are focused on the individual.*
- *I will only consider what can be done for the greater good if it doesn't interfere with my career.*

In the Kaizen system organization:

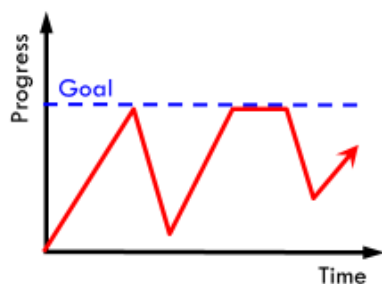
- *One voice, one system; the steps for improvement never stop.*
- *A good example: the challenge by John F. Kennedy to land someone on the moon by 1970.*
- *The Lean UK program is self-funding and we support others in UK. The only reason that our program survives is Customer Satisfaction.*
- *In this type of organization both business and society get better.*

System Comparison

TOP-DOWN ROBUST vs. BOTTOM-UP KAIZEN

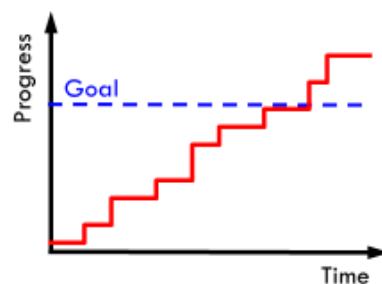
TOP-DOWN ROBUST

System falls back to the start every time
new administrators make new policy



KAIZEN SYSTEM

System sustains regardless of changes in
administrations
making continuous improvement



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Figure 4: Top-down management system vs. bottom-up Kaizen system.

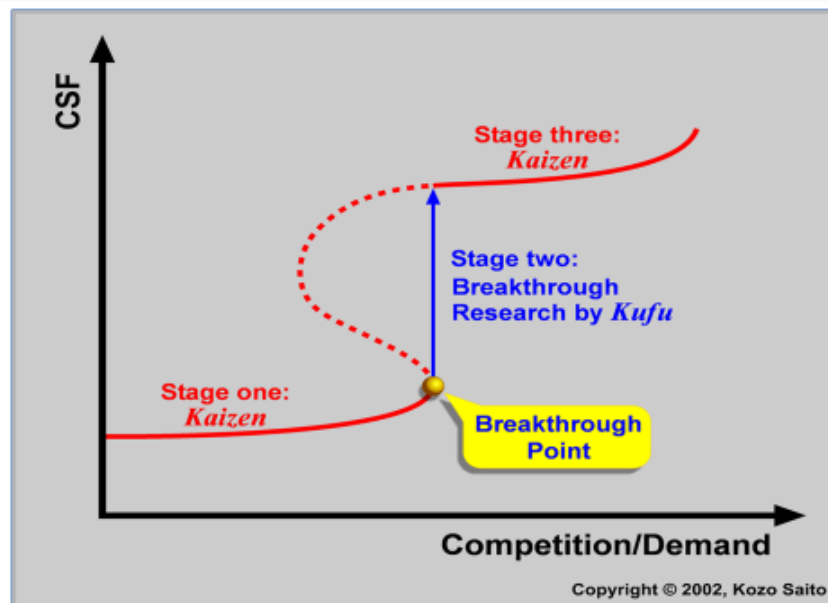
Kaizen 改善 and Kaikaku 改革 Lean Research and Engineering Research

The original concept of this Kaizen-Kaikaku diagram is based on the combustion theory of ignition (Williams, 1985). Figure 5 shows CSF: customer satisfaction as a function of competition and demand, which is essentially the time scale. The original combustion theory plots temperature as a function of the Damköhler number, the ratio of diffusion time to chemical reaction time. For the combustion theory, when the temperature increases, the Damköhler number also increases. When temperature hits an ignition temperature, then suddenly flaming occurs. Before this there is no flame. This flaming is a non-linear event occurring suddenly.

The difference before and after ignition is huge; before ignition there is no flame, while after ignition there is flame. The ignition temperature is about 350 °C and the flame temperature is about 1500 °C. The mechanism of this sudden jump is rather complex. The similarity of this ignition theory to the Kaizen-Kaikaku chart is: when CSF demands increase, competition/demands also increase. At a critical point of competition, a new technology emerges, in the same way that ignition creates flame, that is Kaikaku.

Figure 6 shows the evolution of automotive painting technology. Brush painting to manual spray painting is Kaikaku; Manual spray painting to robotic painting is Kaizen; Robotic painting to digital painting is Kaikaku.

Kaizen 改善 and Kaikaku 改革



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Figure 5: Kaizen-Kaikaku in CSF (customer satisfaction factor) - time coordinate.

Evolution of Automotive Painting Technology

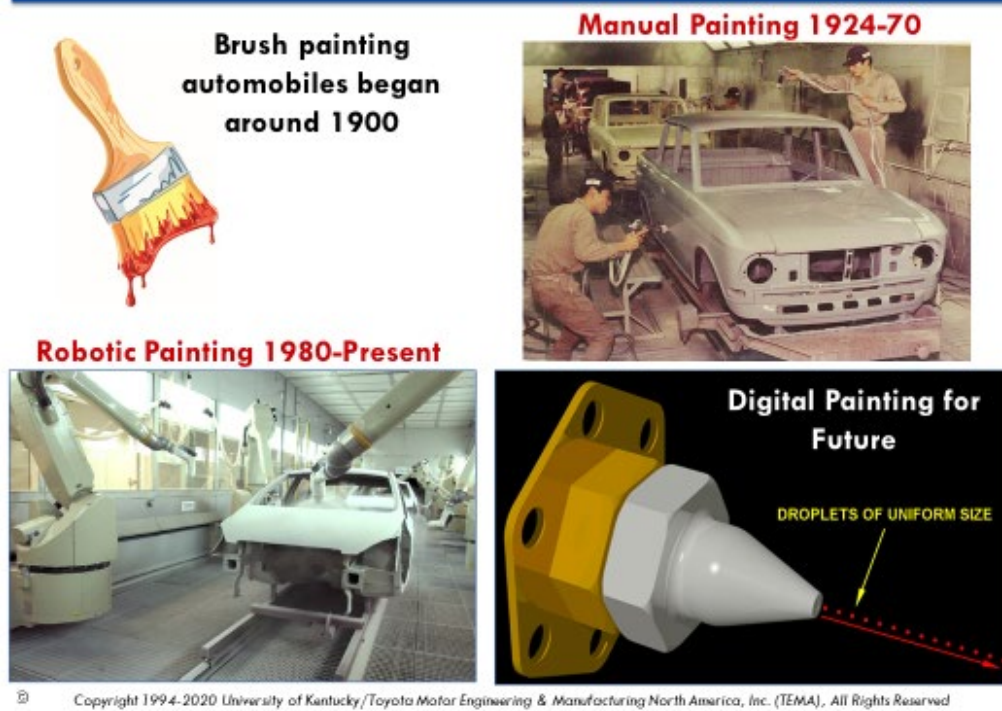


Figure 6: Evolution of automotive painting technology. Brush painting to manual spray painting is Kaikaku; Manual spray painting to robotic painting is Kaizen; Robotic painting to digital painting (which is a future technology) is Kaikaku.

Note by Tony Chamblin: There are truly two types of Kaizen:

- Small incremental improvements to the process and product.
 - An example of this is the advancement of a wooden stick as a pointer to the telescoping wand that you can place in your pocket.
- Large scale dramatic changes to the process and product. Think of hybrid technology and how it has changed the auto industry. Kaikaku is a large, quantum leap.
 - An example of this would be the transition of a telescoping wand to the laser pointer.

The majority of an organizations focus should be on classical kaizen. By focusing on simple Kaizen, we start creating the mindset of improvement. This starts building experiences that influence the ability to look at the bigger picture. By focusing on Kaizen, we are developing the muscle of Kaikaku. This is the part of the Kaizen of the person. Develop the person and they will improve the process and product.

VIII. Cho Goroku on Service

We contribute to society by making good products in an honest, steadfast and uncompromising manner. If companies can't provide service to society, they have no reason to exist.

This Cho Goroku has two different elements: the corporate mission and the personal mission. Why do Toyota workers conduct their work in an honest, steadfast and uncompromising manner? Because they are told to do so? If that is the only reason, there is no Hitozukuri, one of two core pillars of TPS. The corporate mission and the personal mission must have some overlaps. Finding the overlaps is crucial for Hitozukuri.

How do we create a personal mission statement? One goes through a process similar to the one followed by an organization. Ask the following questions to members of your organization: why do you want to work here? What do you want to accomplish? What do you expect from your company and what do you want to give to your company?

This mission alignment is the key to energizing and respecting people, so that they will wholeheartedly engage in doing kaizen; gaining satisfaction through Monozukuri and Hitozukuri, while sustaining your organization and fostering the future growth of your people and organization for the benefit of all.

If there is no alignment (and no overlaps) between your organizational mission and your personal mission, Hitozukuri is not possible. Therefore, there is no TPS in your organization. (For mission alignment, see Covey, 1994).

Service becomes the core value of our life. "Service to society is the rent we pay for living on this planet." (Joseph Murray).

Note by Tony Chamblin: *This is why the Hoshin Kanri (方針管理) system is so vital to Toyota. It is more than the long-term strategic planning that most organizations already do. It is about aligning the organization to the achievement of the vision at all levels. Most organizations only focus on the upper levels when doing strategic planning. In Toyota, all levels of management focus on a hoshin that is in alignment all of the way to the top. But as the hoshin cascades down through the organization it becomes more focused and relevant to the work being done by a particular group and team.*

Note by Bill Cooper: *This alignment and the overlapping of an organization's mission with the personal missions of its people is deceptively simple to describe, but how do we go about honestly and sincerely achieving this in what are more often than not highly competitive and impersonal work environments? Mr. Cho and others have passed on simple, yet firm, advice; rooted in the common ground of service.*

Cho Goroku on Hitozukuri (人づくり)

Losing well trained workers will hurt the company because they have accumulated know-how and experience which can help lead the company. Actually, they are the company.

People are the most important asset of a company. There are no useless workers. It is always possible to develop a worker and find the job that the worker can do very well. Another words: students can't fail, but only teachers can fail.

The above Goroku shares the same common value of two previous Cho Goroku: "It is impossible to correctly understand TPS without understanding human elements," and, "If companies can't provide service to society, they have no reason to exist."

Cho believes that companies shall exist to develop people who will become valuable members, not just of the company, but of society as well. This is Hitozukuri and profit will follow Hitozukuri. When the trust and commitment of well-trained, experienced workers has been earned by the company's Hitozukuri principles and practices, they will all do amazing things for the company. Therefore, Cho's Hitozukuri principle, similar to western culture's golden rule, comes into play in the above Goroku.

Note by Pete Gritton and Ownie McBride: *At Toyota, this is not left to chance. Many organizations say people are their most important asset, but they do not dedicate the resources or build the necessary supporting infrastructure to ensure it occurs. At Toyota, Respect for People is one of the two pillars of Toyota Way, and they manage that the same way as safety and quality - with clear measurable standards, and they develop and coach their people to succeed and continuously grow.*

Mahatma Gandhi describes seven deadly sins: Wealth without work; pleasure without conscience; science without humanity; knowledge without character; politics without principle; commerce without morality; worship without sacrifice. The left side items are related to the external world, and the right-side items come from our inner world value, where Hitozukuri plays an important role in developing a sense of calling to serve society rather than being driven by greed. Gandhi's message helps us balance our life by cultivating our inner world to find answers to the ultimate questions shown in section III. It also resonates with Mother Teresa's message on the path to a service-centered life.

The Role of Struggle on Hitozukuri

Mahatma Gandhi stresses struggles as a necessary means to develop strengths. "Strength does not come from winning. Struggles develop your strengths..." (Mahatma Gandhi).

A Zen master Kajiura Itsugai (梶浦逸外 老師) stresses struggles as the necessary first step to attain enlightenment in Zen Buddhism. When we are working on a project, it is common to face problems. Sometimes we may face a difficult one and struggle to overcome it. The harder the problem, the more we struggle. But remember, during your struggles, your brain is working to develop new wiring. Interestingly, all of a sudden, new wiring to open a new circuit appears and you are able to see a new world ahead of you. This breakthrough moment of success is created by constant struggles (Itsugai Kajiura; K. Tani, 1986). Once Zen Master Kajiura gave advice to a famous Japanese baseball homerun king Tetsuharu Kawakami when he retired from playing and decided to become a coach: "Develop your baseball philosophy using your attained baseball skills. These skills become obsolete over time but baseball philosophy will stay with you as long as you live, and, if you can cultivate your philosophy deeper, you can attain wisdom. Wisdom can guide you whatever you do - playing baseball or coaching, in the right direction.

Struggles in the western way of thinking, tend to carry a somewhat negative meaning, in that, when you struggle to achieve the job, there is a sense that you are not up to the required skill. There is then an expectation that what will happen next is to assign you a different job or let you go. In marked contrast, struggles in a TPS/Lean environment are seen as the necessary first steps in a process of development and growth.

Note by Tony Chamblin: Mr. Cho refers to applying TPS in an uncompromising manner. This is important to understand. If we create a culture where we don't compromise on our core beliefs, there will be a struggle to accomplish this. Through struggle we grow in our knowledge, abilities and confidence. We have to hold true to our beliefs and this may require harshness. Dr. Saito refers to a tooth infection he had to illustrate this point. He had to endure a lot of pain to remove the infection. If the infection had not been removed it would have led to some serious health issues.

Note by David Parsley: TPS highlights the purpose of struggle as the first step of learning. The UK Lean Certification class has reflected on that point and how meaningful it was for them to think that if we don't feel that initial struggle, then no learning happens because we never feel the need for change or growth.

Struggles Make You Creative

Ohno Goroku: Innovative thinking comes through a painful process. When people struggle to find solutions to problems, they want to escape from this painful process, thus awakening their innovative and creative minds. Humans have unlimited capabilities. (A. Saito and K. Saito, 2012).

Learning is to Steal the Spirit of Art (Suzuki, 1973)

"The son of a burglar saw his father growing older and thought, 'If he is unable to carry on his profession, who will be the breadwinner of the family, except myself? I must learn the trade.' He imitated his father and gained the approval of his father.

One night the father took the son to a big house, broke through the fence, entered the house, and, opening one of the large chests, he told the son to crawl in and pick out the clothing. As soon as the son got into it, the father dropped the lid and securely applied the lock. Next, the father came out of the courtyard and loudly knocked at the door waking up the whole family; then he quietly slipped away by the hole in the fence. The residents got excited and lit a candle, but they found that the burglar had already gone.

The son, who had remained all the time securely confined in the chest, thought of his cruel father. He was greatly mortified; then, a fine idea flashed upon him. He made a noise like the gnawing of a rat. The family told the maid to take a candle and examine the chest. When the lid was unlocked, out came the prisoner, who blew out the light, pushed away the maid, and fled. The people ran after him. Noticing a well by the road, he picked up a large stone and threw it into the water. The pursuers all gathered around the well trying to find the burglar drowning himself in the dark hole.

In the meantime, he went safely back to his father's home. He was deeply angry at his father for his narrow escape. The father said, 'Be not offended, my son. Just tell me how you got out of it.' When the son told him all about his adventures, the father remarked, 'There you are, you have learned the art.'"

IX. Eastern Philosophy, Mother Teresa, and TPS

Buddhism and Heart Sutra: Prajñāpāramitāhṛdaya. It can be translated as "The Heart of the Perfection of Wisdom" (Takagami, 1968)

Japanese culture was greatly influenced by Buddhism and the Analects of Confucius. Both came to Japan around the 6th century.

Heart Sutra has played a significant influence on Japanese culture, people's day-to-day living, and philosophy. Accurate descriptions of conventional truth are mere statements about reality. They are not the reality itself, therefore, they are not applicable to the ultimate truth that is by definition beyond mental understanding.

Buddhism relies on the wisdom (*prajñā*) that perceives reality directly without conceptual attachment thereby achieving nirvana. This direct method is meditation, which differs largely from traditional logical thinking. *Kufu* is an example of this direct method to solve problems as explained in *Learning is to Steal the Spirit of Art*.

The sutra starts with *Prajñāpāramitāhṛdaya*, attain wisdom and move to the other shore, and concludes with the mantra *gate gate pāragate pārasaṃgate bodhi svāhā*, meaning "gone, gone, everyone gone to the other side of shore, awakening." Unless we wake up, we are sleeping and drifting without finding the real meaning of life. Wisdom can help us to wake up from this situation. The heart sutra stresses attainment of complete wisdom. When it is achieved, then one is able to cross the bridge from the illusionary life to the real one, which is accomplished when one became one with nature. This also resonates with Lao Tzu's desireless mind, which is the nature's mind, and can be accomplished when one became one with nature.

Shifting ego-centered life to service-centered by Mother Teresa

"The fruit of silence is prayer.

The fruit of prayer is faith.

The fruit of faith is love.

The fruit of love is service.

The fruit of service is peace."

Mother Teresa

This is a wonderful example of developing our spiritual being using the inside-out principle (Covey, 1989).

What is the purpose of life? This is one of those ultimate questions that everyone should explore, but instead, somehow, we become busy in day-to-day chores and work. Therefore, we too easily forget this, and other important questions; why do we exist, what are we here for, and where are we going? Her journey began with silence to explore her inner world. During silence she started to pray. Her prayer seems to be a contemplative prayer, which gave her faith. Through this process, she began cultivating her inner world. Then, with a suddenness, she met love. In this gigantic moment, her inner world exploration yielded a transformative shift in the focus of her outer world action; to serve people with her love. Through her dedication to service, she attained inner peace.

Mother Teresa reminds us how important it is to explore these ultimate questions. Her inner peace stage resonates with *prajñāpāramitāhṛdaya* in the Heart Sutra of Buddhism, Confucius's final stage attained at 70, and Lao Tzu's desireless mind.

Note by Tony Chamblin: *Mother Teresa was a former schoolteacher who felt a 'calling'.*

"I don't know what I am supposed to do, but I must do something."

She went to the poorest people in Calcutta where people were dying in the ditch, they were being eaten by rats as they lay dying. Her goal became giving comfort to the dying.

X. Finally the West and the East came together under the same Principle

One day, one of Confucius's disciples, Shikou asked Confucius, "My teacher, you taught me a lot of lessons. If I have to choose only one from these lessons and keep for the rest of my life, what would it be?"

Confucius replied: "That is compassion (恕の心). What you do not wish for yourself, do not do to others." (Confucius 551-479 BCE; Analects of Confucius, 1982).

This core value of Confucius's teaching is readily recognizable as the Golden Rule in America. As simple as it can be, but how difficult it is to practice all the time under any circumstances. TPS is a practice-driven learning method, i.e., learn by doing based on respect for people. The core principle of Hitozukuri also lies in the golden rule. Once Fujio Cho was interviewed by a major Japanese television network about his role as part of the unique cultural DNA of Toyota. The interviewer asked Cho a key question, what is the most important value of TPS? Cho's reply was: "that is Aijyou 愛情(compassion) toward people. Without compassion, there is no TPS."

There is a common principle between Confucius' teaching and Fujio Cho's on TPS; compassion toward people resonates between them.

Note by Bill Cooper: *I am so glad to finally see the west and the east come together to send a unified message to the world. I hope we can work to continuously improve following the golden rule within our own IR4TD/Lean Systems group and "practicing what we preach." Only by doing this, can we earn the right to continue teaching and passing on our own learnings from Mr. Cho and other TPS/Lean mentors to new learners as a model of truly Lean research, on-going learning, and teaching. I am extremely delighted to learn that Mr. Cho's name is under consideration to name our new Engineering Technology Department, where strong Hitozukuri and Monozukuri education will be practiced.*

Epilogue

If you are reading this, congratulations! You have made it through a tremendous amount of information and material very different from the usual Lean writings! You likely have many thoughts and questions and hopefully it has stimulated your curiosity and drive to more deeply consider and work to understand the many aspects of what really underlies The Toyota Production System (TPS).

I was very fortunate to join Toyota from their wholly owned North American manufacturing beginnings in 1987 in Georgetown, KY (TMMK), before the facility was finished being built. I spent the next 27 years of my life in a variety of leadership roles on a grand adventure, at the front edge of Toyota's rapid establishment of their North American manufacturing base. After 10 years at TMMK, I

was among the first to lead the startup of Toyota's North American Manufacturing/Engineering Headquarters near Cincinnati (TEMA). And I had the privilege to spend several years at Toyota's Motor Sales (TMS) in Los Angeles. Thus, I have experienced many parts of Toyota throughout my career adventure!

I can honestly tell you that the information presented in this article is extremely valuable and offers a deep, realistic insight behind the walls of TPS. It is very difficult to write about and capture the culture that is indispensable to what really drives TPS success. This article through Dr. Saito's accurate and deep portrayal of Mr. Cho's Gorokus combined with the embellishing comments from the True Lean practitioner staff delivers a tremendous amount of insight into that culture. I would suggest multiple rereads concurrent with reflecting upon your workplace over time to truly grasp, internalize and take advantage of the numerous learning points offered here.

I would like to share a few firsthand stories about Mr. Fujio Cho. We had open offices at TMMK, my desk happened to be the next one over from Mr. Cho for years, but he had special space as the President, a whole 20 feet between his desk and mine! Yes, there was a large walled off President's office available to him, but he had no interest in isolating himself from all of us. He only used this office for convenience when he had visitors. This was not a gimmick, it is who Mr. Cho is, extremely humble and part of the team. I rarely saw him stressed as he came and went from his desk all day since he was constantly out and around the operation. But he had the weight of the Toyota world on his shoulders with the startup of such a huge commitment by Toyota! That smile you see in the picture above was his typical everyday demeanor at TMMK. I only saw him say "no" one time as he was always redirecting while smiling. One group did not catch his redirects as he smiled and nodded for 30 minutes meaning I hear you. The group was unsure if that meant approval so they asked him directly, Mr. Cho, can we spend the money? For an instant he turned off his smile, shook his head and firmly said "no", then back came his smile and the same redirecting he had been giving them. But this time they were listening! He was a teacher who genuinely respected all of us Americans as new teammates at TMMK.

His leadership style spread to all of us as East met West and this became the culture at TMMK and now throughout North American operations. Thus, I can say firsthand that the Mr. Cho Gorokus are very accurate and extremely meaningful! It is difficult to explain the engagement and will to succeed generated in each of us from the respect, coaching efforts and partnership we experienced. And yes, that did translate to very successful business results!

In our True Lean teachings, we work to pass this experience on in our teachings and coaching. We have found it is transferable with the right effort and commitment.

Once again, I think there is much to be gained from reading this article closely and multiple times! Enjoy and good luck!

June 2020

Glenn Uminger

Former Toyota executive in residence and senior member of UK IR4TD/True Lean Systems' program.

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References

- Albert Einstein (1932), in Preface for *Where is Science Going?* Ox Bow Press, pp. 9 - 15.
- Analects of Confucius (1982), translated by O. Kanaya, Iwanami Bunko, Tokyo, Japan, *in Japanese*.
- Capra, F (1991), *The Tao of Physics*, Third edition, Shambhala, Boston, MA.
- Cho, F (1988), A special lecture on Toyota Production System for ME 310 class, Department of Mechanical Engineering, University of Kentucky, Lexington, KY 40406.
- Cho, F (1994), Letter to Kozo Saito, Department of Mechanical Engineering, University of Kentucky.
- Cho, F (1995), Toyota Production System, in *Principles of Continuous Learning Systems*, K. Saito Ed., McGraw-Hill, New York.
- Cho, F (2005), Hitozukuri and Monozukuri, Keynote Lecture given at the 10th Anniversary of Toyota Motor Vietnam, Hanoi, Vietnam, September 13.
- Cooper, W., Maginnis, M. A., Parsley, D., and Saito, K., 2020, "The Model Area in Successful Lean Transformation and Scale Modeling," *Progress in Scale Modeling*, 1(1), pp. 1-12.
10.13023/psmij.2020.08
- Chopra, D (1994), *The Seven Spiritual Laws of Success*, Amber-Allen Pub., San Rafael, CA.
- Covey, S., Merrill, AR, and Merrill, RR (1994), *First Things First*, Free Press.
- Covey, S (1989), *The Seven Habits of Highly Effective People*, Simon & Shuster.
- Dalai Lama, Desmond Tutu, and Abrams, D. (2016). *The Book of Joy, Lasting Happiness in the Changing World*, Penguin Random House, New York, NY.
- Emori, R.I., Saito, K and K. Sekimoto, K. (2000). *Scale Models in Engineering (Moikei Jikken no Riron to Ohyou)*, Third edition, Gihodo Publishing Co., Tokyo, Japan, *in Japanese*.
- Iwatsuki, S (2010), *The Living Philosophy: Toyota Production System, about my teacher, Mr. Taiichi Ohno*, Gentousha Shinsho, Gentousha, Tokyo, Japan, *in Japanese*.

Kreafle, K (2011), A lecture on the eight-step problem solving for ME 565 class, Department of Mechanical Engineering, University of Kentucky, Lexington, KY 40506.

Kreafle, K. (2017), Models, University of Kentucky Lean Systems Program, Lexington, KY, p. 3-32.

Lao Tzu, Tao Te Ching (2012), translated by Gai-Fu Feng and Jane English, Vintage Books.

Maginnis, A. Cooper, W., Parsley D. (2020), "Challenges to Lean Implementation from a True Lean (TPS) Perspective," "International Handbook of Lean Organizations," Cambridge Press.

Merton, T. (1969). The Way of Chuang Tzu, New Directions Pub., New York, NY.

Milward, H.B. (1986). "The estimated economic impact of Toyota on the state's economy.," December 1992, "Review and Perspective: The economic significance of Toyota Motor Manufacturing, USA Inc. in Kentucky; January 1998, "A report on the significance of Toyota Motor Manufacturing Kentucky, Inc. to the Kentucky economy." all published by The Center for Business and Economic Research, University of Kentucky, Lexington, KY 40506.

Miyamoto Musashi (1974). The Book of Five Rings, translated by Victor Harris. London: Allison & Busby; Woodstock, New York, NY.

Parsley, D. (2018). "Regression analysis of factors impacting problem solving engagement within Lean Systems implementation," Ph.D. thesis, Department of Mechanical Engineering, University of Kentucky, Lexington, KY.

Saito, A. and Saito, K. (2011) edited, Seeds of Collaboration: Seeking the Essence of the Toyota Production System, Larkspur Press, Monterey KY.

Saito, K (1995), "Kufu: Foundations of employee empowerment and kaizen," in Principles of Continuous Learning Systems, McGraw-Hill, New York.

Saito, K (1996), Teamwork: What makes "one plus one" greater than 'two', in Principles of Continuous Learning Systems, vol. II, McGraw-Hill, New York.

Saito, K (2000), The art of engineering, in Preface for Scale Models in Engineering (*Moikei Jikken no Riron to Ohyou*), Third Edition, Gihodo Publishing Co., Tokyo, Japan, *in Japanese*.

Saito, K (2008) edited, Progress in Scale Modeling: summary of the first International Symposium on Scale Modeling (ISSM I in 1988) and selected papers from subsequent Symposia (ISSM II in 1997 through ISSM V in 2006), Springer.

Saito, K, Kreafle, K, Salazar, AJ and Grulke, E (2011). "Hitozukuri and Monozukuri: Centuries' old eastern philosophy to seek harmony with nature," *Interdisciplinary Information Science*, 17: 1-9.

Shinagawa, Y. (2019). The 2020 art calendar, Japan airline.

Suzuki, D.T (1973), Zen and Japanese Culture, Princeton University press, Princeton, NJ.

Takagami, K (1968), Lectures on the Heart Sutra, Kadokawa Bunko, Tokyo, Japan, *in Japanese*.

Tani, K (1986), Scoop water with a bottomless pail (*Sokonashi Tsurube de Mizuokumu*), about Zen Master Itsugai Kajiura, Hakujusha, Japan, *in Japanese*.

Toyota Motor Corporation (1980). Open the window, you will see a big world there, Toyota-shi, Aichi, Japan.

Williams, F.A (1985), *Combustion Theory*, Benjamin/Cummings, CA

Wilson, E.B, Jr. (1954), *An introduction to Scientific Research*, McGraw-Hill.

Womack, J.P., Jones, D.T., and Roos, D (1991), *The Machine the Changed the World: The Story of Lean Production*, Productivity Press.