Transitions of Japanese manufacturing methods from the viewpoint of constructing and utilizing explicit and tacit knowledge: the second report: The win-win relationship between tacit knowledge and TRIZ

松原, 幸夫
Former professor at Kyushu University

出版情報：pp.1-12, 2021-09-02. 日本TRIZ協会
バージョン：
権利関係：

Transitions of Japanese manufacturing methods from the viewpoint of constructing and utilizing explicit and tacit knowledge: the second report ～The win-win relationship between tacit knowledge and TRIZ～

Sachio Matsubara (Former professor at Kyushu University)

Abstract

This is the second report in a series; the first was presented at this symposium in 2009. The first report considered societal transition, comparing the Meiji Restoration era in Japan with the period that began after the end of the Second World War. The author hypothesized that the tacit knowledge of the previous era disappears within 50 years, and that society prospers when this tacit knowledge coexists with new explicit knowledge.

The first cycle, which began with the Meiji Restoration, shifted to the second cycle after 75 years. If we apply this pattern to the era that began at the end of the Second World War, we should expect that era's tacit knowledge to disappear and a new era to begin in about 2020. Consistent with this premise, major global cataclysmic events began in 2020.

A new era is dawning. To make this imminent era rich and fruitful, and full of harmony between humans and the environment, we must be more proactive than previous generations in incorporating the intentional transmission of tacit knowledge into education and production.

To achieve this aim, the current study leverages TRIZ as a tool for cultivating in-depth tacit knowledge, examines tacit knowledge as a context that maximizes the functions of TRIZ, and considers the conditions for building a win-win relationship between the two.

1. Introduction

This paper attempts to solve a variety of problems facing modern society by taking a bird's-eye view of historic transitions in Japanese manufacturing from the perspective of tacit and explicit knowledge and clarifying the causes of these transitions.

Tacit knowledge, according to social scientist Michael Polanyi, is a form of knowledge that can be used empirically but cannot be fully explained in words, such as how to play the piano or how to ride a bicycle. The current paper reverts to this original definition of tacit knowledge as knowledge that is not explicable in words, giving the term its broadest meaning.

Section 2 introduces previous studies on the subject. The present author has been involved not only in education related to the invention process but also in fields such as intellectual property and social cooperation; accordingly, the author uses tacit knowledge as a keyword in a wide variety of domains. Therefore, the summary of literature on the subject is quite broad.

Section 3 provides an overview of several decades-long transitions in manufacturing, and considers the factors involved in each.

In section 4, to allow for a detailed discussion of concrete examples of tacit knowledge, the analysis is limited to tacit knowledge specifically related to manufacturing.

Section 5 considers the ideal forms of TRIZ and tacit knowledge to provide a concrete example of how tacit knowledge is used in manufacturing based on the considerations outlined in the previous section.

2. Previous Research

The author's former research, which was selected for a KAKEN grant in 2007, compared Japanese-style techniques for creating inventions with Western-style techniques for creating inventions such as TRIZ, a method based on forecasting patterns in problem solving.

I presented my first report on this topic at the TRIZ Symposium in September 2009. The following month, I gave a talk on the same topic at the intellectual property forum run by "Hatsumei," a journal curated by the Japan Patent Office.

The Kondratiev wave is well known as a theory of long-term economic fluctuation, but there is no clear explanation of the causes of each wave. The present hypothesis that tacit knowledge has a 50-year life cycle could explain what triggers Kondratiev waves.

In 2011, thanks to a Grant in Aid for Scientific Research (C), the author compared tacit knowledge education in highly skilled technology companies in Japan and Europe.

At that time, the Japanese economy was in the grips of a long recession; to address this, the author wrote a paper titled "Learning from the Lost 20 Years." This paper

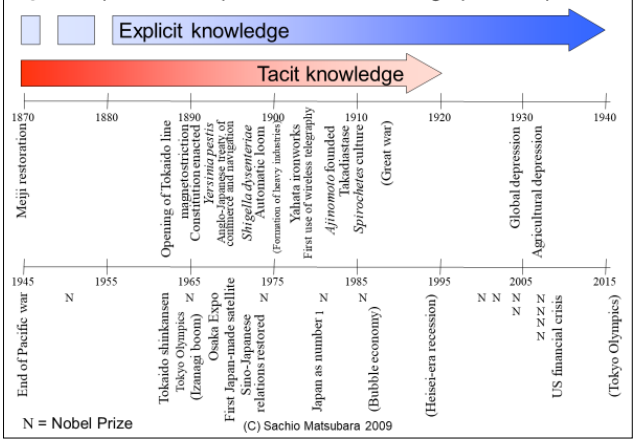
considered how highly skilled technology companies that emphasized tacit knowledge education and management were able to maintain their distinctive corporate cultures and perform well financially even during the economic slump.

In 2017, thanks to assistance from the "North East Think Tank of Japan," the author conducted a survey on professional development in Awashima Island in Niigata Prefecture and Taketomi Island in Okinawa Prefecture. These islands were chosen based on the hypothesis that modern Japanese craftsmanship originated in the craftsmanship culture of the Edo Period, that the craftsmanship culture of the Edo Period in turn originated in the rural culture of that period, and that the rural culture of the Edo Period survives to this day on some remote islands. The craftsmanship culture on both of these islands is similar to what we know about the craftsmanship culture of the Edo Period as described in the literature.

As practical initiatives related to the transmission of tacit knowledge through education, the author has implemented the "Yume Rikkoku Project" (with Nigata University and the Ministry for Education, Culture, Sports, Science and Technology) and "How to Polish Sensibilities" (with the Tokushima University Faculty of Dentistry, Seiwa Joshi Gakuin Secondary School, and the Cabinet Office's Intellectual Property Creation Education Consortium) as well as lectures and workshops at institutions like the Japan Intellectual Property Association.

This study is based on the aforementioned research results.

Fig.1 Comparison of explicit and tacit knowledge pre- and post-war



3. The Wave of Time

> "The farther backward you can look, the farther forward you are likely to see."
> Sir Winston Churchill

Originally, my intent was to focus on manufacturing and economic factors; when the actual periods under study were explored, however, I realized that these were inextricably linked with sociopolitical and natural phenomena, so these were also adopted as subjects for consideration. [1]

To consider transitions in manufacturing from the perspective of explicit and tacit knowledge, it was necessary to find a society that could serve as a reference in order to compare changes. Japan's Edo period emerged as the first candidate for this reference society as it is thought to have been rich in tacit knowledge.

3.1 Learning from history

Currently, the global community is being hit by multiple and repeated cataclysms, forcing us to fundamentally re-examine how our society should operate. Before we can begin to problem-solve our way out of these crises, however, we must acknowledge that any attempt at problem solving will occur in a particular thought framework. Which framework best suits our goals: a Western system such as TRIZ or a Japanese-style system?

TRIZ is a theory about patterns in invention and a methodology for using these patterns to predict future problems and solutions. Its basic premise is that patterns in invention tend to repeat themselves across fields and industries. However, we cannot identify the best direction in which to proceed when we encounter a period of rapid change without thinking about society, how people live, and how craftsmanship should operate.

Given this, what is the optimal direction our world should take to proceed into the future?

When pondering this question, a particular set of quotations came into my head. These were the words of Dr. Shimomura Osamu, a Japanese government official who led the country through a period of rapid economic growth.

1. "The Japanese economy harbours the potential to become a beautiful swan."

2. "Japan should adopt a way of life similar to that which it had in the Edo Period. The dawning era should be one in which our efforts are strengthened in the domains of culture, the arts, and education."

(In 1960, then Prime Minister Ikeda Hayato announced his Income Doubling Plan, which was associated with the catchphrase, "Your salary will double in ten years." It was Shimomura, an economist at the Ministry for Finance, who actually developed the plan. Quotation 1 above was stated when the policy was announced, while quotation 2 was uttered after the country had entered a period of stable economic growth.)

Since that time, Japan and other countries have progressed towards material prosperity. Now we have reached a critical point as we transition into the next stage. Yet the cultural milieu of Edo Japan was completely different from that of contemporary Japan, such that, even if we agree to return to an Edo-Period way of life, we do not know specifically how to go about it.

Decades have passed since Shimomura made his recommendation, but it may not be too late to change course. A first step would be to determine what exactly was the Edo Period of which Shimomura spoke?

3.2 What kind of era was the Edo period?

In the Edo period, no cycle corresponding to the hypothesized 50-year lifespan of tacit knowledge occurred. In the early days of the Edo period, however, the situation was similar to that of the present day.

In the first 50 years of the Edo Period, streets and bridges were constructed and new fields were brought under cultivation in the greatest infrastructure endeavour in the history of Japan. At the end of these 50 years, however, the excessive felling of trees and overdevelopment of forests led to largescale flooding and landslides, and the newly developed land was devastated.

With this in mind, in 1666, the Shogunate enacted the “Mountain and River Law,” completely outlawing future development. The leadership determined that it would be better for Japan’s agricultural production to invest their labour and money into improving fields that had already been developed and to cultivate them more carefully as opposed to bringing new land under cultivation. To encourage more efficient farming, agricultural technology and selective breeding techniques were intentionally improved, and many books on agriculture, collectively called “Nosho”, were published. This technology spread throughout Japan because of initiatives like the Sankin-kotai system, whereby local feudal lords were required to alternate living one year in their local area and one year in the capital, Edo.

In addition, domestic resources were re-evaluated, and silk, which had hitherto been imported, was now produced domestically. New marine products such as kelp, sea cucumber, and shark fin were discovered and developed into major export industries.

To summarize, infrastructure was rapidly developed in the first 50 years of the Edo period, but after those first 50 years, Japan turned its focus on making the best possible use of its existing infrastructure. Using infrastructure in the most efficient way possible did not require much money, and the resulting surplus was converted into tax cuts. As a result, the standard of living for ordinary people improved, the rich Genroku culture blossomed, and, for the next 200 years, the people were successful in establishing a cultural nation.[2]

A kantengi (simplified armillary sphere) at the Asakusa Astronomical Observatory / “100 Views of Fugaku” A map of Asakura Torigoe
(Chiba City Museum of Art Collection)

3.3 The standards of civilization in the Edo period

The Tokugawa Shogunate considered the maintenance of the status quo a key factor in ensuring continued social order, and feared that the Shogunate would be destroyed by the effects of technological progress on society. The types and sizes of the chisels used by carpenters as well as those of the hoes and sickles used by farmers were regulated, and the sizes of ships were also restricted. The technology used in guns and cannons was also intentionally stabilized at the beginning of the period.

In apparent contrast to this suppression of development, the establishment of the terakoya, schools that taught reading and writing to ordinary civilian children, raised Edo Japan’s literacy rate to one of the highest in the world at that time. Ino Tadataka’s map of Japan was more accurate than any other map produced in the same era anywhere in the world. Seki Takakazu (1642–1708) independently and simultaneously developed and began using the principles invented by Newton and Leibniz for calculus. Yasui Harumi (1639 –1715) rejected

the usage of the Chinese calendar in Japan, devising the Jokyo calendar based on the results of his own observations. Asada Goryu (1734–1799) independently discovered Kepler's third law.

In the Edo Period, though the word "hatsumei" was used to mean "invention," this same word was not used in "Shinki-hatto" law; therefore, it is difficult to state that new inventions were forbidden by law. Not only was technological information originating overseas known in Edo Japan, but also, as non-Japanese records from the close of the Tokugawa Shogunate show, a wealth of new invention took place within Edo Japan. [3]

How, then, did the Edo culture persist and flourish in spite of this excess of explicit knowledge and knowledge bias?

It was commonly stated among ordinary citizens that "if you put something on paper, it becomes vulgar." Among the samurai class, likewise, people were aware of the limits and dangers of knowledge and skills, as stated by Yamada Hokoku: "It is impossible to rule the nation if it is not virtuous. There is no place for wisdom." The concept that it was dangerous to write knowledge down in order to pass it on soon spread throughout the population. Truly important knowledge, they believed, could only be conveyed through experience, through the body and the eyes. This approach is reflected in the oral traditions of the carpenters who worked on shrines and other craftspeople.

3.4 The 50-year tacit-knowledge lifespan and the 75-year explicit-knowledge lifespan mean that 2020 marks the transition to a third cycle

The Meiji Restoration, which marked the end of the Edo period, was a massive economic, cultural, and political revolution the like of which has rarely been seen in history.

The Meiji first cycle came to a close in 1945 with the end of the Second World War, a global conflict involving the entire world and causing both victorious and defeated nations to experience tragedies that could not be described in words. These experiences engraved certain tacit knowledge into the minds of those who lived through them. They represent the starting point of a second cycle in Japanese cultural and intellectual history, although because of the global impact of the war, every other country also started a new cultural cycle at the same time. Thus the 75-year cycle has become an international phenomenon.[4]

Two conditions are predicates for the 50-year tacit-knowledge lifespan hypothesis: (1) those who were approximately ten years old at the beginning of each new era inherit the tacit knowledge of the previous era, and (2) assuming that most of those individuals retire around the age of 60, the tacit knowledge of the previous era disappears from the workplace after 50 years. As these conditions are present in most societies, and as most societies experienced social cataclysms in the wake of the Second World War, new cycles began in 1945 not just in Japan but all over the world, although the first cycle (the Meiji period) only occurred in Japan. If we posit that the 50-year tacit-knowledge and 75-year explicit-knowledge lifespan hypotheses hold true, then the various natural and social phenomena currently disrupting our contemporary world may be the result of a loss of tacit knowledge, leading to an excess of reliance on explicit knowledge and an imbalance between explicit and implicit knowledge. Moving forward, the solution is to promote the development of tacit knowledge and to restore the proper balance between explicit and tacit knowledge.

This does not mean that only tacit knowledge is important while explicit knowledge is not necessary: rather, both tacit and explicit knowledge have their own roles and functions. In the modern day, however, societies rely too much on the roles and functions of explicit knowledge, such that explicit knowledge replaces tacit knowledge even in situations where tacit knowledge is essential. This is the source of many problems. Is there an example or role model that offers a solution?

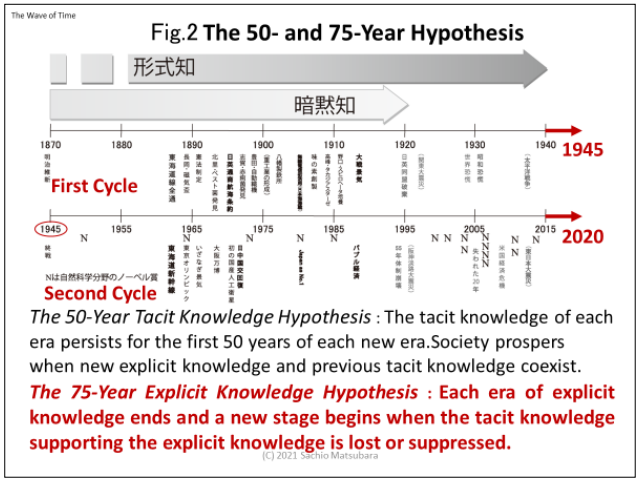


Fig.2 **The 50- and 75-Year Hypothesis**

The 50-Year Tacit Knowledge Hypothesis : The tacit knowledge of each era persists for the first 50 years of each new era.Society prospers when new explicit knowledge and previous tacit knowledge coexist.

The 75-Year Explicit Knowledge Hypothesis **: Each era of explicit knowledge ends and a new stage begins when the tacit knowledge supporting the explicit knowledge is lost or suppressed.**

3.5 Why is society disrupted when tacit knowledge is neglected?

One of the unique characteristics of tacit knowledge lies in its capacity for foresight. Regardless of the period, any society grows and changes like a living thing. It is necessary to accurately identify these small and large societal changes from the various signs they leave and take prompt action in response. This is exactly where tacit knowledge can be most useful.

The neglect of tacit knowledge and overreliance on explicit knowledge are most likely to occur after long periods of peace and stability. In periods of stability, daily tasks can be completed even if only the most formal and superficial knowledge of how to do things is handed down,

so people do not think about the meaning of the work they are engaged in on a daily basis and no longer consider why their work is necessary. Subsequently, the importance of tacit knowledge is forgotten, and the passing on of techniques and legends becomes reduced to a mere formality. In the words of Kobayashi Koji, “A stable company is unstable, and an unstable company is stable.”

To deal with societal change, the most crucial wisdom is not the individual rules in an instruction manual but rather the code of conduct underlying the rules. Going further, the proper mental attitude as espoused by each craft’s code of conduct is even more important, and more important still is how we pass on good mental attitudes to the next generation.

In this sense, the process of shuhari is critical. Shuhari is a concept pertaining to professional development in fields such as manufacturing, tea ceremony, and martial arts that embrace a cycle of “growth, destruction and creation,” as described in the Kondratiev wave theory, and incorporate this cycle into their programs of professional development.

The process of ‘Ha’ (destruction) is incorporated to ensure that the individual acquires not only patterns, which are easy to learn, but also the ability to respond to various changes, as well as the attitudes and tacit knowledge required to respond to new situations. A flexible mindset continues to evolve in the face of social changes and natural disasters.

In the world of traditional crafts, it is important to maintain the traditions learned from those who went before us, yet it is also necessary to continuously innovate in order to preserve these traditions. Tradition can only be maintained by having the foresight to anticipate the changes that will succeed the impending change and by taking up the mantle of innovation for each new era. Managers and craftspeople from long-established companies recognize this Ha of shuhari, so they are able to anticipate upcoming changes.

3.6 Why is Japan approaching this turning point into the third cycle gradually?

Japan seems to be transforming more slowly than first cycle. One reason for this may be our recent experience of the Lost 20 Years, which meant that the process of losing the second cycle’s tacit knowledge began a long time ago. The kinds of sudden and violent destructive processes that occurred at the start of the first and second cycles are not occurring now at the start of the third cycle. As Japan lost the Second World War, the Japanese nation and society tend to be flexible in their ways of thinking, which has allowed them to respond well to the defeats and other upheavals they have experienced. This flexible mindset means that, as soon as the previous generation’s tacit knowledge disappears, the process of destruction begins immediately, and a new body of tacit knowledge was gradually cultivated. This is thought to be the reason why Japan is approaching the current point of transition in a gradual manner.

The first cycle was strongly regimented around the Bushido system, which may explain why attempts were made to preserve the societal system as a form of stubborn explicit knowledge until the very end, meaning that the point of transition became a ferocious point of contention.

3.7 Comparing the first and second cycles and Edo period

At this point I would like to reflect on the similarities and differences between the Meiji period (the first 75-year cycle) and the post-war period (the second 75-year cycle). While these two periods were very similar, there were also some notable differences between them.

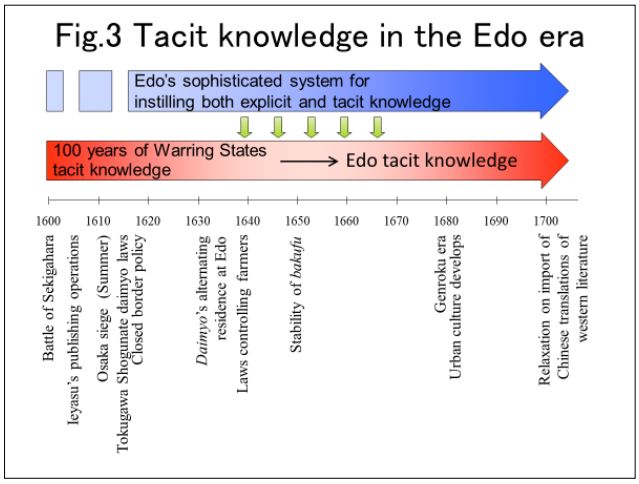
Which cycle does the Edo period more closely resemble: Meiji Japan or post-war Japan? At first glance, it may seem as though the Edo period resembles the first cycle in the sense that both the Edo and Meiji periods were new eras. It should be noted, however, that directly before the early Edo period began, Japan was unified under Nobunaga and Hideyoshi; in that sense, the early Edo period can be said to be more similar to the second cycle in that the groundwork for both the Edo period and the post-war period was laid by the formation of a strong central government. The first cycle, in contrast, emerged amid a period of great confusion: a succession of wars led gradually towards unification. In this sense, the other historical period that most closely resembles the first cycle is the Azuchi-Momoyama period, while the early Edo period, which began in 1600, most greatly resembles the second cycle, which began in 1945.

The development of infrastructure on a previously unprecedented scale is another point of similarity between the second cycle and the Edo period. Likewise, both eras banned military research in order to create a peaceful world with no wars. Another point of similarity is that, in the latter half of both cycles, large-scale infrastructure development led to environmental issues. The vigour poured into the early Edo cultivation of new fields and the post-war plan to double incomes are similar in their emphasis on the economy. Moreover, the recent memory of the tragedy of war means that both periods developed a sensitive and flexible culture.

Post-war Japan poured effort into education, and Edo Japan also made education a top priority. In post-war Japan, the academic excellence of Japan’s elementary and middle schools was the greatest in the world, while in the Edo period, as stated earlier, the literacy rate was the highest in the world. Yet one difference between the

periods is reflected in the content of the education delivered to the youth. Whereas both the first and second cycles encouraged a Western-style education, the Edo period emphasized tacit knowledge as well as mathematics and literacy. Through the terakoya, Daigaku, Onna Daigaku, Jitsugokyo, and Doushikyo, education regarding how people should behave and how society should operate was implemented.

A common saying states that “repeated reading makes the meaning become clear.” Yet learning from a text can be viewed as a form of making explicit learning into implicit knowledge through the process of “fundamental wisdom,” one of the three forms of mastery inherent in shuhari. In this manner, the *terakoya* in the Edo period seemed to be a very strict place, but it was in fact not. Given the ways people were taught through reading and writing, the classroom was so free and uncontrolled that it would seem chaotic by current standards. Here, what Kondratiev refers to as cultivation, destruction, and creation were being carried out simultaneously.



3.8 Deep knowledge and bright knowledge

The tacit knowledge of the first half of the first cycle as well as that of the second cycle involved the kinds of deep thought and wisdom that cannot be accurately expressed in words. However, there are surely some elements that differ between them.

The tacit knowledge of the first cycle was that inherited from the Edo period, received by the common people through what they were taught at terakoya, Daigaku, and Doushikyo,. It was extremely high-quality tacit knowledge, capable of sustaining the society that relied on it for 300 years.

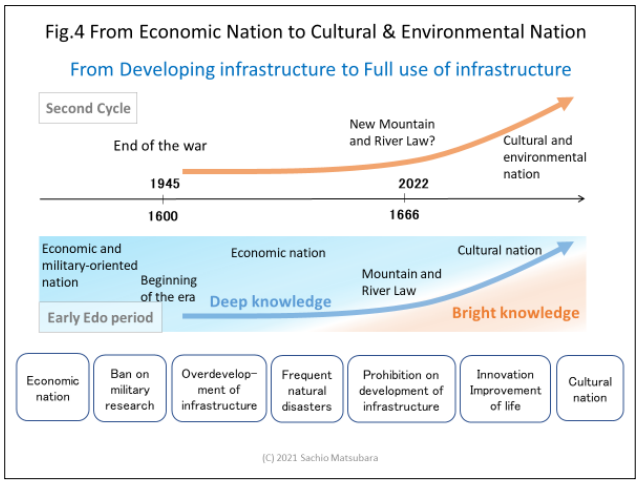
In contrast, the tacit knowledge of the second cycle pertaining to the experience of losing the war can be said to be even deeper tacit knowledge as it obliterated various forms of delusion. However, the situation differs from that of the Edo period in the area of sustainability. Tacit knowledge can only be cultivated and passed on if there is an education system that understands and is particularly aware of such points.

To distinguish these two forms of tacit knowledge, I have named the tacit knowledge of the second cycle “deep knowledge” and that of the first cycle, inherited from the Edo period, “bright knowledge.” If you plough a field deeply, any weeds will disappear; yet bright knowledge enabled people and nature to co-exist for 300 years and can be considered the knowledge that helped Japan emerge as a cultural nation. This is why I chose this name. This bright knowledge, which persisted for 300 years, would have been lost within 50 years if there had not been an education system intentionally passing it down.

It is said that “losers learn more than winners.” When Japan lost the Second World War, we gained a massive amount of tacit knowledge. This tacit knowledge was useful from the outset, but, if we had not worked at improving our mindset in light of what we had learned, it would not have become as useful as bright knowledge.

When a farmer transforms a piece of wild land into a cultivable field, there are usually many different weeds on the land, so the farmer must engage in some intensive weeding for a while and plant good seeds to create a good field. Similarly, if post-war Japan had not incorporated its new knowledge into education with particular attention to the cultivation of tacit knowledge, the tacit knowledge that it had acquired through losing the war would not have become sustainable tacit knowledge. Faced with the beginning of the third cycle, an intense debate is required to determine the form that education should take to cultivate sustainable tacit knowledge.

Could the current deep knowledge be converted into bright knowledge and transform the nation from an economic nation into a cultural one? It is said that chances come with a pinch, but is now not the best time?



4. Tacit Knowledge in Manufacturing

4.1 The difficulty of speaking about tacit knowledge

My first report considered the current status of TRIZ with regard to manufacturing. Therefore, in this paper, I will consider the ideal form of tacit knowledge.

When we write tacit knowledge in Japanese, we write it as 暗黙知 (anmokuchi, literally, “dark [暗] and silent [黙] knowledge[知]”). Yet I do not think that this is the most appropriate translation. The underlying meaning of the English word “tacit” is “silent, unspoken.” There is no sense of darkness in this term. Even if I accept [黙] (“silent”), I cannot agree with the use of the character for “dark.” I think the reason why the character for “dark” is found in the Japanese version is the desire to use compound characters [暗黙] (“unspoken,” “implicit”). There are other translations such as [無言知] (“unspoken knowledge”) that may be more apt. In any case, it is difficult to proceed with a positive argument and discussion while using such a negative definition of tacit knowledge.

When I try to think of words that are similar to “tacit knowledge,” words like “sensitivity” and “sixth sense” come to mind. The word “sensitivity” [感性] (kansei) was coined in the Meiji period. When you translate a phrase including the word [感性工学] (kansei, “engineering”) into English, you usually retain the Japanese term “kansei” in the translation. The reason for this is that, as with many other Japanese words, there is no appropriate English translation. I will continue with my considerations with reference to these two words.

What should we do to cultivate tacit knowledge? The cultivation of that which cannot be expressed in words seems like an impossible topic for discussion. Yet we must remember that some things that cannot be expressed in words may be more important than those that can.

Please understand that what follows can only offer some hints as to the idea of fostering tacit knowledge, which is something akin to trying to grasp a cloud. In this endeavour, it is hard to avoid violating the maxim that “the mediocre have no right to criticize the great.” However, I will state what I believe without fear of misunderstanding or of being misunderstood. It may be that my descriptions of these concepts are only as accurate as the constellations in the night sky, which resemble the majestic characters of Greek mythology but little, yet I hope that we can all discern the same stories in the vague shapes described here.

4.2 Keep it a secret in order to cultivate it

In the manufacturing culture of the Edo period, techniques were kept secret and never committed to print. This was because, otherwise, apprentices could become greater than their masters. Here are some quotations from highly regarded experts of the time:

“You should not simply be receiving knowledge from masters. You should instead be diligently applying yourself with body and soul to surpass your master. This is the essence of Takumi culture.”

Suishinshi, Masahide “Kenkohidensi”

(The Mysteries of Making Swords)

“It is not that I will not tell you because I would hate to or would regret it. Even if I say it innocently, if the apprentice’s skill has not reached a certain level, it will hinder their training.”

Nishioka Tsunekazu, Ogawa Mitsuo, “Ki no Inochi, Ki no Kokoro” (The Life of Wood, the Heart of Wood)

In the Edo period, knowledge was often not committed to print in order to ensure that entire traditions rather than piecemeal information would be preserved and to ensure that techniques, which cannot be adequately described on paper, would be passed on. However, since festivals were not held continuously for art and other non-manufacturing fields, these industries are comparatively well documented so that the knowledge related to them would be passed on. Many of these techniques have been passed down to the present day, to the teams participating in the World Skills Olympics or to individuals working in highly skilled technology companies.

“Short words are best, and the old words, when short, are best of all.” These words of Churchill also apply to Japanese craft culture. When they passed on knowledge, the transmission was oral, not text-based. This was also the case for terakoya and martial arts. That which could not be passed on orally was taught through gestures and other visual cues. When you have truly understood a matter, you in turn may not be able to express it in words.

There is a saying that “he who knows does not speak; he who speaks does not know” (Laozi). Truly, when you understand something deeply, I wonder if it is not that you no longer speak about it but simply that you become unable to speak about it.

4.3 Fundamental training

Repeated practice of fundamentals is especially important in developing fundamental wisdom in shuhari. Through repetitive practice, you can learn things that cannot be conveyed in words.

This relates not only to physical training but also to language. In institutions like terayako, the passing down of old traditions using a small number of words was a pillar of professional development. Even the best old words only have meaning when they are used consistently.

There is a saying that “repeated reading makes the meaning become clear.” In other words, the meaning of a

text that you initially do not understand may become clear through repeated reading, although the knowledge gained by doing so may be somewhat different.

The knowledge gained by reading something one hundred times permeates the five senses and has the potential to change one's actions and one's mind within one's actual life. It sometimes goes beyond the ideas of the original author, and even has the power to develop further.

If you read a detailed primer on a particular topic only once, you can only be said to simply "know" the information, i.e., to be aware of the facts, but not to have steeped yourself in the knowledge. At this level of knowledge, the information does not have the power to change your daily behaviour and thinking.

4.4 How to raise craftspeople [5]

It may seem unlikely that modern people could come to understand the craftspeople of the Edo period. However, carpenters specializing in temple and shrine construction have managed to transmit their traditions and craftsmanship culture with relatively high accuracy from the Edo period to the present day.

The skills, sensibilities, and ways of thinking embraced by these specialist carpenters are acquired physically. They cannot be taught without also teaching the entire lifestyle of the carpenter, but if the environment is prepared, they will grow within each trainee. The job provides the context for this learning, and the trainer will push through when it matters.

Japanese craftspeople have long known that certain things cannot be taught using words. If they did not willingly move away from a strict reliance on words, they would no longer be able to speak with their heads and their bodies. To encourage their trainees to think, Japanese craftmasters do not begin by teaching. While crafting things and cleaning up, trainees learn to think with their hands. Through a devotion to one single thing, humans refine themselves. Master carpenter Nishioka states, "There is no master who is not clumsy. If you devote yourself to a single thing, you will refine yourself and grow. Constructing a sincere ands strong building, that is the sole method of cultivating an apprentice."

4.5 Know the earth [5]

Wood is the partner of the carpenter. Nishioka was the master carpenter who worked on the Horyu-ji temple. He was told by his grandfather that, "in order to know about trees, we must know about the earth that nurtured them. In order to know about the earth, go to school." Nishioka attended an agricultural school; after graduating, he immediately spent a year working in farming without engaging in carpentry.

In modern times, likewise, the managers and engineers at highly skilled technology companies in Japan still plant and harvest rice and plant vegetables in their gardens on the weekends.

One founder of foreign IT company not only nurtured love of calligraphy and woodprint but was also a vegetarian with a deep knowledge of Zen and Japanese archery who enjoyed vegetable gardening in his spare time.

I once interviewed an engineer at a highly skilled European company called Hidden Champion. During the long summer days, he habitually finished his work on time and went home to tend his kitchen garden. During the winter, he would engage in some kind of handicraft at home after work. After his child was born, he bought a second-hand car in poor condition and repaired it, fixing the broken parts one by one; when the child had grown up, he gifted it to his child as a classic car.

In both Europe and Japan, areas where metal processing is common were originally farmlands. During the winter, when the land is infertile and the people cannot cultivate crops, many people take on a side job of metal processing in the winter.

4.6 Work and play

Almost none of the craftspeople of the Edo period left behind any records. The only evidence we have of their craftsmanship is the products that survive to this day. Except for the most famous among them, no authors' names were left on the works. Moreover, from the perspective of the Japanese people at the time, because the work of craftspeople was so commonplace, it was a culture with a nonlinguistic character, and we are forced to rely on the descriptions of non-Japanese people who came to Japan at the end of the Edo period to understand it.

How did the craftspeople of the Edo period work and play? The following descriptions are found in "Remnants of Days Past: A Journey Through Old Japan." [6]

· Japanese craftspeople have an instinctive and strong sense of beauty, so whatever they produce, whether they are trying to make money from it or not, is beautiful. When you go to a shop that deals in the kinds of cheap ceramics that common people use, there is a beautiful shine from the colours, shapes, and decorations. … Here in Japan, even on the kitchen tables of the poor, you will find the finest quality and greatest attention to detail. (Alice Bacon, p. 223)

· Morse was not only surprised by the incredible artistry evident in the products of craftspeople even in small rural towns and villages but also angry at the comparatively shoddy work of the rural carpenters in his own country. This writer believed that the crucial

difference was that Japanese craftspeople "learned the job" and "felt a sense of freedom as they worked." (p. 227, 228）

・ "I have seen people work as much as they can within the scope of their lifestyle, and I see them living only to enjoy life. Against this backdrop, the craftsmen were passionate about what they made. It doesn't matter how many days it took them to do their work. … They would only be released from the job when they were suitably satisfied with it. When they get tired, they leave their workplace, go out with their friends in the area around their house, and rest up to their heart's content." (Annebelle,p. 236)

From these texts we can see that, after devoting themselves entirely to their work, craftspeople had time and space to relax in nature and chat with their friends. It is said that the townspeople of Edo gathered with close friends on the beautiful nights of the full moon and drank until the morning. The craftspeople of the Edo period understood work as a form of happiness.

When you enter a world without words, your spirit is free to relax. A conversation begins with animals, plants, and the wind, and the rhythm of nature returns to your life. When your spirit is enriched, you become creative and are full of joy. Tacit knowledge serves as the soil in which the ideas born through TRIZ can flourish. Since tacit knowledge itself is born of nature and culture, will the ideas that arise from it not bear fruit and exist in harmony with the environment?

There is a saying that "the personality of the person who created a technique is manifest in the technique. Engineers constantly need to cultivate personality" (Niwa Yasujiro). Tacit knowledge cultivated within nature and culture and the products created by an engineer who aspires to a bright future will surely bear good fruit.

4.7 Being optimistic

"I am an optimist. It does not seem too much use to be anything else." Sir Winston Churchill

Tacit knowledge offers a bird's-eye view of the past and future from the perspective of deep insights. Taking a long-term perspective, the future will incorporate more freedom of thought, such that options that are impossible in the short term will become possible in the future. People will be free to choose from many options including those that offer a bright and hopeful future, so they will always be optimistic when tacit knowledge is plentiful.

The people of the Meiji period not only practiced execution and decisiveness; more than anything else, they were extreme optimists. The people of Meiji Japan adopted Western technology and culture as a form of explicit knowledge; in terms of tacit knowledge, however, they were extremely optimistic as they retained the spirit of the Edo period. That is why they were able to surmount difficulties that seemed impossible and move from strength to strength. The phrase "Japanese spirit with Western learning" is common; is this not the best mix of the ethos of the Edo Period and Western civilization? Ninomiya Sontoku stated the following regarding the importance of holding a long-term perspective:

"Those who plan for the distant future will be wealthy; those who plan for the short term will be poor.

Those who plan for the distant future plant cedar seedlings that will grow for 100 years.

Moreover, they are rich because of the bounties that are planted in the spring and bear fruit in the fall.

Those who plan for the short term do not plant things that grow in the spring and bear fruit in the fall. They take without hesitation because of the richness of what they see in front of their eyes.

They only cut down what is in front of their eyes without planting.

That is why they are poor."

There is a way of thinking that states that, in order to cultivate tacit knowledge, a special capacity for foresight is required. However, when you are freed from the work that is in front of your eyes, you achieve a sense of peace of mind, and your mind will begin to expand and move on its own. From the distant past and stretching far into the future to the time of your descendants, freedom will spread, and your spirit will be free to look around while you will be empowered to figure out new methods of achieving things, methods that will appear obvious once you have thought of them, as well as to identify the path that you should walk and the form that you should adopt.

When we sometimes divert our gaze from the everyday and place ourselves within nature and listen to the sounds of the koto and the shamisen, will we not find a path forward?

5. The Win-Win Relationship between TRIZ and Tacit Knowledge

5.1 *Shuhari* and TRIZ

Moving forward, our society needs to find ways to promote and speed up the cultivation of tacit knowledge. Before discussing that, however, I would like to re-examine the relationship between tacit and explicit

knowledge. Tacit knowledge is fostered when a student learns the basics of a craft and when that student goes on to deepen his or her knowledge. If the learning process is limited to these two stages alone, however, both technology and individual mastery will stagnate and become frustrated in the long run. To avoid this, in both Japan and the West, the idea of a craftsperson's journey has long existed. Throughout the history of craftsmanship, craftspeople have sought to deepen their skills while also maturing as craftspeople. It may be said that this craftsperson's journey fulfills the need for *ha* as imbued in the concept of *shuhari*.

Modern engineers are often required to resolve issues quickly; TRIZ, however, presents the principles of invention, not the elemental technology that solves issues. Therefore, engineers who use those principles require the capacity for deep insights. Only those who have undergone sufficient training in the shu (traditional wisdom) and ha (breaking with traditon) of shuhari have the ability to discern what is useful from among the many principles of invention. Traditional wisdom and deep thinking can be viewed as processes that hone the sensitivity of the engineer.

During this fundamental training, it is important to eliminate the base knowledge processes of TRIZ. This is comparable to the process of fermenting alcohol, in which, during the period of fermentation and aging, the temperature must be controlled from the outside, and it is better to keep the alcohol in a warehouse that is isolated from outside effects.

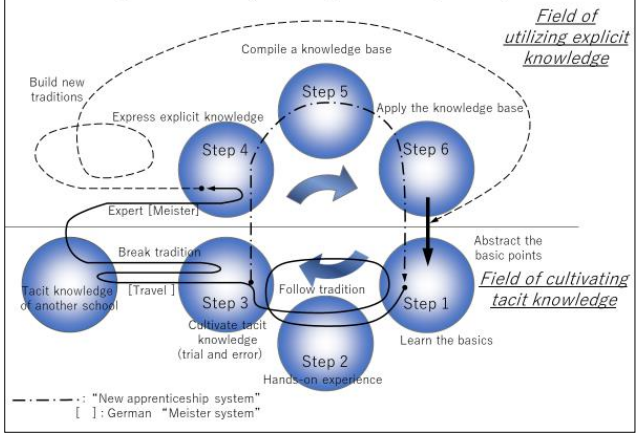
TRIZ and tacit knowledge are like the two wheels of a bicycle. The process of fundamental training that allows a craftsperson to cultivate tacit knowledge was originally a time for dialogue with one's own sensitivities in which one thought with one's hands and feet, using all five senses without prejudice, in tandem with the materials and tools that are used to solve technical issues.

There is no question that this is a most important time. After this process, however, incorporating the TRIZ principles can obtain a new perspective and a deeper understanding of the process of developing tacit knowledge.

There is a method that attempts to use TRIZ to skip over the fundamental training and deep thinking stages to suddenly obtain a solution (described in my first report). TRIZ, however, can be a tool to overcome stagnation after the process of fundamental training and to activate the process of deepening one's thought. In other words, it can be said to be a tool for the activation of tacit knowledge, but not a means of eliminating the need for tacit knowledge.

However, if it is used carelessly in the deepening process, it may destroy the very process itself. It is important that it is leveraged under the guidance of a good leader for the appropriate person in the appropriate place at the appropriate time. The more comprehensive the fundamental training, the deeper the deepening process, and the more expansive, deeper and richer the development process will grow.

Fig.5 Creation cycle of apprenticeship in Japan



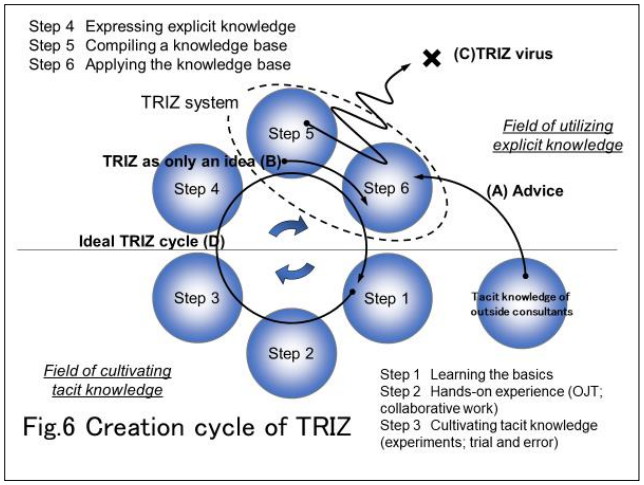


Fig.6 Creation cycle of TRIZ

5.2 What TRIZ can do for tacit knowledge

The following is a summary of what TRIZ can do for tacit knowledge.

1) Regarding the shu in shuhari, TRIZ can be used to organize the concepts and express the steps required in basic training in words. This method can be used to create basic texts on a craft.

2) Regarding problem solving, TRIZ can be used to organize concepts that have not yet been put into words and convert them into explicit knowledge. TRIZ can be leveraged as a tool to clearly express what is not in words. TRIZ can function as a bridge connecting the world without language to the world of language. The processes of organizing concepts and the verbalization of concepts themselves may allow inventions to evolve and develop.

3）TRIZ can replace the function of craftsperson's journey as part of ha of shuhari. In the apprentice system, craftspeople learn the process of ha as part of shuhari from within the "journey of the craftsperson." In modern times, this craftsperson's journey has disappeared, and it is thought that TRIZ can replace its function. Even in modern times, in the large-scale construction of temples and shrines, the finest shrine and temple carpenters from across the country gather, pitting their skills against one another and learning from each other.

4）TRIZ leverages the ri (transcendence) in shuhari. By going through the TRIZ process, the research results developed through a person's own efforts can be further expanded in many ways.

5）In future generations, if we take the "full utilization of infrastructure" as a lesson emanating from tacit knowledge, we can expect TRIZ to be a useful tool in realizing this full utilization. To this end, new inventive principles of TRIZ is expected to be developed.

5.3 What tacit knowledge can do for TRIZ

"Human emotions are at the centre of academia. Today's emotions will be the creativity for tomorrow." Oka Kiyoshi, world famous mathematician

1）Since the materials and tools that are the target of research and development can become deeply known through traditional wisdom and through breaking with such tradition as part of shuhari, tacit knowledge will yield the ability to gain deep insights into technical problems.

2）Tacit knowledge has the potential to foster sensitivities that will enable the selection of optimal principles and technologies from the variety of extant principles for innovation and elemental technologies.

3）Tacit knowledge makes technology more human. Because tacit knowledge makes the personalities of engineers who use TRIZ constructively harmonious, the technology born from their cooperation will also bring a sense of harmony to humankind and the environment.

4）TRIZ is like medicine in that it must be used at the right time and in the right place. Not only is TRIZ used as an appropriate tool for research and innovation; tacit knowledge is utilized as a tool for professional development to foster young engineers in a comprehensive manner.

5） As Kobayashi Koji stated, "Tacit knowledge gives power of choice without being swept away by the progressively expanding waves of knowledge and information. At such times, be aware that the important information will not reveal itself." Rather, one must seek it out intentionally. The more information one has, the more necessary discernment becomes to identify good-quality information. Tacit knowledge enables us to sift out good information like gold dust from the sand at the bottom of a river. Tacit knowledge nurtures the ability to discern the optimal invention principles that will bring harmony and prosperity to both the environment and society from among the many solutions provided by TRIZ.

6. The Japan of the Future and the Future of the World

"The best way to predict your future is to create it."
Drucker

6.1 Tacit knowledge in its narrow and broad definitions

Tacit knowledge ranges from technical tips and know-how to things that relate to all areas of people's daily lives, life itself, and society as a whole. The tacit knowledge of the shuhari cycle, as discussed in the first report in the context of the TRIZ invention creation cycle, can be said to be a type of tacit knowledge in its narrow sense. In fact, even people who are not aware of TRIZ generally believe that how a person uses his or her leisure time, i.e., time that is not spent on manufacturing, is deeply related to that person's capacity for innovation and creation.

I have interviewed key people in highly skilled companies that are world leaders in technology. On their days off, these people tend to engage in farming; to work in vegetable gardens; and to have a deep knowledge of fine arts, literature, and cuisine. They all share an unexpected common trait: each one has a favourite restaurant that has honed its craft to the same degree that these technology managers have honed their skills in manufacturing. These restaurants are not necessarily haute cuisine, but they are home to chefs who are as trained in their craft as the managers are trained in their own crafts. They look as if they are enjoying life in every respect.

When I was hired by a company for the first time, I was told by a manager that I should watch "Nichiyou Bijustsukan" (The Sunday Museum) every week on NHK, read the classics, and listen to classical music. I am still thankful to this day for these three pieces of advice.

In the Edo period, to cultivate sixth sense, it was necessary to hone the other five. In other words, by enjoying nature and culture, arts and music, clothing, food, and housing to your heart's content, you can foster a fresh sensitivity and enjoy both work and leisure.

While these people pass on tacit knowledge in a narrow sense as part of the cycle of shuhari as it relates to manufacturing, they also go through a cycle of tacit knowledge in a broad sense in their leisure time. In

developing TRIZ, tacit knowledge in a narrow sense but also in a broad sense (i.e., getting close to nature and culture) is important. The next figure shows this.

The three keywords of nature, culture, and the future represent the essence of what I learned from my survey on Taketomi Island. A positive future requires that people are recharged through nature and culture so that they nurture even bigger dreams, hopes, passions, and ambitions as they think about the future. I think that, if the people of the Edo period were alive today, they would encourage us to look to these three keywords as we step into our new era.

6.2 Tacit knowledge will save the world

Our modern society is currently grappling with a major predicament in the form of the novel coronavirus. Yet this crisis also offers the opportunity to develop tacit knowledge. Tacit knowledge can never evolve while it is closed off and kept separate from practical experience. In the spirit of self-help, in response to a problem in front of us, both explicit and tacit knowledge are fully leveraged, and, when we do our very best, tacit knowledge evolves from deep knowledge into bright knowledge. As tacit knowledge evolves, our various shortcomings and problems disappear. TRIZ can function as a catalyst to promote a synergistic reaction between tacit knowledge and explicit knowledge, working towards this evolution.

As seen above, I have described explicit and tacit knowledge in great detail although both can be difficult to express through language alone. Speaking in the style of tacit knowledge itself, in short, it involves running around in nature, turning everything into play, and enjoying it. When you have been recharged, you do your best at your work. When you are tired, you sleep soundly. When you want to eat, you eat, and everyone sings and dances together. Through this, you will remember that there is a world in which ,without any word, you can communicate with anyone in any country, little birds, flowers, trees and even the wind. If that is all it takes to make everyone able to live happily, there would be nothing more incredible.

I hope that a powerful advantage can be obtained by diving deeply into both leisure and work as part of your human nature, and by incorporating the depth of tacit knowledge that can only come from embracing your full humanity into manufacturing and invention.

I would like to thank all those who supported me in the writing of this document.

(Date of submission of the manuscript - July 16th, 2021）

References, Notes

[1] The relationship between sociopolitical and natural phenomena is described in “Great Learning”, one of the Four Books, a set of foundational texts in Confucianism.)

[2] My essay on the JPDS blog.

[3] Kobayashi Satoshi, “Edo Jidai ni okeru Hatsumei Sosaku to Kenri Hogo” [Creating Inventions and Protecting Rights in the Edo Period], Sosaku Patent, 2008-54-Vol.61 No.5

[4] Although the political event known as the Meiji Restoration occurred in 1868, the cultural and intellectual starting point of the Meiji period can be placed in 1870, when the new educational reforms were first implemented. Therefore the cultural Meiji period, which ended with the educational reforms implemented after the Second World War in 1945, was exactly 75 years long. For our present purposes, the Meiji period represents the first of several cycles in Japanese cultural and intellectual history.

[5] Ogawa Mitsuo, “Toryo / wazawo tsutae hitowo sodateru” 2008

[6] These English quotes from non-Japanese people include translations from Japanese to English.