Meta-engineering that promotes innovation

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The Engineering Academy of Japan has the Committee on Technology Policy that proposes effective policy upon analyzing what kind of science and technology policies are necessary from the standpoint of engineering for society. Under this committee, a proposal for the science and technology on which Japan should focus was presented. Motoyuki Akamatsu, the executive editor of *Synthesiology*, interviewed Dr. Hiroshi Suzuki, the chair of the task force for this proposal. He discussed "meta-engineering" and the relationship to synthesiology.

Synthesiology **Editorial Board**

Hiroshi Suzuki: Technology Executive, General Electric International, Inc.
Motoyuki Akamatsu: Executive Editor, *Synthesiology*

What is meta-engineering?

(Akamatsu)

The Committee on Technology Policy, the Engineering Academy of Japan, set forth "meta-engineering" as a "proposal for the science and technology on which Japan should focus". I read the proposal, and it states it is necessary "to propel radical innovation that does not stop at the application of science and technology to exposed issues". What exactly is meta-engineering?

(Suzuki)

In the United States, cloud computing, smart grid, and iPod and iPad are coming out as innovations. On the other hand, while Japan is said to be extremely good at engineering, capable of making excellent products, and has competent craftsmen, not so many innovations are coming out from Japan. We intended to explore the reason at first.

There are many definitions for engineering, and it is often defined as a way "to provide an optimal solution under a limited given condition". We asked ourselves whether that definition was sufficient. We may obtain a totally different answer that may lead to innovation, if we start openly by removing the limiting conditions, not by narrowing things down. In studying innovation, we decided to look at "converging technology (CT)", which is a way of thinking about science and technology in the United States and the European Union. If this fits well in Japan, we can think of a Japanese-style converging technology. That was the starting point of the task force.

What is the American-style converging technology?

(Akamatsu)

You mean you started from the research of converging technology, and found that it was not the goal in Japan, and you came up with the concept of "meta-engineering"?

In 2002, the National Science Foundation and the U.S. Department of Commerce released the "Converging Technologies for Improving Human Performance". Since then, Europe and other areas have offered various definitions.

(Suzuki)

CT, as well as meta-engineering, starts with identifying what the future challenges will be and exploring what sciences and technologies will be needed for them. In the final proposal of CT, the four fields of NBIC – nanotechnology, biotechnology, information technology, and cognitive science – are said to

Dr. Akamatsu (left) and Dr. Suzuki (right)

be the core technologies. It also says that any single field of them will not be enough to address global issues and that converging multiple fields will be necessary. “Converge” means “to bring together”. While the four fields of NBIC are originally independent, they should be converged keeping the original parts.

(Akamatsu)
Does that mean that they do not merge to create a new field?

(Suzuki)
It’s okay if a new field emerges, but the original fields must also remain.

It is “converg-ing” rather than “converg-ence” probably because the Americans want to express the dynamism that things are occurring this very moment. In some places like Europe and Korea, it is called “convergence technology”. I think this shows the character of the countries.

Japanese soccer is like Japanese innovation: why?

(Akamatsu)
The keyword of the American converging technology is the “expansion of capacity”, and it seems to be trying to create a future of technological utopia. On the other hand, Europe seems to be dealing with the problems at hand.

However, I feel there is no clear picture of the specific issues, or what must be solved by NBIC. In the task force, did you discuss what is insufficient about CT?

(Suzuki)
When we were discussing, the Japanese national soccer team came to my mind. They’ve got wonderful skills, are good at passing, and dominate the ball 60 % of the time in international matches. They are excellent at passing to switch sides. However, when they advance before the goal, no one shoots. They can’t score. They end up with a draw at best. The Japanese soccer shows the situation of the Japanese innovation. The countries that can score and win aren’t necessarily great at teamwork, though they certainly have wonderful individual skills. But they’re capable of those scoring shots, and show superior concentration when they have the chance to score.

In the United States where innovations continue to flow out, the Americans are great at picking out unseen issues. They find issues to which they want to find solutions, and then spend full-force effort to find the solutions. The Japanese are good at finding a solution for a given issue under limited conditions, but are very weak when they are told to “think of something” without any limits or conditions. You cannot score unless you approach the unseen issues and seek solutions. You must think what is behind the visible issue, what are the real issues, and what are the hidden issues.

We lack the ability to find unseen or potential issues, and then to solve them using science and technology. We thought those were the issues for Japanese engineering.

Japanese and American engineers think differently

(Akamatsu)
You mentioned that the Americans are good at finding the issues while the Japanese are good at solving problems under certain conditions. I think there are American and Japanese engineers working at General Electric. Do you see their differences?

(Suzuki)
I think they are different in the way they come up with ideas. When a Japanese company does business, it thinks, “We are capable of doing this. How could we make this into business?” However, in the GE style, the thinking is, “We, as GE, want to do this kind of business”. A project starts in a top-down style, where the top people think what we have, what we don’t have, and what we should do. In Japan, the bottom-up style is very strong, where the technology that the company possesses is molded into a new product.

(Akamatsu)
The bottom-up approach is a way “to capitalize one’s strength”, and this method was a textbook example of diversification during the period of rapid economic growth. In the case of GE, this isn’t necessarily the case.

(Suzuki)
That’s right. We often refer to “total available market (TAM)”. For example, GE was very strong in power generation, but withdrew from the electric power network business 20 or 30 years ago. However, there is an 80 trillion yen market for electric power around the world, and we decided to take up electric power network business again. The technology remaining at GE was for transformers, and there wasn’t anything for the breaker or the power system control. So we considered what we had to do to restart the business. Since we had hardly any technology left, what do we do to fill in the lacking technology? The options were: engage in R&D ourselves, acquire companies, or form partnerships with others.

In the case of a Japanese company, if it has the technology for the transformer, it tries to do electric business by making a line-up of peripheral products for the transformer. It is totally different.

(Akamatsu)
GE is not of the bottom-up style. I think the corporate

management is not in that style. Do you think there are differences in ways the on-site Japanese and American engineers come up with ideas when they're faced with "the company has this policy, and I want to do this"?

(Suzuki)
I think there is. I don't know the reason. Perhaps it is education. In the Japanese elementary school arithmetic class, they ask, "What is 5 plus 7?" However in the States, they ask "what two numbers do you add to get 12?" If it is 5+7, the only answer is 12. I think the Japanese students are fed this type of problems and have grown used to it.

I often use the example of a Japanese air conditioner. It is highly efficient. It uses intelligent inverters and heat pumps, and utilizes very fine technology. Also, the hybrid vehicles combine the gasoline internal combustion engine and the battery motor in a sophisticated manner. Since the Japanese are capable of such skills, they try to solve problems in that manner.

(Akamatsu)
I see, so you suggest meta-engineering because that is what is lacking in propelling innovation in the Japanese science and technology.

(Suzuki)
We decided to call the effort where the potential issues are found and solved by removing the limitations as "meta-engineering". We also considered the other names such as "holonic engineering", "comprehensive engineering", "ecological engineering", "transformative engineering", or "Japanese converging technology", etc.. However, since we wanted to redefine it as metaphysical engineering as a level above current engineering, we decided to call it "*konponteki* engineering" in Japanese. The word *konponteki* translates into "radical" in English, but that may also mean "aggressive" in Japanese, so we call it "meta-engineering" in English.

Dr. Hiroshi Suzuki

Meta-engineering is to circulate the four processes in a spiral

(Akamatsu)
You mentioned that the process of finding the issues is important in meta-engineering.

(Suzuki)
That is the starting point. We call them the four processes. First, one finds a potential issue or buried issue, and then finds the necessary science and technology to solve it. If the issue cannot be solved by current science and technology, the fields and technologies are integrated. Finally, the solution to the issue is implemented. Then, a new issue is found in this process. The image of the four processes turning round and round is important.

(Akamatsu)
On that "turning round". It seems that the process of finding a potential issue, selecting the necessary technologies, integrating them, and then solving the actual problem is a complete process in itself. Why do you have to return to the process of finding new issues?

(Suzuki)
One is that innovation is meaningless unless it continues. As the process turns round and round, society gets better cyclically, or the innovations occur continuously. We want that to happen.

(Akamatsu)
In that sense, it is a spiral rather than a cyclical feedback. It means that, the world may change by introducing new things, but some other potential issue arises because of that new introduction.

The most difficult part, I think, is the discovery of the potential issue, but what is the key point to this?

Point in discovering the potential issue

(Suzuki)
I cannot find a specific plan, but let us think in terms of marketing.

A salesman visits a client, and the client says, "I want to drink some juice". In a Japanese company, the salesman will purchase an expensive juicer and some fresh fruits, makes juice, and takes it to the client. The client is 100 % satisfied and may buy the cup of juice for 10 dollars. However, it actually costs 9 dollars to buy the juicer and the fresh fruits. The cup of juice sells for 10 dollars, so the profit is 1 dollar. In a Japanese company, this is evaluated highly because the customer satisfaction is 100 %.

However, when GE looks at the root of the issue, if the client says, “I want some juice”, the salesman will ask, “Why do you want juice?” When the client answers, “Because I’m thirsty”, the salesman comes back with water to sell. This will solve the issues of the client’s thirst. Another client may say, “I want cola”, but maybe he is just thirsty. Then, the salesman sells cups of water to, say, 10 thirsty clients. If he sells water for 1 dollar a cup, the sales will be 10 dollars. Since the original cost of water is low, for example, if the original cost of 10 cups of water is 5 dollars, the profit is 5 dollars.

As you can see, the way of doing business is different, but I feel that the process of asking “what is really necessary” is lacking in Japan. I think the engineers themselves must work on the issues with such an attitude. The Japanese look at “how”. The “how-to” books sell well at bookstores. But behind the “how” is a “what”, and one must investigate what is really important and “why” it is important to get to the hidden or potential issues. I think this is fairly close to synthesiology practiced at AIST.

(Akamatsu)
Taking the example of the juice, “what” is the level where the person is saying he wants juice, and “how” is what kind of juice should be made. But “why” will investigate the reason the person wants juice, and that’s because he’s thirsty.

In conventional engineering, “what” is given as a problem, and the engineer figures out “how” to make something. You are suggesting that the engineer must return to the cause of “what” and look into “why”.

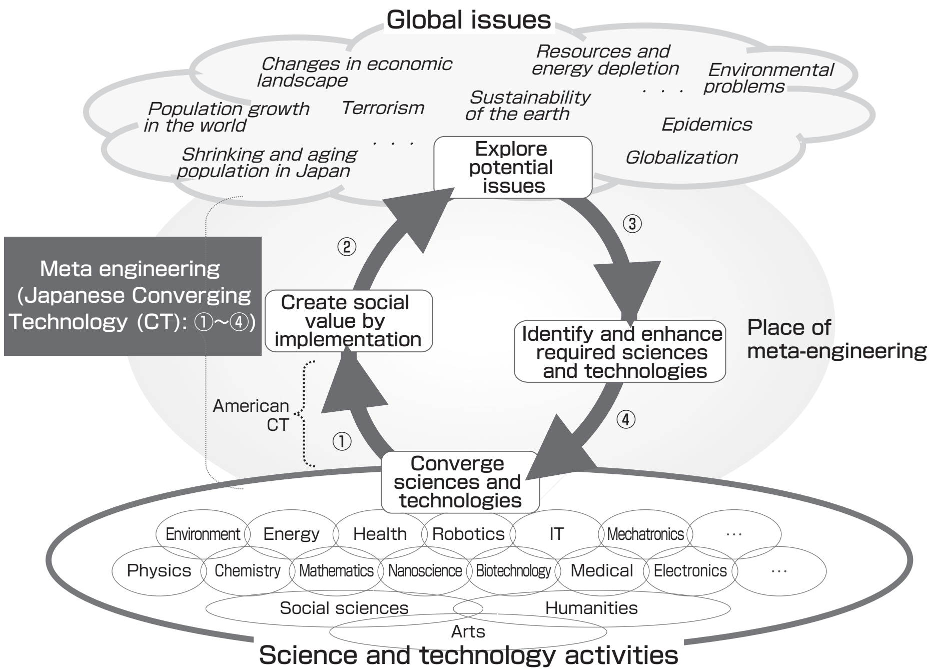
(Suzuki)
Discussions are continued in our task force, and I think there are two major points. One is education. How can we educate people who can realize such things through education? Another is to research meta-engineering itself. Including case studies, can we study it academically? Currently, we are pursuing these two lines.

In education, debate is always a part of the courses in the United States. The discussion progresses by changing the settings and perspectives. Debate is not preferred in Japan.

(Akamatsu)
To switch the perspective and discuss what should be done; I feel this type of training is insufficient in Japan.

(Suzuki)
The other day, there was a symposium on security by photographing the people on the streets, organized by the Engineering Academy of Japan and the Royal Academy of Engineering of U.K. From Japan, there were discussions about how pattern recognition could be accomplished by TV cameras and at what angles the cameras should be set. The U.K. started the discussion on the institution itself, of how to protect personal information while maintaining national security. I felt that the way of looking at things was fairly different.

(Akamatsu)
I think the engineering people in Japan are accustomed to not saying anything about the system. Their job is doing technological things.



(Suzuki)
Yes, exactly. They think that is the proper thing to do. I think it will be interesting to do education that removes that kind of framework.

(Akamatsu)
I think the shift in perspective is important, and engineers tend to get fixed perspective if they stay in one place too long. I'm sure there are many technologies in GE, but do people go to different sections?

(Suzuki)
At GE, mobility is fairly high. Someone in sales may go to marketing, or become in charge of acquisition, which we call business development, or do project management. People experience different types of work to enhance their own expertise. If one stays in a position for 18 months, you earn the right to move to another section.

(Akamatsu)
So it is a right. Are there incentives to encourage mobility?

(Suzuki)
We have an intranet web-site for recruitment. It is called COS or career opportunity system, and it shows which country, what position, and what kind of work types requires people. It allows people to obtain information about their destination easily. Also, the salary format changes when one changes position, and that can be a great incentive. If the person is capable, the salary increases for sure, and that is a powerful motivation. Of course, the person may also loose a position.

Contact point of synthesiology and meta-engineering

(Akamatsu)
When considering the promotion of innovation through meta-engineering, the discovery of the potential issues is important, and shifting the perspective is important to make such a discovery. What else do you think other than case study research will enable this?

Dr. Motoyuki Akamatsu

(Suzuki)
We don't have any specific ideas yet, and I don't know whether it is better to collect the successful innovation stories or find examples of failures of why something did not lead to innovation. Japan is good at manufacturing and many great products have been made, but what is its limit? It will be interesting to investigate this topic.

Returning to the "what" and "how", when we talk of *monozukuri* or "thing-making", it is the multiplication of *mono* or "thing" and *tsukuri* or "making". Japan concentrates on the "making" or the "how", whereas perhaps the "thing" or the "what" may be more important. I think both "what" and "how" are needed to do "thing-making".

In the Unites States, the emphasis is on the thing they make. Therefore, if they are not good at making it, the making part can be outsourced. If many things are made, they can figure out a way of doing it well. If things are multiplied, that eventually leads to great innovation.

(Akamatsu)
In a company, even if the engineer has an idea, this idea may not go into the process of product realization, or the decision-making manager may not give the go to any product other than the one that already exists. I feel there is a lack of decision-making ability to create products with totally different way of thinking. In that sense, are there some relationships between technological management and meta-engineering?

(Suzuki)
I think there is a close relationship. The management in technological management is not necessarily the same as the management of business. It is how one can use a certain technology well. In the example of "thing-making", I said it is the multiplication of the "what" and "how", and I think "technological management" is the multiplication of "technology" and "management". Even if you've got good technology, it won't be useful without good management, and good management won't be effective without good technology. It is necessary to build up this balance through multiplication. I think meta-engineering can play a significant role here.

(Akamatsu)
Then, can people who have been doing only management do meta-engineering? In synthesiology, we think that a person can take the next step because he/she is highly knowledgeable about the technology of the research subject. I think this is a prerequisite for a researcher, but how is it for meta-engineering?

(Suzuki)
Since we are discussing mostly about technology, I don't know whether it is directly linked. There was an interview article with Dr. Lester[Note)] in *Synthesiology*. What Lester and Piore mention in their book *Innovation*: *The Missing Dimension* is that "innovation will take place interpretively rather than analytically". We felt that Japan didn't have that perspective until now, and in that sense, I think it is important to extend engineering to interpretation rather than engineering for analysis only. Of course, people with expertise in engineering have the knowledge, so if they enter the interpretive process even if they had been engaging in analytics only, they may be able to attain meta-engineering. Of course, interpretation includes synthesiological thinking, and if analysis and synthesis can expand within the same background, I think it will lead to some interesting innovation.

(Akamatsu)
Another point. In the United States, the people involved work very hard to create their market. In Japan, research often ends when they come up with some good technology.

While this may simply be a conjecture and I may be wrong, when funding is received from the government, many companies think that they're fine as long as they come up with "technological development". The government provides funding for commercialization, and sometimes I think the companies should be responsible all the way to the market when they receive the funds.

(Suzuki)
Exactly as you say. They are looking only at the technological development. I think Japan should look at the whole system and recognize its importance.

(Akamatsu)
Looking at the *Synthesiology* papers, I feel that the researchers' strong will to take the technology to a certain level is absolutely necessary.

(Suzuki)
Yes. In that sense, I think meta-engineering can be proposed globally. Japan is very good at manufacturing, and therefore it should maximize the experiences accumulated as its strengths. Then, it should strengthen the weaknesses, and start off the process that spirals from the discovery of the potential issues, the identification and build up of the necessary science and technology, the integration of fields and technologies, to the creation of social values, and then back to the discovery of potential issues.

(Akamatsu)
What is the final goal? How can this technology be used to achieve the goal? One must always return to that standpoint and think. Moreover, I think to arouse innovation, you need the ability to think "persistently". I think I saw a glimpse of the relationship between meta-engineering and synthesiology. Thank you very much for the interesting discussion.

(This interview was conducted at GE Japan in Akasaka, Minato-ku on May 13, 2010.)

Note) Hope for *Synthesiology*: Discussion with Professor Lester, *Synthesiology*, 1 (2), 139-143 (2008).

Profile of Dr. Hiroshi Suzuki
Born in Tokyo on December 25, 1946. Graduated from the Electronic Engineering Department, The University of Tokyo in 1969. Completed the doctorate course at the Graduate School of Engineering, The University of Tokyo in 1974. Joined the Mitsubishi Electric Corporation in 1974. Worked at the Central Research Laboratory, and as manager of Electric Power System Technology Division, manager of Electric Power Technology, head of Electric Power System Engineering Center, and as director and advisory engineer. Joined the General Electric Company in 2003 as the technology executive for new business. He was vice-chairman of the Institute of Electrical Engineers of Japan, board member of the Engineering Academy of Japan, chair of Management of Technology Japan Branch. He is IEEE Fellow and vice-chairman of the History Committee for Electrical Engineering, IEEJ. Areas of specialization are energy system and technological management. Doctor of Engineering.