Editorial

Becoming a Truly "Technologically Developed Country"

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1. Introduction

It seems as though the words that have praised the technological capabilities of our country, such as "technology-intensive nation", "monozukuri nation", "robot nation", etc., have been somewhat fading in recent years. However, there are always ups and downs over the long course of history. With a slightly longer perspective, I still think Japan has the capabilities to remain the world's top technologically advanced nation. I have high expectations as someone who has worked in engineering and technology for many years.

I specialize in robots and actuators with a base of mechanical engineering. Since I graduated graduate school, I have been involved with technological development from a number of different positions in industry, government, and academia, such as research and development in private companies, research management in a national project (micromachine), research education in university, and venture management.

As a researcher/engineer in such positions, I would like to share my expectations and opinions on how Japan can continue being an exceptional "technologically developed country".

2. Let's Become a True Pioneer

Many robot-related "leading technologies" have been exciting the media and society. There are too many of these technologies to list, including AI, IoT, automatic driving, drones, 3D printers, humanoids, MEMS, microrobots, soft robots, cleaning robots, and surgical robots.

The creation and turnover of technological booms have been moving very quickly in recent years. To take the exhibitions that I have attended in the past several years as examples, 2016 was all about AI. 2015 was all about drones, and I wondered where the 3D printers from 2014 had gone.

Many of these new trends start in the U.S. These booms were created by topics, such as AI and IoT being used for research by Google and universities in the U.S., drones being commercially utilized by Amazon, and 3D printers receiving a massive investment by the Obama Administration.

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However, these technologies were already in Japan as well. With AI, for example, NHK Science & Technology Research Laboratories was already promoting deep learning research around 1980. With drones, Keyence had commercialized quadcopters around 1990. With 3D printers, Mitsui Engineering & Shipbuilding had developed laser beam lithography in the 1980s. In terms of MEMS, pioneering research was already being promoted many years ago mainly by Dr. Teru Hayashi of Tokyo Institute of Technology in the form of micromachines. NEC has also developed a number of micro capsules that enter the human body to provide medication and collect biological fluid.

However, these unfortunately did not become major technological trends. After some time, they received attention in Europe and the U.S., and technological development was restarted as if to follow the trend. For example, a number of cleaning robots were tested by multiple major domestic electronic manufacturers around 1990. When we look at the photos of the prototypes at the time, robots similar to the current Roomba by iRobot were already completed over 20 years ago. When you restart the development after Roomba starts selling, you have no choice but to focus on the development of peripheral technologies. It is not that you voluntarily pioneered the new technology area to "have a robot clean the house", which is the core of the innovation.

Even if you promote research and development based on novel ideas in Japan, evaluation from others doesn't go beyond "That's interesting. It sounds like it has potential." And this evaluation is sufficient for the researcher. I have seen many such cases. However, once this theme becomes a boom in Europe and the U.S., it is suddenly regarded as an authorized research field in Japan, triggering others to follow. Unfortunately, there are many such cases.

I think that this is caused by the fact that Japan lacks "confidence and pride" that are supported by the history that has established the current "natural science" with Copernicus, Newton, etc. However, with the exceptions of European countries and the U.S., Japan now has the largest number of Nobel laureates. I think it's high time that we have the "confidence and pride" of being in the forefront of "human wisdom" pioneering and become true pioneers of science and technology.

3. Research Simultaneously Sprout Worldwide

I have a very "disappointing experience".

When I was in my late 20s, I launched a research project called "medical micro manipulator" (M3). Fig. 1 is the drawing that I drew then. It was for a small robot to enter a body to perform minimally invasive medical procedures or accurately perform delicate and precise surgery[1)]

Now, it sounds like an obsolete idea. However, back in 1986 when this project was launched, the general public (including myself) had not known the concept of micromachines or surgical robots. Thinking back, this was a research project that focused on the two trends of the following robotics development before others.

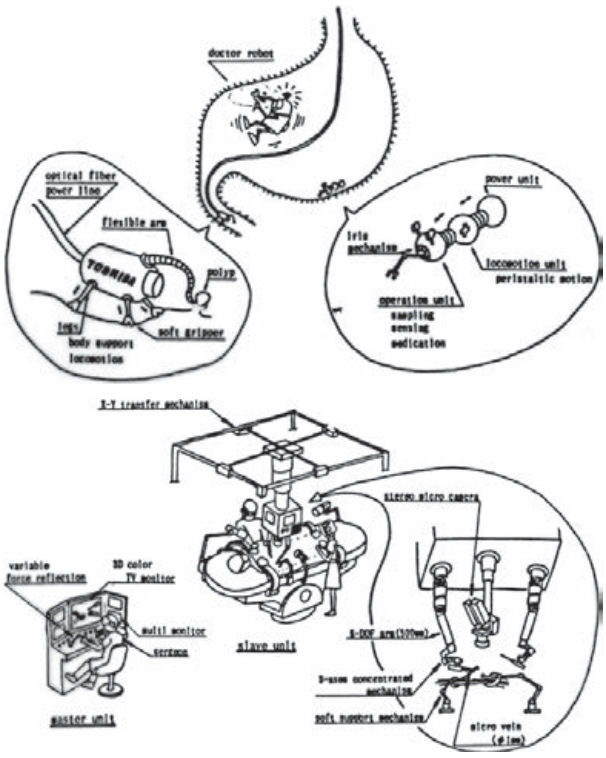

Fig. 1 My disappointing experience (medical micro manipulator; M^3)

The project obtained the approval to launch as an official research theme and I was the main person in the research. However, the project ultimately could not develop as hoped. We were completely beaten by the research and development of MEMS and surgical robots, which rapidly developed mainly in the U.S. immediately after our project launch.

I regret that one of the biggest reasons for this failure was that I had a hesitation deep within my mind that it might not be a good idea to seriously work on something no one else was doing (although the research had simultaneously started in the U.S.) or on a research theme that was far from the hot topics of robot research at the time. I think this is a result of a lack of the "confidence and pride" that I mentioned above. In other words, I did not have the self-awareness at the time that we were in the forefront of robot research and that I was the one leading it.

There is another reason. I had the optimistic mindset in which I thought "There must be no one else working on such a novel idea. I'll slowly work on this between the projects my superior gives me". However, in reality, someone else somewhere else in the world had thought of the same thing at the same time, and that someone had started taking action.

New technologies sprout at the same time in several different places in the world. I have actually encountered such an experience 3 times so far. Researchers with the similar awareness and skills in similar conditions come up with similar "amazing" ideas.

No matter how novel you think the idea may be, you should consider that someone somewhere has thought of the same thing at the same time. Whether or not you can achieve this depends on how boldly you can move to action.

4. Let's Overcome the "Nah, I'm just kidding" Way of Thinking

One of the biggest enemies of engineers, who should be the ones to create innovations, is the "Nah, I'm just kidding" way of thinking. This is often seen in idea-creating meetings and brainstorming. I believe this was one of the reasons for M3's failure.

Since negative statements are taboo in brainstorming, a number of ideas fly around the room. "It would be good to have a robot like this. What if we make it time travel like a cartoon character? Nah, I'm just kidding…" And people laugh and discussions grow bigger.

This is not the problem by itself. The problem is what happens next. You must take action based on the ideas that were created. We have to make this process function smoothly.

If there is even a small amount of the feeling "It's impossible anyway…" when we reach the execution stage, we can never create innovations. At the same time, we cannot create innovations solely by implementing "what we can do".

However, there are people in the world who look at seemingly impossible ideas and think "They are possible". Although it depends on the case, I feel as though these people often make small revisions to presuppositions for the argument and draw the path to achieve the essential goal. And these are the only people who are qualified to complete technologies. Even some subjective convictions sometimes end up working. The important thing is to believe that it is "possible" and take action.

5. Let's Positively Work with "Crazy Ideas"

Japan also has many examples of pioneering completely new "technological fields". Some of these examples are the gastroscope and WALKMAN.

The Gastroscope was a joint innovation by doctors of the University of Tokyo Hospital and Olympus engineers. I think it is impressive that they turned a

“crazy” idea at the time, which was to see a world that people had never seen, into action. After this, Olympus continued developing fiber endoscope, electronic endoscope, and endoscopic surgery, leaving other companies far behind. How were they able to achieve such original technological development?

For one, it must be the passion and conviction of the doctors who led the development. Technological development requires leaders with “passion” and “confidence”. Doctors at the University of Tokyo Hospital brilliantly played this role. Another reason must be the ambitious spirit of the engineers at the time. It does no good to plausibly list reasons to remain where you are by saying “The Japanese Pharmaceutical Affairs Act is strict…”

We can say that the WALKMAN was a result of the “crazy” idea of Mr. Morita and Mr. Ibuka being turned into action. I still remember the excitement of the stereo sound source that I heard for the first time walking outside when I was in university. I felt that a new world had opened up.

My laboratory recently developed a 20m-long robot arm (Fig. 2)[2]. When I suggest to students “Let’s make a 20m giant arm”, some students react positively and some react negatively. Talented students who react negatively would bring up textbook theories and formulas and explain why it cannot be done. This is indeed important, because working on something that cannot be done in principle is the same as alchemy. In many cases, however, they are voluntarily creating argument presuppositions and hypotheses and restricting their own possibilities. I think creation of innovations is about practicing ingenuity and overcoming such restrictions. Even with alchemy, if we go beyond chemical reactions and consider nuclear reactions…I will stop here, as it’s not my specialty.

Fig. 2 20m-long robot arm (Taking on the “impossible” challenge)

6. Fusion of Various Fields Sharing Common Awareness for Issues

One method to create innovations is fusion of various fields. Innovations may come from fusion of two pieces of “knowledge”, which previously had no common ground.

In the field of actuators, which is my specialty, fusion of various fields is especially important. While my fundamental field is mechanical engineering, a mechanical engineering framework alone is no longer enough to create new actuators. New actuators are only possible through collaboration with material specialists and new mechanical materials. Application is also important. I was once involved with the development of a motor that functions in special environments between 10 [T] and -270 [˚C]. This project was driven by the passion of chemical researchers who needed this motor.

One of the key points in fusion of various fields is sharing common awareness for issues. This is actually difficult when members’ backgrounds are different. If the fields differ, “ideas” naturally differ.

For example, the ideas toward “experiments” completely differ between the “physics type”, such as electrical engineering and mechanical engineering, and the “chemical/bioengineering type”, such as chemical engineering and bioengineering, even though they all belong to the engineering field.

This is a rough expression, so I’m sure it doesn’t apply to all cases. However, in general, “physics type” experiments are about confirmation of logic. For example, you apply 1V to 1Ω resistance, and the current of 1A is observed. This is called an “experiment” of the “physics type”.

This is different for the “chemical/bioengineering type”. “What happens if we inject this substance to a cell? We don’t know, so let’s do it.” This is an “experiment” in the field of the “chemical/bioengineering type”. A chemistry specialist once told me that the “experiment” I perform on my robots is “verification”, rather than an “experiment”. Differences in the environments in which we grew up obstruct fusion of various fields in a deeper sense than we would expect.

We also should not listen to the field’s specialists without questioning them. Regardless of how much explanation you may provide, specialists’ opinions are often based on the conventional common sense of the field. The value of fusion of various fields is in taking a step outside of the conventional common sense in each field, so it is necessary to share common awareness for issues by holding sufficient discussions.

I have seen many cases in which people give up, saying “I asked a specialist, and he/she said it lacked common sense or that it was impossible”. The significance of fusion of various fields is to go beyond this limit.

7. Human Exchanges based on Mutual Trust

Another form of fusion is exchanges of people with different positions and backgrounds. When I was involved with the management work of a national project for micromachines, I had opportunities to closely work with researchers/engineers from many different companies that were part of the project. Through these encounters, I was made acutely aware of how great the influence of corporate climate and superiors was. There

were gentlemanlike companies, aggressive companies, companies that pursue research/technologies to the limit, etc. The attitudes of the superiors and subordinates in each company were exactly alike. I witnessed that people receive a great amount of influence and sometimes even restrictions from their organization and superiors without realizing it. In different environments, people's ideas differ and so does the way they promote work. It's necessary to sometimes change the environment or exchange ideas with different people to cultivate a broad perspective. When doing so, we must accept and respect others.

Our ideas and the way we promote work also differ greatly with different positions, such as private companies, universities, public organizations, and managers. In my experience with industry, government, and academia, I think those who do their job thoroughly do their job in all of their positions. However, I sometimes feel as though people lack understanding of each other.

Between industry, government, and academia, our ideas toward research and development and the way we promote work should clearly differ. Having a solid understanding of this enables industry-government-academia collaboration to function smoothly.

I think that the natural roles of "academia" in technological development are; 1) Pioneer completely new sprouting technologies and demonstrating their potential through theories and experiments and 2) Promote analyses/designs by utilizing special experimental technologies and theories, which "industry" does not possess, etc. Development that presupposes the wide scope of practical knowledge of the industry, such as to enhance the completion level close to the product level or to promote development exactly as the initial research plan with no deviation, is naturally impossible with "academia". Such industry-academia collaboration does not achieve a sense of satisfaction for either party. Furthermore, in my experience, it often leads to great results to actually send people from "industry" to "academia" instead of funding the research and holding meetings every few months.

I sometimes feel that "industry" should focus more on commercialization and practical application. Especially when we promoted basic research in research centers of major corporations, I sometimes was concerned that they might not really see the end of the project. In some cases, I would even feel as though these corporations position "research centers" like a court orchestra of aristocrats, and I feel as though the resources are being wasted. However, it is not appropriate for me to complain from the sideline.

Dr. Yoshinori Ohsumi of Tokyo Institute of Technology, who was awarded a Nobel Prize last year, stated something along the lines of "They should spread research funds more liberally". Under the policies of "competition" and "concentration", the main distribution of research funding in the current "academia" is competitive funds. Due to this, there is a great difference between the budgets of researchers with massive research budgets and those who struggle to maintain the minimum research activities. My understanding of the gist of Dr. Ohsumi's statement was that Japan's overall academic activities would be better enhanced by spreading even 1 million yen per person without condition, instead of leading to such an extreme situation.

Some people may think "Universities have it too easy. They should introduce the elements of competition in private companies more. Spreading the funding is out of the question." This statement is acceptable because it comes from a Nobel laureate. If I say it, I may be in a big trouble.

However, from the field of "academia", I can fully understand Dr. Ohsumi's opinion. It is a fact that there are research projects that should receive funding with more weight, and they are important. However, if researchers voluntarily promote many different types of sprouting researches, the potential of some of these sprouts blooming big flowers in the future would also be great. I personally think it would lead to great contributions for the healthy development of academia and technology to trust the skills and good conscience of researchers in "academia" and to "spread" a certain amount of research funding to research other than those that were noticed by the "government" or some evaluators.

What are your thoughts on this matter? I think that it is necessary for us to at least accept that there are different views and trust and respect others. Only with these aspects, industry-government-academia collaboration functions smoothly. In that sense, I think fluid transfers/exchanges of human resources among industry, government, and academia are necessary to develop human resources that possess a wide scope of views with balance.

8. Let's Strive for True Globalization

It is often discussed how Japanese universities rank low in global university rankings.

Rankings that we often see use the evaluation criteria that give high scores to universities in English-speaking countries. For example, prestigious German universities also rank quite low in these rankings. However, this does not seem to be a big issue among people in Germany. Someone who has studied abroad in Germany once told me that he was asked why he was reading English articles and was told to read German articles.

On the other hand, the situation is different in Japan. The media don't hesitate to release articles, such as "High school students with more talent aim to attend universities in the U.S. instead of the University of Tokyo". These articles accelerate the poor reputation of "Japanese universities being no good".

However, my colleagues who are familiar with the actual situation of overseas research also say "We are not sure if high-ranking U.S. universities are really that much better than Japanese universities".

The danger is that we would lose the true strength by being overly affected by one-sided value. Our natural strength was that we provide “higher education in our native language”. I do not think it’s a good idea to simply regard this as “Galapagos”. Japan’s national isolation (It seems that this concept itself is also being questioned in the current historical science. “Values” change with the time.) also nurtured our original culture that we can proudly show the world. We must not lose sight of our natural strength and identity.

In that sense, I strongly regret that we had to stop the development of high-functioning and high-technology mobile phones by masochistically calling them “Galapagos”. I think that it is in such times that we can pave the road by promoting activities with truly “global” perspectives from a wide variety of positions, such as product/technological development, standardization, research and development, and management.

9. In Closing

Thanks to our predecessors’ efforts, Japan has become one of the top technological nations and economic nations in the world. I have shared some of my opinions in the hopes that Japan will further develop as a truly technologically developed country in the future.

Let’s strive to become a truly technologically developed country from each of our own positions with a sense of challenge and a humble, sincere attitude without being overly swayed by the trends of society.

*「WALKMAN」and its logo are registered trademarks of Sony Corporation in Japan and the United States,and are registered trademarks or trademarks of Sony Corporation in other countries or territories.

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