Science and technology policy and synthesiology – Bridging science and values

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One of the aims of the Fourth Science and Technology Basic Plan, which was decided by the Government of Japan last August, is to create "solution-seeking" or "issue-driven" innovations such as green innovation and life innovation. The Research Institute of Science and Technology for Society, Japan Science and Technology Agency (JST-RISTEX) is promoting various R&D programs that lead to the implementation of the research results in society. Because this approach is in line with *Synthesiology*, we talked to Dr. Tateo Arimoto, Director of JST-RISTEX, in a roundtable talk session.

***Synthesiology* Editorial Board**

Participants of the round-table talk

Tateo Arimoto	Director, JST-RISTEX and Professor, National Graduate Research Institute of Political Studies
Naoto Kobayashi	Vice editor-in-chief, *Synthesiology*
Motoyuki Akamatsu	Executive editor, *Synthesiology*

Kobayashi

Last year, the Fourth Science and Technology Basic Plan that covers the fiscal years from 2011 to 2015 was established. In face of crises in Japan including the Great East Japan Earthquake as well as the various global issues, the Plan spells out the basic science and technology policy for Japan to realize the ideals. Dr. Arimoto, you speak actively from your position where you have overviewed the national and global science and technology policies. Can you discuss your thoughts and experiences on the future trends, both domestic and overseas, on the science and technology policies, with focus on the Fourth Science and Technology Basic Plan?

The characteristic of Fourth Science and Technology Basic Plan "Significance of emphasis on solution-seeking research"

Arimoto

The Science and Technology Basic Law was established in 1995 with unanimous vote of the ruling and opposing parties in the Diet. In the background was a sense of crisis, though not as strong as it is now, that Japan's competitive capacity might decline as globalization progressed. During the 15 years from Phase 1 to Phase 3 of the Basic Plan, I believe there was a value in the emphasis on certain fields such as biotechnology, information technology, and nanotechnology, to fortify Japan's science and technology activities. However, with the changing global socio-economic system over the course of time, various weaknesses were exposed. Therefore in Phase 4, the direction shifted to problem solving and issue driven policy. It was supposed to be approved by the Cabinet at the end of March 2011, but after experiencing the East Japan Earthquake on March 11, it was reviewed and the weight has shifted even more toward demand-driven or solution-oriented topics. This is also a global trend. The science and technology policies of the world are driven from the policy of heavy emphasis on R&D upstream toward emphasis on innovation of how to create "value" from downstream as well as upstream.

Another point is that the Fourth Basic Plan proposes "deepening the relationship between society and science and technology" and "promotion of science and technology innovation with immediate effect." On the other hand, it is important to keep an eye on whether the support of basic science and basic research upstream is okay, and whether diversity and richness are maintained.

Kobayashi

In Phase 2, priority of resource allocation was given to the four focal areas of life science, information and communication, environment, and nanotechnology/materials. In Phase 3, selection and concentration were on our focal areas. In addition, national core technologies,

solution-seeking R&D, and response to emerging and fused disciplines were set as main policies. Looking at the selection of the Funding for World Leading Innovative R&D on Science and Technology (FIRST), I got an impression that the effect of concentrating investments on nanotechnology and life science is clearly observed. What do you think about the promotion of life innovation and green innovations in Phase 4, and the "linkages" to system reformation for promoting science and technology innovation?

Arimoto
In general, I think there were many papers produced during these years. When you say "linkage," if you mean whether it is progressing toward the creation of final values, I'm afraid that is not necessarily going well. That is a total issue, and it is the fault of the scientific community, funding, policies, as well as companies. It also includes the issues of people's capabilities, consciousness, education, and whether there are paths to advance careers in the future.

Akamatsu
Synthesiology is a term where *synthesis* and *-ology* are joined, and perhaps "linkage" is a keyword. The researchers thought it was simply okay just to generate good research results, but now it is important to "link" those research results to social values. It is important to think what kind of approach should be taken to create a system that can utilize the research results in society, and to train "people" who are capable of working in that system.

Arimoto
It is important to share the roles and structures of the university research and education and the funding programs to see whether there is wide and diverse support and whether the support matches the research phases. There are the basic science and curiosity-driven research phases, and then there are the mission-oriented basic research, application, and prototype development phases. The scales of funding, research management and evolution systems are different according to the stages. I don't think such process and eco-system of innovation are shared among the scientists/engineers and bureaucracy/government and companies.

Trends of science and technology policies and promotion activities in other countries

Kobayashi
You have mentioned that the system or the structure for promoting innovation is not well understood in Japan. Is this a characteristic only of Japan? What is the situation overseas?

Arimoto
It is not as bad as in Japan. In other countries, there is a wide coverage from science and technology policies to science and technology innovation policies. As values become diverse and the world becomes connected, countries, particularly the advanced countries, are struggling to redesign an innovation system including funding management and reviews, human resource training, and others. How to maintain their competitiveness; how to sustain the development of science and technology to maintain the quality of life of their citizens; those are the important viewpoints.

What I wish to emphasize is that a funding system plays an extremely important role. The public research funding system was started by developing the system of grants, contracts and fellowships around 1930. The mechanism for convening the researchers and engineers to solve the research and technological issues across the boundaries of research institutes and universities was organized and nurtured. I think we must now return to the history of science policies and build a new model.

Kobayashi
You have mentioned the situation in the 1930s. The United States experienced the Manhattan Project where "amazing things could be accomplished when scientists are convened nationally." After World War II, this became the DARPA model. Are you suggesting that there is a reemergence toward the direction that scientists should cooperate across the boundaries to solve problems?

Arimoto
Exactly. Now, countries are trying to change the funding mechanism. While upstream has quite matured, the

Dr. Motoyuki Akamatsu

Dr. Tateo Arimoto

mechanism for downstream values is very weak. USA is trying to create a DARPA style mechanism under various agencies, and the Advanced Research Projects Agency - Energy (ARPA-E) under the US Department of Energy is one such example.

Giving examples of other countries, France set up a competitive funding organization called l'Agence Nationale de la Recherche (ANR) a few years ago, and it gives out fairly large amounts of funds. Sweden also created the Swedish Governmental Agency for Innovation Systems (VINOVVA). Britain has traditionally the strong Research Councils. In Germany, the Max-Planck-Gesellschaft zur Förderung der Wissenschaften e.V. is for basic research, while the work of the Fraunhofer-Gesellschaft, FhG is interesting as an innovation system. Other developing countries are emulating the examples and are creating their own funding systems.

Funding strategy for future science and technology

Kobayashi
You say "funding is important," and that is absolutely true for us who apply for funding. We create a matching proposal and the good ones are accepted. That means how to strategically create good funding is important for the policies.

Akamatsu
What one must not forget along with the importance of funding is who reviews the proposal and how it is reviewed. I often discuss with Dr. Kobayashi, "Is it possible to do reviews of proposals that are not analysis?" If one tries to score high to get funding, the content often ends up being one that can withstand analytic scrutiny.

Arimoto
That must be included in the objectives when designing the funding. If it is selected by peer review only, it tends to become conservative. In the United States, program officers (PO) and program directors (PD) have some level of decision-making authority based on their insights on the direction of the development of their specialties. The reason there is such a sense of crisis in the advanced nations is because they are faced with a situation where, to use the funds effectively, the current system must be changed and human resources must be recruited, as R&D money won't increase or perhaps will decrease as the financial status declines. I'm afraid Japan does not share this sense of crisis.

Dr. Naoto Kobayashi

Kobayashi
In the case of the United States, the PDs and POs are being trained as specialists at the National Science Foundation (NSF) and the National Institutes of Health (NIH). However, I don't think there is a system that trains such people in Japan. When the Japanese economy was moving upward on an incline in the 1970s and 1980s, were such roles filled by the technology officers of the Science and Technology Agency (STA) or the Ministry of International Trade and Industry (MITI)?

Arimoto
I think they were doing that in large-scale projects. This could be done, even if the officers in charge shifted in one to two years, because it was a catch-up model. They simply had to copy others. However, now that Japan's status has changed completely, it has to be done by professionals research administrators (or managers). Japan failed to respect such professional groups, or failed to train young people. That is why we are in deep trouble in this great turning point.

In Japan, there is a polarization of people who do research versus people who hand out money, and even in universities, they are divided into professors and managers. We suddenly realized that we have failed to train people who can "link" the two, or the mediators. There is no mechanism where people, like the science communicators, can carry out their jobs as a stable profession.

Kobayashi
In Japan, the training of researchers and policymakers for "science for the science and technology innovation policy" is important for building a new policy forming process.

Arimoto
In Japan, the Council for Science and Technology Policy has led the science and technology policy making. I think it will be important to establish the process of integrating the various policy analyses, designing the policy, and providing alternatives in an evidence-based manner, even though the politicians will make the final decisions. It is also important in the future to nurture the "people" and solidify the "methodology."

Kobayashi
In the United States, NSF is funding the Science of Science and Innovation Policy (SciSIP). Is US advanced in that aspect?

Arimoto
I think the US is doing alright so far, but it has its own problems. It has been five years since the Science of Science Policy fund was started, but a major part of the budgets has gone to analytical economic methodologies, according to information, and I think there's a feeling that that isn't right. When I introduced the Japanese SciSIP at the 2012 Annual Meeting of the American Association for the Advancement of Science (AAAS), Dr. Lewis Branscomb, former professor of Harvard University and a prominent figure of the science and technology policy, said, "I claimed that one should maintain balance of policy analysis and policy design in these fields, but there are still lots of analyses and no resolutions." This was a statement that made a powerful impression. Looking at the US and European university programs related to SciSIP, they are so diverse, and I believe there is still plenty of room for Japan to create a program that is internationally viable.

Activities of RISTEX and *Synthesiology*

Kobayashi
RISTEX engages in funding and program formation for the science for science innovation policy. Can you tell us what the current situation is?

Arimoto
The philosophical foundation of RISTEX is the Budapest Declaration (Commitment of Science in the 21st Century: "science for knowledge," "science for peace," "science for development," and "science in society, science for society"). Based on this declaration, the "Study Group on the R&D for Social Challenges" (Chairman Hiroyuki Yoshikawa) declared the following three points: "technology to solve the problems of society," "technology by the fusion of natural science, humanities, and social sciences," and "technology not affected by market mechanism." The Science and Technology for Society System was established, and this was reorganized and renamed as the Research Institute of Science and Technology for Society (RISTEX). Actually, the first five years were in the style of ordinary research grants that was immature as a methodology. Therefore, we were criticized severely that papers were produced, but it was not quite in line with the initial objective of solving the social problems. In the past five years, we intensively changed the mechanism of priority setting, the standard for screening, and the ways of funding and doing management and evaluation. I think now these methods are becoming fairly mature.

Kobayashi
The RISTEX research projects are conducted throughout Japan. Can you give us some interesting cases?

Arimoto
We have been supporting about 80 projects across Japan, For example, the representative of the project "Measurement of crime damages against children and the establishment of demonstrative core for crime prevention activity" in FY2007 was a section manager at the National Research Institute of Police Science. He said, "There is no scientific data for preventing crimes against children, and it is not set up so we can accumulate case studies. I want to do a scientific version of the traditional detective's 'a lot of legwork and the use of one's insight to gather information.'" With the help from the region, data was collected, and areas of high risks were marked. Last year, the World Congress of the International Society for Criminology was held in Kobe where the case studies were presented, and the work was highly acclaimed.

Another case that was beyond our expectation is the "Development and training for forensic interviews to protect children against crimes" that was selected in FY2008. The representative of this project was a psychology professor of the Hokkaido University. This is about who would interview a child when the child has become a victim of a crime. For example, when a stern-faced policeman asks questions or depending on how the questions are asked, the child may not tell the truth or become reluctant to talk out of fear. Therefore, with the cooperation of the Children's Guidance Center, methods have been developed and personnel members of the regional centers have been trained. This method is spreading throughout Japan. This is a good example.

In the "Nagahama Rule for the genome epidemiology research open to the region," the representative was an official of Nagahama City. There was a proposal from a university to Nagahama that it wanted to use Nagahama citizens for a genomic epidemiology research. A committee was formed, and discussions were held among the university researchers, citizens, officials, and mediators. This resulted in an ordinance of Nagahama City, and an NPO was created to continue and expand these activities.

As you can see, there is a story behind each project. It is said that the generalization of such stories is important, and I truly think so, being involved in the projects myself. To conceptualize, we need lots of case studies and scientific methods, and it is important to know and understand thoroughly the actual situation behind each case.

Contact point with the utilization of research results in society, the aim of *Synthesiology*

Akamatsu
The problem is searched and extracted, the R&D is conducted, and a prototype is made. Perhaps it is small and much effort is needed until a certain stage, but it will be gotten done. To implement this in society, probably it may not be done in three years, but it may be done in five years. When it is done and can be shown, people will say "Great!"

and then you can step up. I think we have to install some kind of "mechanism" for that.

Arimoto
Exactly. Something that was done in a certain place can be done in another place if the region is about the same size and has a similar social capital culture. As Dr. Hiroyuki Yoshikawa mentioned after the 3.11 earthquake, one of the touchstones for how to spread that to a wider region is perhaps by creating a fellowship system where young researchers and post-docs are sent to the various disaster areas. Maybe that will generate new ideas and insights. I think this is an important advice.

Kobayashi
To actually apply the prototype to society, the effort of how to express this as a study is necessary. *Synthesiology* started from that point of view. When Dr. Yoshikawa came to AIST, he said that *Full Research* where the *Type 1 Basic Research*, *Type 2 Basic Research*, and *Product Realization Research* are done coherently is important. *Type 1 Basic Research* is mostly analytical research evaluated in the traditional peer review. We were thinking about promoting research that widely selects, synthesizes, and integrates the knowledge of different fields based on a scenario centering on *Type 2 Basic Research*. Since we felt that there was no place to publish the results and to evaluate them as a study, we published *Synthesiology.* Therefore, the greatest concept is "for society," but as Mr. Arimoto said, the most important is how to write the scenario and how to link results to implementation in society.

Since this journal is an –ology or "study," it may start from a researcher's curiosity. However, we have the authors clearly state how the research may link to society, write the scenario, describe which elemental technologies are selected, explain the relationships among the elements and their integration, and state the future prospects, in an academic paper form. While listening to you today, I thought that your work done at JST and RISTEX seems to be similar to *Synthesiology.*

Arimoto
I think there are similarities. The "Message" for the launch of *Synthesiology* is very carefully written. It is important to nurture this approach as a type of discipline and to increase awareness. On the other hand, when a discipline creates its domain, it attempts to exclude others. Both *Synthesiology* and RISTEX, however, must create associates and communities that support them in order to help this approach grow.

Akamatsu
RISTEX states that it attempts to link the "observing scientist" who understands the regional demands and social issues and the "engineering scientist" who proposes the methodology and design to solve the problem, as well as linking the "actors" and "scientists" in society. I think the problems of "science for society" and how to set the career path of the people who are capable of such engineering research are closely related.

Arimoto
Yes indeed. I feel many people who engage in "science for policies" are similar to engineering scientists. I am very concerned about their career paths.

Kobayashi
It is indeed "science for society."

Arimoto
AIST conducted a synthesiology workshop at the annual meeting of the Japan Society for Science Policy and Research Management last year. I think it is very important to conduct activities outside of your institution. It is "co-creation" where each part maintains independence. I think this "co-creation" will be the keyword in social technology.

I think this is a movement. This movement has been done individually, as *Synthesiology* by AIST and practice of specific cases by RISTEX. Both have arrived at the phase where the methodology could be organized by meta-phase. It is important to collect case studies. I hope we can summarize the case studies that continuously accumulate along some axis.

In *Synthesiology*, the names of the reviewers and the discussions are disclosed, and this is very important for the development of new methodologies and the axis of evaluation. I think you are doing very well. I hope you continue.

Akamatsu
When the reviewers are selected, one is selected from those who understand the field and another is from outside the field. One of the characteristics is that it is not a peer review.

You mentioned the career path of the personnel. This is a very important subject.

Arimoto
Yes, indeed. It is the issue of human resource. At RISTEX, if there is one post-doc or a young researcher for one project, then there are nearly 100 people. One case that made an impression on me is that of a professor at Gunma University who developed a "comprehensive disaster scenario simulator for tsunamis." He was working on activities to raise consciousness for disaster among the residents and to provide disaster prevention education to elementary and junior high students. One of his activity sites was Kamaishi which was hit badly by the 3.11 tsunami last year. He told people of the town, "Do not trust the tsunami simulation. Nature very

often outdoes simulation." This was imprinted so deeply in their minds that the children could make decisions on their own and wisely fled from the tsunami. That is why 3,000 children in Kamaishi successfully survived. It is called the "Kamaishi Miracle."

That is it. It is ultimately "people" who are the key. People who focus on social implementation have different goals than production of papers—not writing papers, but "I want to save as many people as possible at times of emergency." The traditional discipline-based researchers of modern science will not say that because that will be denying their own work. However, many young researchers who engaged in action research suffer from the fact that they cannot write papers. That is probably why *Synthesiology* was created.

Akamatsu

Indeed, it is difficult to write about social implementation in an academic paper. I think *Synthesiology* is a receptacle for such papers.

Education at the engineering department must shift from paper first to value first

Kobayashi

I think engineering was originally for making things that are useful for society. However, engineering turned into science and has moved toward analysis.

One such example is the architecture department in the university. The evaluation is higher for people who can leave excellent architectural work rather than someone who writes a lot of papers, but that makes it difficult for architecture to be considered an academic discipline. Therefore, we decided to create a journal where the making of an architectural work can be published as a result.

Arimoto

What Dr. Kobayashi just said is very important, and Dr. Yoshikawa has stated this recently also. The method of education and training at the engineering department must be changed, and there must be a shift "from paper first to value first." The curriculum of the engineering department must be changed. When the Japan Accreditation Board for Engineering Education (JABEE) joined the Washington Accord in 2005, an international panel came to Japan for screening, and I was surprised that it was written clearly in its report, "Japanese engineering education should be redesigned. It does not teach systems or design. There is no training." The Imperial College of Engineering at the beginning of the Meiji Period, however, did provide world-leading sandwich-style engineering education with thorough basics, practice, and training.

One of the greatest reasons for this change is because people have walked into their own little narrow paths and have become discipline-based. They cannot provide overall, synthesized knowledge and policy options that the citizens desire or the government wants. For example, they cannot discuss what will become of Fukushima in the future based on scientific knowledge. After March 11 last year, the responses of the Japanese scientists and engineers to the public and policies were so divorced from the expectations of society. The citizens saw this. There is a spread of distrust for science. We must do something about this.

Kobayashi

What we, the scientists, can do and how *Synthesiology* can contribute are topics we would like to continue to discuss. Thank you very much for today.

This roundtable talk was held at JST-RISTEX in Chiyoda-ku, Tokyo on February 27, 2012.

Profile

Tateo Arimoto
Completed the master's course at the Graduate School of Science, Kyoto University in 1974. Joined the Agency of Science and Technology in 1974. Worked as the Deputy Director General for Policy on Science and Technology and Director-General, Science and Technology Policy Bureau, Ministry of Education, Culture, Sports, Science and Technology. Works as the Director, JST-RISTEX and Deputy Director, Center for Research and Development Strategy, JST from 2006. Professor of the National Graduate Institute for Policy Studies, Visiting professor of Doshisha University, Waseda University, and Tokyo University of Science. Books and papers include "Science and Technology Policy",(by T.Arimoto, in *Have Japanese Firms Changed*, edit. by Y. Nakata and H. Miyoshi, Palgrave Macmillan, 2011) and "Rebuilding Public Trust in Science for Policy Making"(by Tateo Arimoto and Yasushi Sato, *Science*, Policy Forum, in press).