Defining the contribution of engineering to society

Engineering turns science and technology into something tangible and useful to society.

It is applied in creating various structures, home appliances and other infrastructures and equipment, which make human lives safe and convenient.

From Nov. 29 to Dec. 2, Kyoto will host the World Engineering Conference and Convention (WECC) 2015, in which engineers from around the world gather to discuss importance of engineering and showcase their technologies. The World Federation of Engineering Organizations (WFEO) holds it every four years.

How can engineering contribute to society? How can Japan contribute to global engineering? What is the significance of Japan hosting the WECC?

The Japan Times held a forum to discuss these issues on June 11. Participating in the forum were Ryoji Chubachi, president of the National Institute of Advanced Industrial Science and Technology; Keisuke Hanaki, a professor in the Department of Urban Engineering and adjunct professor of Integrated Research System for Sustainability Science at the University of Tokyo; Hideo Nakamura, president emeritus of Tokyo City University; and Junichi Sato, president of The Japan Federation of Engineering Societies. The moderator was Yoshitaka Uchijo, an advisor and contributing editorial writer for Kyodo News.

Below are excerpts of their discussion:

Panelists and a moderator (center) pose before their discussion on the definition of engineering, Japanese contributions to engineering in the world and the challenge in training people with the right skills to be engineering leaders at The Japan Times' offices in Tokyo on June 11. YOSHIAKI MIURA

Moderator: Thank you very much for participating in this forum. Today's theme — as it is for the WECC 2015 — is "Engineering that Contributes to Society and Japan's Contribution." This is a very expansive theme and I hope to get a variety of viewpoints from the panelists.

First, Mr. Sato, will you explain the significance of engineering for society, this country and the world? Also will you explain the significance of the WECC being held for the first time in Japan this year?

Sato: I have a degree in engineering, but I considered what engineering actually is very seriously for this forum. I had never thought about it so seriously before.

We often use the words "science and technology." What does engineering have to do with science and technology? I thought about that and did some research, which led me to the conclusion that engineering is an act of planning and designing something that contributes to society by using and arranging science and technology.

This does not mean science equals engineering. Engineering is creating something based on a request from society. Science is not like that. You discover something existing in nature, find its mechanism and systemize it; that's science, which is different from engineering.

Engineering is creating a complete product by using scientific knowledge and technology, which is the skill of creating something. The technology of creating something is not perfect, and thus creative arrangement is necessary. Then you will find rules and mechanisms and produce a complete product. For that, you need planning and design matched with social demand. That, I think, is engineering.

As such, engineering study is very complicated and people may misunderstand that point. Newspapers and other media rarely use the word "engineering" in such context. The words "science and technology" are more easily understood and people have the impression that science and technology are directly applied to society. But it is engineering that is directly applied to society. The achievements of science are always filtered through engineering when felt by society.

Japan is a country that engaged in engineering education at an early stage of its history. A long time ago, the study of engineering did not exist in Japan, but Japanese erected castles and temples such as Horyuji Temple. Back then, there wasn't any idea to treat structures or mathematics as study subjects, but people built them with creativity and their ability to understand nature. In that sense, we have understood engineering for a long time.

The first engineering in Japan was the engineering for the purpose of increasing wealth and military power before World War II. But, it's now 70 years after the war. Our engineering after the war focused on how we can improve society, develop industries, be wealthy and make our country safe. I think it is very rare for engineering to develop this way and, in that sense, I think Japanese engineering is a role model for the world.

Take environmental technology as an example. This small country has such an established manufacturing industry, and thus it also has a well-established environmental policy. And because Japan has experienced so many natural disasters, Japanese engineering will be developing to overcome those things.

WECC 2015 will be the second WECC in Asia after Shanghai, but the first in Japan. It's an opportunity to showcase the engineering that Japan has developed over the past 70 years to Asian and African countries. WFEO hosts the WECC and is an organization under UNESCO, with more than 90 countries belonging to the federation. Most of the member countries are in Africa, the Middle East, Southeast Asia and South America. There will be about 700 people from those countries attending the WECC. For them, the engineering Japan has developed in the last 70 years must be very important. I'm sure it must be very useful for them, so the WECC grabs lots of attention.

In that sense, the fact that the WECC will be held in Japan means people pay attention to how engineering should contribute to society.

We encountered the Great East Japan Earthquake and tsunami in March 2011. Since then, we have been working to recover from the disaster. The nuclear disaster also hit us hard and we were forced to think seriously about what engineering is. I think we can show the world how engineering should develop moving forward. The other panelists here probably have different opinions on engineering because they have different backgrounds.

Chubachi: In Japan, there is science and technology and innovation is what's coming after them. Japanese take the steps of science, technology and innovation as a whole package. Industrializing by undertaking those is called manufacturing. I think engineering plays a role as a catalyst of making "manufacturing" closer to "industry."

I worked for a company and have been engaged in electronics business for a long time. Mr. Ibuka (one of the founders of Sony Corp.) used to say, "Let's say inventing one thing takes one unit of effort. The technology of lowering costs and mass-producing it takes 10 times as much effort as inventing it. Then, commercializing it to turn it into a socially and economically influential business takes a further 10 times effort. It's the rule of 1-10-100. It's true that Bell Laboratories invented semiconductors, but Sony created transistor radio using semiconductors. Thus, we can be proud of ourselves."

I think the technology part, 10 of the 1-10-100 rule, is important. The step of turning 1 into 10 on the way to 100 is an important one.

Hanaki: The outstanding characteristic of engineering is, as you have said already, that it solves existing social problems and is useful to society. That's a very important point. There's a Nobel Prize in science, but unfortunately not in engineering. Meanwhile, engineering becomes valuable after people actually use it. I guess the basic value of engineering is different from that of pure science. I strongly believe that engineering is meaningful only if it is of social use.

Nakamura: Mr. Chubachi talked about "science, technology and innovation." I want to make it "science, technology and society." Japan has conducted engineering for social needs since the beginning of Meiji Period. For example, the Lake Biwa Canal was a huge project to bring water from Lake Biwa to Kyoto.

Sakuro Tanabe proposed creating the Lake Biwa Canal as part of his thesis works at an engineering university. The Kyoto governor liked the idea and asked young Tanabe to lead the project. There was no electricity at the time and they had to make a very long tunnel connecting Lake Biwa and Kyoto. Tanabe supplied Lake Biwa water to Kyoto, which had languished after the relocation of capital from Kyoto to Tokyo. Tanabe implemented hydroelectric power generation in Kyoto and ran the first electric train in Japan. That was purely the work for social needs.

The engineering discipline I was involved in was doboku engineering. Doboku engineering is translated in English into, as you know, civil engineering. You can assume that "civil" means society and scientific technology based on society.

We deal in infrastructure. That's something you can realize only in the land you are in. In other words, it's not portable. Recovery from natural disasters and revitalization work after them are examples of civil engineering work.

Japan has gone through recovery and revitalization after March 11, 2011. And it is important for people with a great deal of social influence come to Japan for such an opportunity (the WECC) to discuss engineering and look at Japan.

I think (the WECC) is not a place for young researchers to have highly specialized discussions like an academic symposium. Rather, people with a variety of experience, knowledge and the power to influence society will come and see technology we can't move in its natural environment. The WECC is a great opportunity for that.

Chubachi: Mr. Nakamura saying, 'It's not science, technology and innovation,' but it's 'science, technology and society,' may make sense if you view innovation as a technological advance from a narrow point of view. But I would add that innovation can only exist if it has economic and social impact.

Sato: I checked the origin of the word "engineering" in English. Engineers were originally makers of military equipment. In contrast, doboku, which creates something for society, is civil engineering. I think current engineering is civil engineering in a real sense.

Moderator: Mr. Hanaki, you're an expert in environmental issues. One of the themes of the WECC is a sustainable future society, which has something to do with engineering's contribution to the realization of that society. Will you talk about the WECC and the role and expected contributions of Japanese engineering to world environmental study?

Hanaki: Let me explain about a recent global movement. There is a huge worldwide program called Future Earth. It's not something as fancy as making the Earth beautiful in the future, nor is it a program to pessimistically talk about the future. It's a very large research program to study how to make the Earth sustainable.

The biggest characteristic of Future Earth is that it encourages conducting research from an engineering point of view, not only from a scientific one.

There are various problems in the world, such as climate change, scarcity of natural resources, sustainability of biodiversity and poverty. There have also been various research programs looking to tackle those issues since around 1980. Many scientists have been involved, but the earth has not necessarily become a better planet. Future Earth was launched out of the feeling that we need to do a better job.

So, how do we make use of research in enhancing the sustainability of the Earth? It wouldn't work to conduct research in a conventional way; it should be done in a comprehensive way in which researchers combine their findings to come up with solutions. This is what has proposed for a long time.

In addition, what's new in Future Earth programs is that they don't use the word interdiscipline, but transdisciplne. What it means is that we should strengthen interaction between society and research. It's not that researchers do it alone; they do their work together with society.

There are also three key words: Co-design, coproduction and co-delivery. Co-design means making research plans together with society. Co-production means conducting research together. Co-delivery means applying the research achievement to society.

If we try to do these, we should not keep researchers in laboratories staring at computers to conduct research alone, but they should design research around various stakeholders. Also, instead of simply showing the research results to people, researchers must interact with society to discuss what research they will conduct from the beginning.

This type of program comes from social needs. As engineers speak with society during the process of creating something, they apply the outcome of their engineering to society and engineers receive feedback from society, good or bad. In that sense, engineering uses the same methodologies as Future Earth.

We've suffered from pollution in the past. We may have listened to the opinions of the people who use the products we manufactured. But, we may not have necessarily thought of whether production would cause environmental problems, poverty and other social problems.

Of course, engineers today consider environmental impact when they manufacture something. Still, engineers must think of working together with various stakeholders, including the national government, local governments, companies and residents.

Engineers will make up the majority of the WECC participants this year. But it is widely open to the public. Feedback from ordinary people, the central government and local governments is welcome and it will be a great opportunity for such face-to-face feedback.

The WECC is one of the triggers for engineering to be close to society and engineering will continue to get closer to society. That, I believe, leads to sustainable society. In that sense, we should be proud of our engineering, as it is more advanced than other areas of academia. But also, I feel there are lots of things we should do.

Moderator: Mr. Nakamura, you are an engineering expert and "resilient

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Ryoji Chubachi, president of the National Institute of Advanced Industrial Science and Technology: Chubachi obtained a Ph.D. in engineering at Tohoku University in 1977, the same year he entered Sony Corp. Having worked in the electronics business of Sony, he climbed the corporate ladder to become the president and electronics chief executive officer, the representative corporate executive officer of Sony in June 2005, and vice-chairman in April 2009. In April 2013, he was appointed to his current post.

Keisuke Hanaki, professor, Department of Urban Engineering and adjunct professor, Integrated Research System for Sustainability Science, the University of Tokyo: Upon graduation from the University of Tokyo, Hanaki began his academic career in Tohoku University and became an associate professor in urban engineering at the University of Tokyo. During that time, he taught at the Asia Institute of Technology, Bangkok, from 1985 to 1987. His research field is holistic environmental management in urban areas for sustainability.

Hideo Nakamura, president emeritus of Tokyo City University: Nakamura obtained an engineering degree at the University of Tokyo in 1958 and began working in what is now subway operator Tokyo Metro Co. In 1986, he began his academic career, starting as an associate professor at the University of Tokyo's Institute of Industrial Science. In 1996, he began working for the Institute for Transport Policy Studies while assuming the post of emeritus professor at the University of Tokyo. In 2004, he became the president of Tokyo City University.

Junichi Sato, president of The Japan Federation of Engineering Societies: After receiving his Ph.D. in engineering from the University of Tokyo, Sato began his career at IHI Corp. serving as board director and managing executive officer, director general of corporate R&D. He is currently an advisor to IHI Corp. and, during his time with IHI, he was also a guest professor at the University of Bremen, Tsinghua University and Tohoku University. His areas of expertise include combustion science and technology, energy engineering and gas turbines.

Yoshitaka Uchijo, advisor and contributing editorial writer of Kyodo News: Born in Tokyo, Uchijo graduated from Tokyo's Hitotsubashi University and entered Kyodo News in 1977. From 1994 to 2002, he held a position at the Washington D.C. bureau. He later served as the science division manager and human resources division manager. He was the president of Kyodo's Sendai branch from 2010 to 2012, overseeing coverage of the 2011 Great East Japan Earthquake and tsunami that struck the Tohoku region. He assumed his current position in June.

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infrastructure for society" is one of the main themes for the WECC this year. Civil engineering and infrastructure have played important roles for social safety and security. Japan has experienced the Great East Japan Earthquake and it is very significant for Kyoto to host the WECC this year. In terms of the role of engineering on the safety and security of society, countries and the world, what would you expect the WECC to contribute?

Nakamura: Earlier, the president of The Japan Federation of Engineering Societies said participants will come from about 100 countries. They are an extremely diverse group, with very different levels of technological and economic development. They also have different social needs.

In the early stages of development, social needs are relatively easy to figure out. They can be things such as a water supply system, wanting to be a little wealthier or wanting better food.

In the later stages of development, though, social needs are more diverse and more difficult to assess. Japan is definitely in that stage. However, safety is definitely what every Japanese needs more than anything.

Japan is notorious for having many natural disasters. It has many more disasters than other developed countries. The shape of the archipelago is also unique, being very thin from north to south and with many islands. It also has mountains running down the center of the archipelago and many earthquakes. It's a country under extremely difficult natural conditions.

That's why we can't rely on other countries to come up with solutions to reduce disaster risks. For example, we should not assume a country such as Germany would come up with excellent research that we can only learn from them. Nobody will do it unless Japan does. Japan must take a leading role in predicting disasters, taking preventive measures, reducing risk and recovering from disasters. All Japanese citizens must think about that. I think the WECC is a perfect place for that.

As I said earlier, natural disasters and the infrastructure to prevent them and reduce their risks are something you cannot see if you live far away. You can understand those things only after you see them close up. I would like everybody to visit such places, understand the environment and see what we Japanese do to deal with natural disasters. Then, I would like everybody to understand the science and technology used as countermeasures against disasters. Then, I would like them to spread the science and technology to countries that need them. We will also make the effort, but I think this is something many people in many countries should do together.

Sato: The U.N. World Conference on Disaster Risk Reduction was held in Sendai, Miyagi Prefecture, in March. We had the Great Hanshin Earthquake in 1995, the Great East Japan Earthquake in 2011 and many other natural disasters. Japan is the most advanced in handling natural disasters. It's unfortunate Japan is prone to disasters but we can be proud that we are the most advanced.

Nakamura: Trains were invented in Britain. But Britain, France and other countries do not work on the quake resistance of trains. Japan did and is now a leader in quake resistance technology for high-speed trains. It's not only trains, but also many other things, that Japan is a leader in quake-resistance technology.

Japan has been successful in many aspects, but isn't perfect. However, many countries are operating high-speed trains, some of which will have to run in quake-prone areas. So, our technology in this area — what we already have and what we will develop — will be very important. The same can be said about nuclear power.

Moderator: Mr. Chubachi has experienced working in a place full of innovation and is now the president of the National Institute of Advanced Industrial Science and Technology. It is without a doubt that cutting-edge engineering is advancing in many new fields. For example, today we see the utilization of "big data" (data compiled from people's demographics and other information) and the multidisciplinary Industry 4.0 (a movement of digitizing manufacturing processes to reduce cost and enhance efficiency). Will you tell us how you think Japan can contribute to the world in your definition of innovation?

Chubachi: Let me first talk about significance of multidisciplines and Industry 4.0. As other panelists have mentioned, the private sector has taken the initiative to do many things and companies have been able to innovate by hiding their intellectual property in a black box. However, technology nowadays has become very complex. Individual companies used to launch new products by themselves, but recently it has become difficult without working with other companies. This tendency can be seen all over the world. Additionally, technology is becoming more advanced and complicated and we may need to stop, review and modify manufacturing methods that have become very complicated. In that sense, I think it is good to come up with an efficient way of manufacturing under an industry-wide agreement such as Industry 4.0.

Also, in the past, civil, construction and electrical engineering could all be learned in their respective university departments. There used to be several different engineering disciplines and each dedicated department could teach everything about each subject.

But now, Japan's engineering does not need big data? That's clearly not the case. Similarly, medicine needs bioinformatics. There is also a materials informatics. I think there are currently many mixed disciplines that need to be combined to teach various engineering specialties.

Kenichi Suganuma, then ambassador of the Permanent Mission of Japan to the International Organizations in Geneva delivered a speech at the closing ceremony of the World Engineers' Convention 2011 in Geneva in September 2011. KAZUMASA ITO

Working to cultivate and grow the next generation of engineers

In the second part of our session, we will discuss in more detail what needs to be done better to nurture tomorrow's engineers

Moderator: Would you please talk about the successful human resource cultivation that will contribute to the development of science and technology and engineering in Japan?

Hanaki: As I've been teaching at university, I feel that teaching undergrad and graduate students the ability to synthesize various fields is a difficult task. The amount of knowledge they need to learn in one field has increased drastically compared to the past, so mastering one area is already a lot of work for the students. But I still expect them to learn more, especially the basic skills and the ability to synthesize the fields.

One thing I'm doing to address this issue is offering a program to cultivate future leaders in the environmental field. In the program, the students go somewhere in South East Asia where they face real problems there such as poverty, development issues, environmental problems and so on. They have the chance to discuss those issues with local students or stakeholders. When it comes time for them to propose solutions for those problems, they are likely not realistic because, after all, they're still students. But having the opportunity to listen, think, analyze and then come up with answers on their own is really important. It will help them to do this process at a much higher level and with more knowledge and experience after they graduate.

Moderator: Mr. Chubachi, you have plenty of interaction with both the private and public sectors. Would you please tell us what you think about human resource cultivation?

Chubachi: Private organizations have a tendency to prefer generalists to specialists. This has the effect of making it harder for holders of higher degrees to get a job in private organizations. If you observe how young employees grow in a private company, you see them spreading their skills and knowledge far and wide, not focusing on a particular area to become specialists. In general, they try to better themselves through synthesizing different fields to become generalists, but I feel ideal generalists should be specialists in principal. I think becoming specialists is the first step and being generalists is the next step, which can be achieved by strengthening their specialties and beyond.

"Generalists versus specialists" was a common argument in the past and there's no consensus on this issue even today. What I can say is that the attitude of cultivating generalists via short cuts should be discouraged. We should also not hesitate to cultivate specialists, because ideal generalists would be produced among them. I believe being a specialist is the essential ground, but the problem is that there are so few chances for specialists to become generalists.

Sato: In that sense, creating a better environment and more chances for specialists to utilize their abilities in various fields is necessary. There are different types of people. For example, Mr. Chubachi and I are the outgoing types, preferring to work on a bigger stage and there are others who prefer smaller environments, but both are equally valuable.

Nakamura: I guess we need many specialists. But we need fewer generalists who can really analyze the whole picture and synthesize the information. The few people with talent and good luck will fill those roles. Discovering those people is the priority.

> **'I'd like private companies to cultivate the leaders of the next generation of engineers and recruit more Ph.D.s.'**
> Hideo Nakamura

Moderator: Do you think the leaders of the next generation in engineering are being produced now? What is your opinion on cultivating future leaders?

Nakamura: I'd like private companies to cultivate the leaders of the next generation of engineers and recruit more Ph.D.s. Recruiting managers tend to think that the skills of Ph.D.s are lacking in broader applicability, but instead of focusing on how the skills can be applied, I would like them to select and hire those with the skills that can be utilized as effective resources in the company. It's a sad reality that Ph.D.s in Japan feel rejected rather often.

Chubachi: There's little room for researchers to dream big in their careers in Japan. I hope researchers receive more respect from society as valuable assets of the country who contribute to society. It may be part of companies' responsibility to encourage this understanding. My institution isn't the only place you can meet the students who are willing to continue post-graduate studies, but it requires a lot of courage to choose that path.

Hanaki: I think engineering is a field that allows a realistic chance to continue studying. Students should study hard and get Ph.D.s, then they can keep studying or do something else, but they still contribute to society regardless. Using Ph.D. engineers more actively and effectively should not be impossible and changes can be made not only at research institutions, but also in central government agencies.

Moderator: That's slightly different from basic science.

Hanaki: Because basic science is the pursuit of truth, people who chose it as their field had a certain motivation. But engineering is for making contributions to actual society, so it is predictable that engineers will further flourish if more chances are given to them.

Moderator: Thank you all for your highly informative comments, opinions and proposals based on your extensive experiences and knowledge.

Mr. Sato, as a summary of today's discussion, would you please give us a message regarding the World Engineering Conference and Convention (WECC) that will be held in Kyoto from Nov. 29 to Dec. 2?

A worker points to the wall of a section of the Furukawa reservoir project being built in central Tokyo on Aug. 7. When completed in 2016, the 3.3-km-long subterranean reservoir will be able to hold 135,000 cu. meters of water, enough to fill 54 Olympic-sized swimming pools. BLOOMBERG

Sato: I did the program construction of the WECC and you can categorize it into nine wide tracks. Each track has a theme such as social infrastructure, how to create a resilient infrastructure, engineering society, energy and so on. The contents cover many issues in industry and society, including engineering education, the issue of women in engineering and even the issues of aquatech. Each track is divided into six sessions, and the volume of one session is basically equivalent to one scientific conference. It means that there will be about 54 conferences held at WECC and those 54 conferences cover all the fields necessary to create world engineering.

I would like all young students, young engineers and the experienced engineers who lead them to participate in WECC 2015. Fruitful discussions should be carried out over issues such as the current level of engineering or problems facing modern engineering. I would like people to think about and discuss those issues in addition to broader issues such as how engineering develops in the future, or what engineering should look like.

Participants, including young engineers, tend to attend only sessions of their own field. In extreme cases, there are even some who only attend the presentations of their laboratories. This is such a narrow-sighted approach, causing them to miss a lot of new discoveries. I would like to encourage them to listen to opinions in different fields, because there are definitely seeds of next generation's engineering that can be used in their own fields. What's important is thinking about transdisciplne or interdisciplne to go beyond their own fields and disciplines. There will be many people from developing countries at WECC and I would like Japanese engineers to talk to them about what is necessary to make a better world and how to protect it.

Moderator: What is the significance of holding WECC 2015 in Kyoto?

Sato: Kyoto has been creating Japanese culture for 1,000 years, and it is home to many unique and internationally competitive companies. So, holding this conference in Kyoto can be a model for people to see the relationship of culture, engineering made by culture, science and the development of technology. Engineering is something definitely necessary to the country, and it inevitably influences the culture of the country, because engineering and society are so strongly connected. I would like to people, especially those in developing countries, to think about Kyoto from that prospective.

Moderator: Thank you for your clear and powerful messages and comments about how Japanese engineering technology," which is mentioned on the WECC website?

Chubachi: The world is becoming very complex and diverse, and thus universities and academia should also become complex. Then they will realize they have analysis, but not synthesis. There is no integration. If something like science analyzes, something has to synthesize. And then something has to assemble. Assembling the individual knowledge from the academic society, that's where integration process comes in.

Making full use of science to form something useful for society. Just as the Future Earth Mr. Hanaki mentioned earlier, manufacturing requires design first. In short, they design, produce and deliver. If you ask for whom this process exists, it's for society.

Sato: I often encounter an occasion in which I'm at a loss responding to a certain argument. That's when people ask me if Japan is advanced or behind in utilizing big data and other things that are trending.

There are too many arguments over those things. Engineering is for society; there's no "advanced" or "behind." What does Japanese society need now? What does global society need now? To meet those demands, we integrate different disciplines, make various combinations of disciplines and challenge to tackle various issues. A lot of people want to argue Japan is behind; that's not the point.

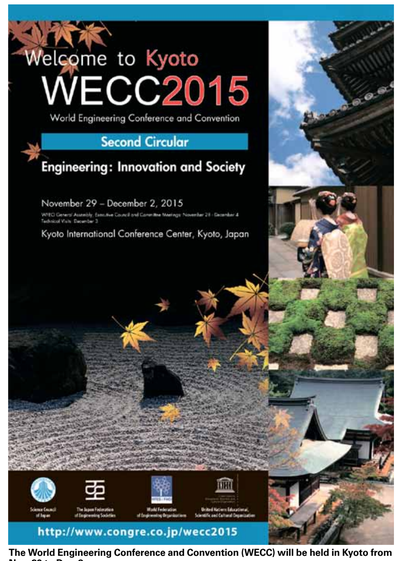
Chubachi: In the field of artificial intelligence (AI), some Japanese scientists are successfully conducting research in the U.S. Japan has technology and money, but AI research is not as integrated as other technologies and scientists are. Integrating them will be very valuable. Also, as Mr. Sato just mentioned, Japan is not in a situation where we have to defeat the U.S. and Europe from the beginning.

Sato: Regarding "integration," a big problem is how to train qualified people. What Japan is struggling with right now is nurturing the leaders of technology integration.

Chubachi: You're right. We don't have many of those people.

Sato: Such leaders will need knowledge in various fields and leadership, or political power to integrate. Training people to become such leaders is very challenging. It's not only a problem in Japan. It's a global problem.

Moderator: Let's take a break here and we will continue discussion on training after the break.



The World Engineering Conference and Convention (WECC) will be held in Kyoto from Nov. 29 to Dec. 2.

ing can contribute to the world. I believe WECC 2015 will be an occasion to spread a strong influence to the world. Thank you very much.

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