# Chapter 3 Human Resource Development and Establishment of Research Environment to Support Research Capacity

Among the initiatives for the realization of a science and technology nation, those related to human resource development and the establishment of a research environment, such as new projects to strengthen the research capacity of universities and initiatives to support young researchers and doctoral students, are introduced in this chapter.

## Section 1 New Projects for Strengthening Research Capacity of Universities

Universities produce more than 70% of papers in Japan (see Figure 1-1-7), and it is essential to enhance the functions of universities to strengthen research capacity. This section introduces new projects for enhancing the functions of universities carrying out R&D at par with the world, regional core universities and universities with strengths in specific fields.

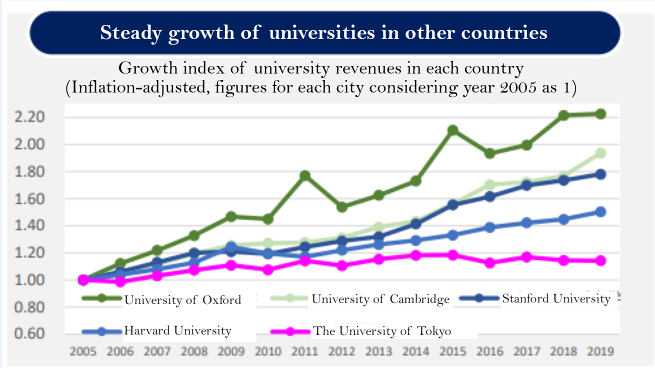
### 1 Establishment of University Endowment Fund

From the first half of the 2000s, the research capacity of Japanese universities has been on a relatively downward trend compared to the world, as can be seen from the decline in the number of papers. It has been pointed out that major universities in Europe and the U.S. have formed their multi-trillion-yen funds and are utilizing the investment profits to expand the investment in research infrastructure and young researchers. Since it is difficult to immediately overcome this gap in funding ability solely by the strengths of individual universities, the Japanese government recently decided to establish a University Endowment Fund of 10 trillion yen using national funds and provide long-term and steady support to the research infrastructure of universities through investment profits.

Universities are the connecting point for diverse knowledge, and it is essential to strengthen the research capacity of universities to create growth and innovation in Japan. The universities supported by the University Endowment Fund (Universities for International Research Excellence) are expected to build an innovation ecosystem with universities at its core and become global bases of knowledge where competent human resources from across the world will continue to gather, leading to the improvement of Japan's academic research network.

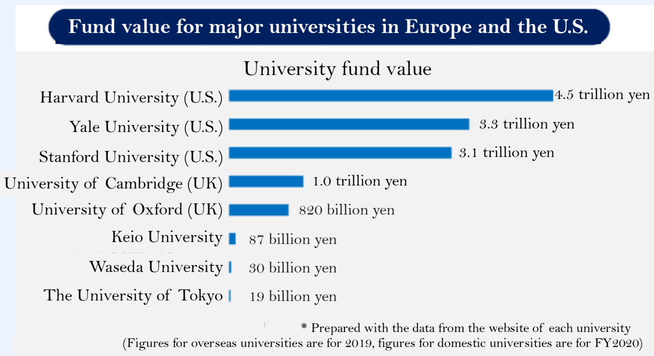
On the other hand, to strengthen the research capacity of Japan as a whole, it is important to not only support top-level research universities through the University Endowment Fund but also to foster competent human resources that form the foundation of such universities. To this end, the University Endowment Fund will also support competent young researchers across Japan, and the Japanese government is already working to radically expand financial support for doctoral students ahead of the support provided by the University Endowment Fund (see Chapter 3, Section 1 2).

## ■ Figure 1-3-1/ Comparison with universities in other countries in terms of growth index




* Excerpts from Document 1 of the Council for Science, Technology, and Innovation (58th meeting)
* Data for overseas universities is compiled based on annual reports from each university (hospital revenues are excluded). Data for Japanese national universities are compiled based on financial statements (associated hospital revenues are excluded). The growth rate is shown taking the year 2005 revenues as 1. The exchange rates used for revenue calculation of overseas universities are $1 = 110 yen and £1 = 135 yen. The growth index is corrected using the consumer price index.

## ■ Figure 1-3-2/ Comparison with universities in other countries in terms of fund value




* Excerpt from MEXT's budget data for FY2022

## ■ Figure 1-3-3/ Future image of Universities for International Research Excellence (conceptual diagram)


Document: Prepared by MEXT

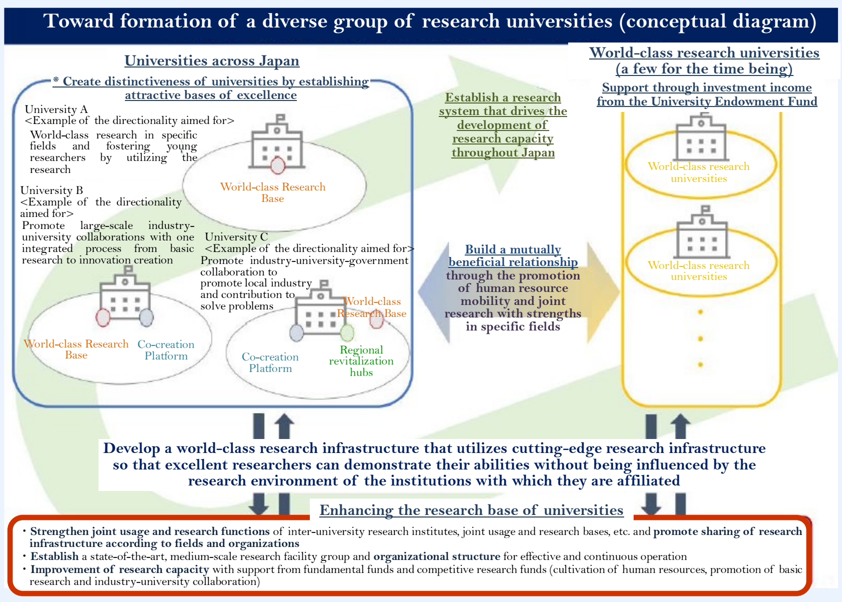
## 2 Comprehensive Promotion Package for Regional Core and Distinctive Research Universities

To boost Japan's research capacity as a whole, it is essential to increase the capacity of various regional universities, which are "Bases of knowledge and human resources," and take measures to increase the number of second-tier universities. The number of papers by Japan's second-tier universities is lower compared to the U.K. and Germany (see Figure 1-1-9).

Therefore, in addition to the establishment of this ten-trillion-yen University Endowment Fund of 1, the government is implementing support measures to enhance the functions of regional core universities and universities having strengths in specific fields in the form of the "Comprehensive Promotion Package for Regional Core and Distinctive Research Universities (The Package)." Through related measures and institutional reforms such as the "World Premier International Research Center Initiative (WPI) Program" (see Chapter 2, Section 2 5) and the "The Program on Open Innovation Platform for Industry-Academia Co-Creation (COI-NEXT)" (see Chapter 4, Section 1 2), support is provided to various motivated universities in order for them to fully demonstrate their respective strengths and characteristics, develop the local economic society, solve international and domestic issues, and expand their distinctive research globally.

The government will provide the necessary support in the future, such as encouraging strategic management that boosts the strengths and characteristics of universities for strengthening the research capacity of Japan as a whole while gradually revising the Package. Through the promotion of human resource mobility and joint research, the regional core universities and universities with strengths in specific fields will be able to build mutually beneficial relationships with research universities that are at par with the world.

■ Figure 1-3-4/ Toward formation of a diverse group of research universities




Document: Excerpt from Document 3 of the Council for Science, Technology, and Innovation (58th meeting)

# Section 2 Enhancing of Measures Related to Human Resource Development to Support Research Capacity

The primary factor behind the decline in the number of papers in recent years is the challenging environment surrounding young researchers, including the decline in the number of secure posts. Securing an environment where young researchers can focus on their research and improving the treatment of doctoral students are pressing issues. Also, the percentage of Japanese female researchers is less compared to other countries, and it is important to foster female researchers and promote their active participation to strengthen the research capacity.

## 1 Comprehensive Package to Strengthen Research Capacity and Support Young Researchers

The “Comprehensive Package to Strengthen Research Capacity and Support Young Researchers” was formulated in January 2020 to overcome the current state of Japan’s research capacity and strengthen it comprehensively and radically. For strengthening Japan’s research capacity, an attractive research environment is required to be provided to motivated researchers, from young researchers to top researchers, and in particular, to enhance the support to young researchers to enable them to engage in challenging research for the future in a stable environment. To achieve this, the goal set in the package is to “drive Japan’s knowledge-based value creation system and realize a virtuous cycle that generates researchers required by the whole society through (1) drastic improvement of the research environment for young researchers, (2) securing of sufficient time for their research and education activities, (3) realization of diverse career paths for researchers and (4) creation of doctoral courses that are attractive for students.”

With the help of this package, the government established a program called "Fusion Oriented REsearch for disruptive Science and Technology" is being promoted, which was launched by the government in FY2019 to provide an environment in which researchers just before and after becoming independent, especially young researchers, can boldly work on ambitious research concepts on a long-term basis. This program provides long-term support of up to 10 years for a variety of free, challenging and interdisciplinary research that is not limited by the existing framework while securing an environment for researchers enabling them to concentrate on their research in collaboration with affiliated institutions.

In addition, under the same package, a “buy-out system” was introduced in the competitive research fund system from FY2020 by soliciting new applications, in which the cost of hiring someone to take over a part of the duties other than research of the Principal Investigator can be covered by the direct expense. This system is expected to allow researchers to outsource educational activities, such as lectures and various administrative tasks associated with the activities within the university, and secure time for research to enhance their research capacity. In the light of this package, the 6th Basic Plan has set numerical targets to increase the number of full-time university faculty members under 40 years by 10% by 2025, and in the future, bring the percentage of university faculty members under 40 years to at least 30% of the full-time university faculty members.

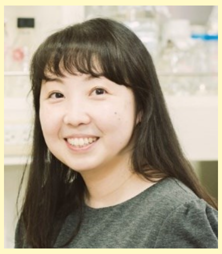
## COLUMN 1-1 "FOREST Researchers" Taking on Challenges

**Fusion Oriented REsearch for disruptive Science and Technology website**
URL: https://www.jst.go.jp/souhatsu/
Source: Japan Science and Technology Agency

"Fusion Oriented REsearch for disruptive Science and Technology" is a program that provides long-term support for free and challenging research by diverse researchers, especially young researchers, while securing an environment in which researchers can devote themselves to research in collaboration with affiliated institutions.

The selected "FOREST Researchers" will cope on their challenging research concepts with vigor and enthusiasm through "Place for Fusion" where researchers engage in friendly rivalry and mutual inspiration under the supervision of a FOREST PRO (program officer) who is active at the forefront of research.

This column introduces two "FOREST researchers" who have been taking on challenges under the Fusion Oriented REsearch for disruptive Science and Technology.



Dr. HATAKEYAMA Jun
Assistant Professor, Institute of Molecular Embryology and Genetics, Kumamoto University.
Research subject: Role of extrinsic factors in primate brain development and their applications to neonatal care

Since childhood, Dr. Hatakeyama has been deeply interested in how babies in their mother's womb develop as human beings. This was the origin of her interest in "development," which later led to an encounter with research on "brain development" at the university.

Dr. Hatakeyama is currently interested in the formation of the brain, which is the basis of advanced human intelligence and is working to elucidate the mechanism of the enlargement of the primate brain and the formation of the numerous folds on the brain's surface. Although primate research is time-consuming, as an emergent researcher, she can now concentrate on research for an extended period. In recent years, preterm and low birth weight babies account for about 10% of all births, and the number is increasing each year. Although more lives can be saved with the development of medical science, early separation from the mother's womb may affect brain development. If we can medically understand the development process of the human brain, we can contribute to neonatal care for a better life.

Dr. Hatakeyama, who continues to take on the challenge of fulfilling a long-held desire to "understand the development of the human brain," is motivated by a strong interest in her research subject. Her message to students is, "Once you find something fascinates you, go for it, and grab the opportunities!"

Dr. ITOH Yuta, Specially Appointed Assistant Professor, Interfaculty Initiative in Information Studies, The University of Tokyo
Research subject: Augmented human perception of the real world by light field modulation

Dr. Itoh developed an interest in science by watching science fiction (SF) from a young age. A Japanese SF animation about augmented reality (AR[1]) broadcast when he was an undergraduate inspired him to make AR his research theme. During his master's program, Dr. Itoh visited an AR research group at the Technical University of Munich, Germany as an exchange student, which he later officially joined and obtained his doctorate in AR displays.

As an emergent researcher, he is working to further develop and foster AR research under the Strategic Basic Research Program "PRESTO."[2] Although AR display technology is becoming increasingly widespread, it has yet to become an omnipresent technology like smartphones. Dr. Itoh aspires to create a world where everyone can freely experience AR everywhere. Examples of his endeavors in research include "beaming display," a near-eye display system that accurately projects images from a distance, programmable eyeglasses that can modulate light according to an individual's eyesight, and a tangible AR system that enables interactions between the virtual and real world. He is confident that further advancement in AR technology can give rise to a society where virtual information is seamlessly integrated with the real world.

As his research career motto, Dr. Itoh believes that fortune favors the bold. Dr. Itoh says, "If you find something interesting, try it out first, and cherish encounters with people who will appreciate it, leading to a fulfilling research life".

1 Augmented Reality
2 In PRESTO, which is a Strategic Basic Research Program, researchers, mainly young researchers, are selected by soliciting applications, which promotes individual basic research that will nurture the seeds of future innovations while forming a network of researchers from different fields.

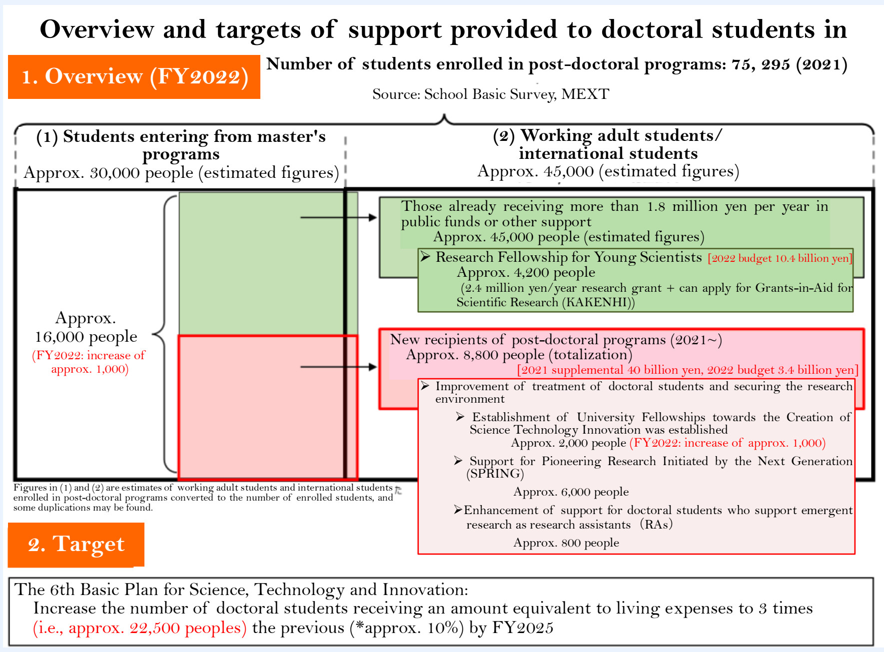
## 2 Improvement of Treatment of Doctoral Students and Expansion of Career Paths

The 6th Basic Plan sets goals as follows: "the number of students in doctoral programs receiving the amount equivalent to living expenses will be increased to three times the current number by FY2025 (equivalent to about 70% of students moving up from master's programs)." Based on this, support initiatives, namely, "Support for Pioneering Research Initiated by the Next Generation (SPRING) Program" and "Establishment of University Fellowships towards the Creation of Science Technology Innovation" were newly launched from FY2021 for universities that integrate financial support (amount equivalent to living expenses and research expenses) to competent and ambitious doctoral students to help them concentrate on their research, with career path development for active participation of doctoral graduates in a wide range of fields including industrial sector (research internships, etc., at companies). It is expected that these initiatives and the existing support measures, such as the "Research Fellowship for Young Scientists (D.C.) Program," will support around 15,000 doctoral students. The government plans to increase further the number of students receiving support by around 1,000 in FY2022.

In addition, the government is taking initiatives to encourage the appropriate treatment of doctoral students engaged in research projects, etc., as research assistants (RA), and promote long-term and paid cooperative education through research internships to expand the career paths of doctoral students and enhance industry-academia joint education at the graduate school level.



■ Figure 1-3-5/ Overview and targets of support provided to doctoral students in Japan



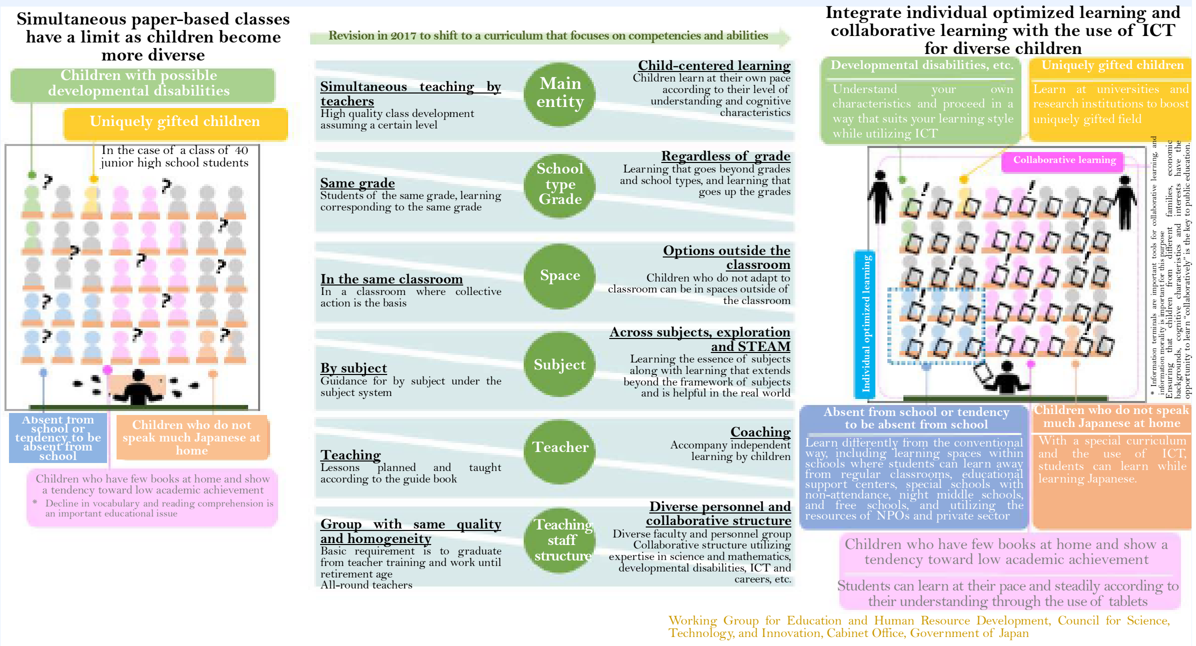

Document: Prepared by MEXT

## 3 Policy Package regarding Education and Human Resource Development toward the Realization of Society 5.0

To promote “education and human resource development to realize diverse happiness (well-being) and challenges for each individual,” which is set as one of the 3 pillars of the policies in the 6th Basic Plan, the “Working Group for Education and Human Resource Development” was established with the participation of the members of the Central Council of Education and the Industrial Structure Council in the Council for Science, Technology and Innovation (CSTI). The “Policy Package regarding Education and Human Resource Development toward the Realization of Society 5.0” was formulated after 8 rounds of discussions.

This package includes 3 policies, namely, (1) Diversification of “time” and “space” for learning, with emphasis on children's characteristics, (2) Establishment of an ecosystem that supports exploration and STEAM[1] education throughout society and learning that does not let go of “liking” and “passion” of children with unique talents, and (3) Breaking away from the dichotomy of humanities and sciences and eliminating the gender gap in science and mathematics learning, and 46 measures, based on the common understanding that while changing social structure, characteristics and interests that are different from other people will be the source of new value creation and innovation in the future. Various entities throughout the government will take initiatives to support the learning of children who will lead the next generation through the formation of an ecosystem that supports the learning of children.

■ Figure 1-3-6/ Diversification of “time” and “space” for learning, with emphasis on children’s characteristics (target concept)



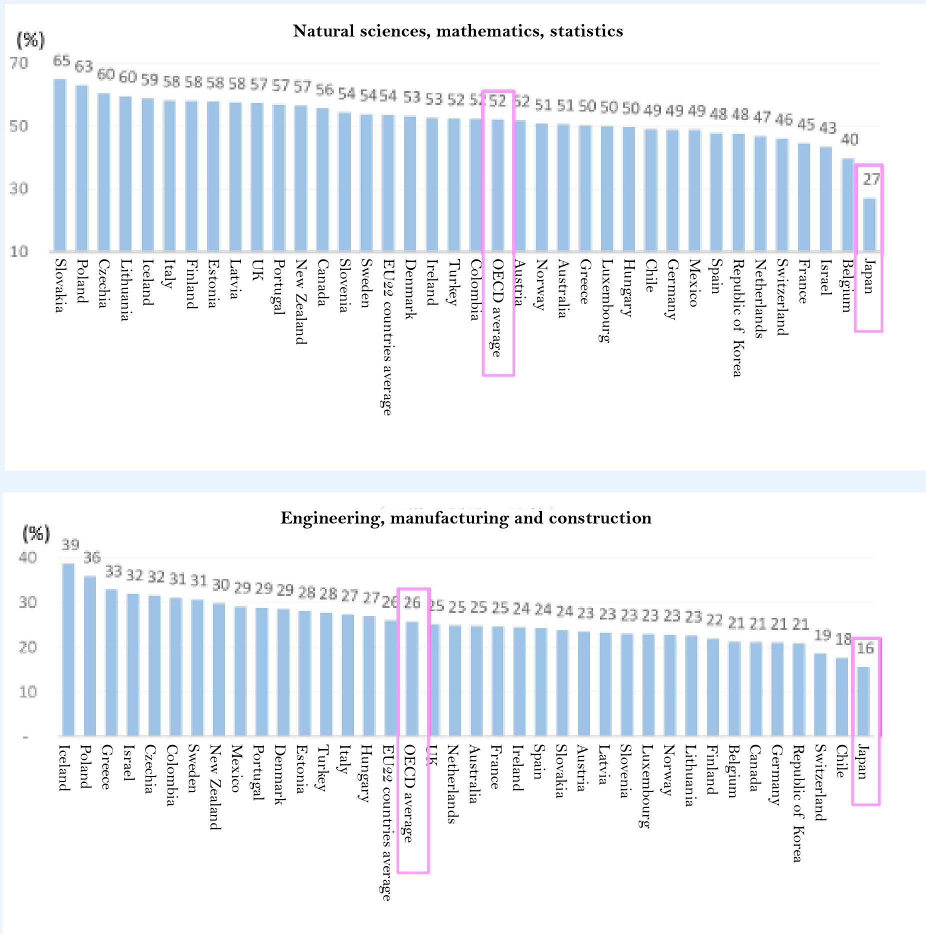

Provided by: Working Group for Education and Human Resource Development, Council for Science, Technology, and Innovation, Cabinet Office, Government of Japan

[1] Science, Technology, Engineering, Art(s) and Mathematics

## 4 Fostering and Promotion of Active Participation of Female Researchers Playing Leading Roles in Science, Technology, and Innovation

Although the percentage of female researchers in Japan is increasing yearly, the numbers are still less than in other major countries (see Chapter 1, Section 3 4). Fostering female researchers is an important issue for enhancing Japan's research capacity; however, according to a survey by the Organization for Economic Cooperation and Development (OECD [1]), Japan has the lowest percentage of women in STEM [2] (Science, Technology, Engineering, and Mathematics) fields among students enrolled in universities and other higher education institutions in 2019 among member countries. For fostering female researchers, it is important to get more female junior and senior high school students interested in STEM fields. In light of this situation, the "Council for the Creation of Future Education" chaired by the Prime Minister, submitted a proposal in May 2022, stating that the financial support to universities and colleges working proactively on securing quotas for female students in undergraduate programs in science fields, will be enhanced.

■ Figure 1-3-7/ Percentage of women among students enrolled in universities and other higher education institutions of OECD member countries




Source: OECD Education at a Glance 2021
Prepared by MEXT based on Table B4.3. Distribution of new entrants into tertiary education by field of study (2019)

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1 Organisation for Economic Co-operation and Development
2 Science, Technology, Engineering and Mathematics

The Japan Science and Technology Agency implements the "Project to encourage female students of lower/upper secondary schools to follow the science career paths" to support female junior and senior high school students for appropriately choosing to major in sciences by holding exchange meetings, experiment classes, and visiting lectures for female junior and senior high school students by female researchers, engineers, and female students who are active in the field of science and technology. Since 2009, more than 100 institutions, including universities and technical colleges nationwide, have implemented this program. The results of a questionnaire survey of the female junior and senior high school students who participated in this program revealed that parents and teachers have a significant influence on the choice of the career path of female junior and senior high school students and that not having female role models who work using their knowledge and skills of science fields, is one of the obstacles in choosing to major in sciences.

These survey results must be considered and foster an understanding of the society in general about the active participation of women in science and engineering fields through industry-university-government collaboration.

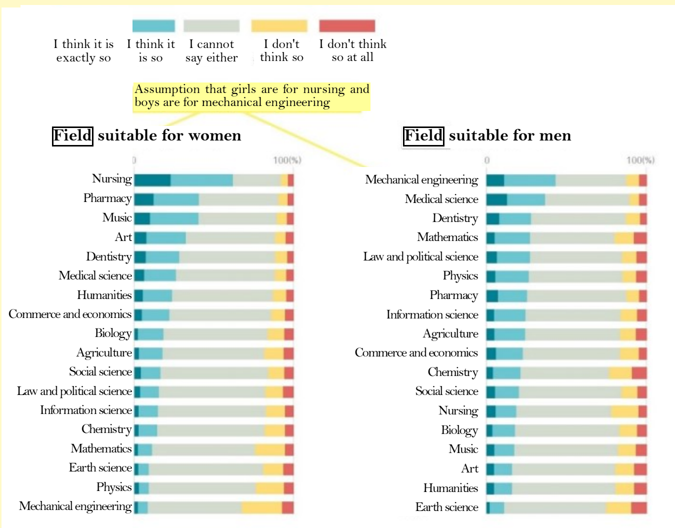
## COLUMN 1-2 Why is the number of women majoring in physics and mathematics less?

The percentage of women entering science and engineering in Japan is among the lowest in the world (see Figure 1-3-7). At the Kavli Institute for the Physics and Mathematics of the Universe (Kavli IPMU), the University of Tokyo, a research project led by Professor Hiromi Yokoyama is being conducted to understand these factors based on social norms for women under the project "Analysis of the factors that influence women and girls to pursue physics and mathematics," which is a part of the JST-RISTEX Science of Science, Technology and Innovation Policy program. This research showed that in Japan, there is a strong image that mathematics and physics are suitable for men, which is due to the image of employment after graduation and the preconceived notion (mathematics stereotype) that men are more inclined toward mathematics, as well as the social culture of gender roles that men and women are supposed to play, which influences women's career choices.

◆ General perception - Nursing for girls? Mechanical engineering for boys? ~

A survey was conducted for the general male and female population to determine their image of suitable and unsuitable fields by gender of 18 fields, including science and engineering. As shown in the figure below, there was a strong image that nursing, pharmacy, music and art are suitable for women and mechanical engineering, medicine, mathematics, physics are suitable for men.

**Image of "suitable" for women and men in each field**



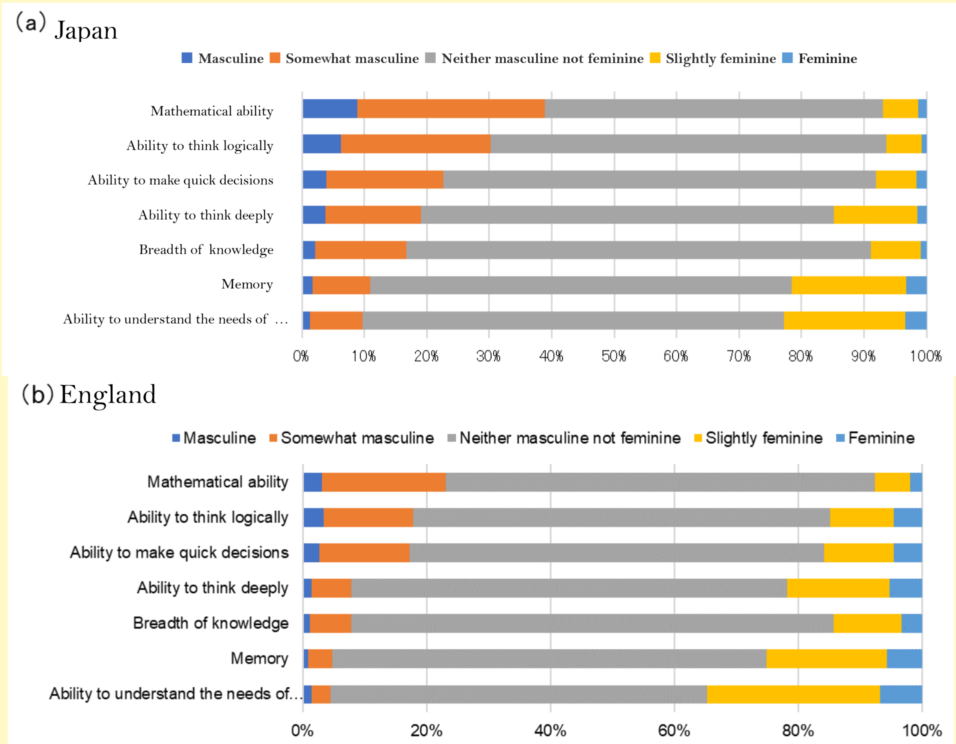

(Survey conducted in 2018. 1,086 (545 women and 541 men)) ("Illustration: Makoto Tomita")

Source: Reorganized by Yokoyama Research Group based on "Ikkatai, Y., Minamizaki, A., Kano, K., Inoue, A., McKay, E., & Yokoyama, H. M. (2020). Gender-biased public perception of STEM fields, focusing on the influence of egalitarian attitudes toward gender roles. Journal of Science Communication, 19(1), A08. DOI: https://doi.org/10.22323/2.19010208".

◆ Are competencies in mathematics and physics specific to men?

A study on competencies needed in the fields of mathematics and physics, where women are notably less in number in Japan, revealed that although the Japanese public do not think that there is a gender-related difference in competency, these competencies are considered to be masculine, as shown in the figure below, and the tendency to think so is stronger than England.

Perceived masculine/feminine image of competency in each field

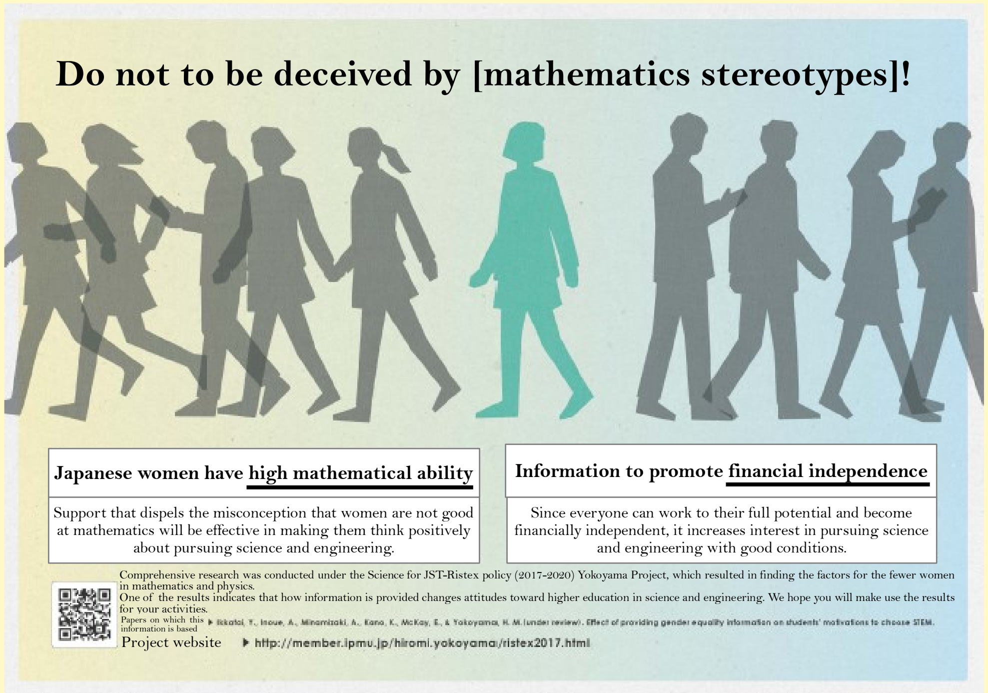



Survey conducted in 2019. Japan: 1,177 (583 women, 594 men), England: 1,082 (553 women, 529 men)

Source: Reorganized by Yokoyama Research Group based on "Ikkatai, Y., Inoue, A., Minamizaki, A., Kano, K., McKay, E. and Yokoyama, H. M. (2021). Gender images of abilities needed in STEM fields: A comparative study of Japan and the UK. (Special Issue: Research on Diversity of Human Resources in Science and Technology). Journal of Science, Technology and Society, 19, 79-95"

◆ In addition to providing information on employment and eliminating the mathematics stereotypes, the government is also working to create an awareness of an equal society

It was confirmed from this study that there is a strong image of what is suitable for women and men in academic fields and that there is a bias of consciousness at the levels of the individual, parents, and social customs, which cannot be separated from each other. These results suggest the importance of not only providing women with information about employment if they major in science fields and eliminating the mathematics stereotypes but also creating awareness throughout Japan regarding women's career choices.




Click here for more information on this study: https://member.ipmu.jp/hiromi.yokoyama/ristex2017.html
"Analysis of the Factors that Influence Women and Girls to Pursue Physics and Mathematics" Project, JST-RISTEX Science of Science, Technology and Innovation Policy
(Principal Investigator: Hiromi Yokoyama, Professor, The University of Tokyo)

## COLUMN 1-3 Establishment of the First Engineering Department at a Women's University

The low percentage of women in the workforce in science and engineering fields, especially engineering, has become a significant issue worldwide. In Japan's industrial sector, there is an increasing demand for a female workforce in the engineering field. This is because there is an awareness of problem that in the male-dominated field of manufacturing, there are few products and ideas from the perspectives of women and other people in diverse positions.

However, according to the School Basic Statistics for the academic year 2021, the percentage of female engineering students was only 15.7%, indicating that there is still a shortage of female engineering workforce. In a gender-balanced environment, there is a high awareness about improving the quality of R&D, which has also given rise to the term "gendered innovations". In countries that aim to become I.T. nations like India and Israel, the entire nation is working on fostering female engineers.

Under such circumstances, Nara Women's University established an engineering department, the first in Japan at a women's university. The curriculum of this department emphasizes liberal arts education that give a broad view of engineering from the perspective of people and society while focusing on project-based learning (PBL) to offer practical engineering. Another prominent feature of this curriculum is its system of free-choice subjects where students voluntarily select subjects according to their career vision while learning about the latest technology and challenges through collaboration with local companies and research institutions, thereby fostering human resources who can flexibly respond to changes in the future. In order to fulfill our responsibility as one of only two national women's universities in Japan, this university is exploring how the future of engineering should look in order for women to find it appealing and how to encourage the growth of female engineers. The finding will be used to make policy recommendations to increase the number of women and develop the power of women in engineering.

Electronics class on IoT

Explaining 3D printers to a new student

Provided by: Nara Women's University

## COLUMN 1-4 "Brilliant Female Researchers Award (The Jun Ashida Award)"

The percentage of female researchers in Japan is 17.5% (2021), which is low compared to other countries (see Figure 1-1-21). To overcome this situation, the development of research environments where female researchers can actively participate is underway at various places. The Japan Science and Technology Agency started the "Brilliant Female Researchers Award (The Jun Ashida Award)" in 2019. As part of its efforts to promote the activities of female researchers, this system honors female researchers conducting outstanding research and other activities that contribute to a sustainable society and future, as well as organizations promoting their activities. The award is made possible through the cooperation of the Ashida Foundation, a fund established by the late designer Jun Ashida, from which the award takes its name. This column introduces the research of the two most recent award winners, the reasons for receiving the award, and interviews about their motivation to become researchers.

○ The year 2021 Awardee Dr. SASADA Makiko

Associate Professor, Graduate School of Mathematical Sciences, The University of Tokyo
RIKEN Center for Advanced Intelligence Project (AIP Center)
Visiting Scientist, Mathematical Science Team

Dr. Sasada uses algebra and geometric theory, which are seemingly unrelated to statistical physics and probability theory, to construct a new theory that explains macroscopic phenomena such as changes in temperature and density. The macroscopic behaviors are derived from the laws of the microscopic world, which are comprised of particles such as atoms and molecules.

Social contribution: her outreach activities include creating the Suri-Joshi website, releasing videos on probability theory, and giving public lectures. She is also dedicated to fostering women in the mathematical sciences, including serving as the International Mathematical Union's Committee for Women in Mathematics (CWM) ambassador.

<Questions to Dr. Sasada>

Q1: How did you become interested in natural science?

→ A1: I have been fond of logical puzzles and interesting arithmetic problems since childhood. The exhilaration I felt in solving a problem was especially fascinating.

Q2. When did you first become interested in becoming a researcher? What was the trigger for this?

→ A2. My father was a researcher, which had a significant influence on me. When I was a child, unlike my friends' fathers, my father used to come home for dinner, making me think that this might be a good profession. I think it was when I was a master's student that I seriously thought about becoming a researcher. I had the opportunity to meet the author of textbook I was reading at the time. He spoke passionately about the appeal of research in mathematics, which motivated me.

Q3: What is the interesting and challenging part about being a researcher?

→ A3: I really enjoy the moment when an idea that has been floating around in my head that I keep thinking about begins to take a definite shape gradually, and at some point, the essence of the idea suddenly becomes apparent. I find it very interesting when I find beautiful connections between various seemingly unrelated phenomena and concepts. The challenging part is that too many things interest me for which I don't have enough time.

Q4. Tell us about the research you are currently working on.

→ A4. My current research is to gain a deeper understanding of mathematical theories to derive macroscopic world phenomena from the laws that explain the movements of the small world by incorporating various perspectives.

Q5. What is your future dream as a researcher?

→ A5. To continue to do research that I find truly interesting.

Q6. Do you have a message for children and students who aspire to become researchers?

→ A6. The joy of research and learning is not limited to a handful of special people. It is important to come across topics that excite you. As you never know where you will find such encounters, I encourage you to be interested in a variety of things and also value interactions with people.

○ 2020 Awardee Dr. SAKAI Nami

Chief Scientist, Star and Planet Formation Laboratory, RIKEN Cluster for Pioneering Research

With her pioneering work in the new field of astronomy, which combines astronomy and chemistry, Dr. Sakai has delved into the fundamental question of astronomy, "How ubiquitously do environments like the solar system exist in the universe?", and has produced innovative results that have led to the elucidation of the origin of diverse extrasolar planetary systems and the formation of planetary systems. She also participates in social contribution activities such as promoting women's social activities and fostering younger generations through outreach activities, including lectures and exhibitions. Dr. Sakai also worked as a lecturer for the Leadership Development Program for Female Researchers.

<Questions to Dr. Sakai>

Q1: How did you become interested in natural science?

→ A1. I think it started with my daily encounters with nature during elementary school. This included activities like observing living creatures, climbing trees, and making hideouts out of dry leaves.

Q2. When did you first become interested in becoming a researcher? What was the trigger for this?

→ A2. I began to think about a career as a researcher in high school. But in my sophomore year at University, I started aspiring to become a researcher. I had an opportunity to talk with a professor in astronomy, and when I told him I was interested, he asked me, "What do you want to know about the Universe?" I could not answer the question because my interest was merely a vague longing. I deeply regretted this fact, and that was the main reason I started research in earnest.

Q3: What is the interesting and challenging part about being a researcher?

→ A3. What I find interesting is that I am the only one who knows facts that no one else in the world knows yet and that there are times when I am confronted with unexpected truths. The hard part is the many chores that are not directly related to my research.

Q4. Tell us about the research you are currently working on.

→ A4. I am exploring how to accurately determine from observations the abundance of organic molecules formed in interstellar cloud. This is crucial in finding the answer to the question, "In how much abundance the organic molecules originally existed when planetary systems came into being?".

Q5. What is your future dream as a researcher?

→ A5. I want to get at least one step closer to solving the question, which is closely related to our origin, 'What conditions are necessary for a planetary system with planets having life on them, like the solar system, to come into being in this universe?'.

Q6. Do you have a message for children and students who aspire to become researchers?

→ A6. I think many of you have a vague sense of admiration for researchers. Even I was like that. Take just one step ahead. You will notice something interesting or discover what you are interested in, which will be a concrete step toward your dream.

## 5 Fostering, Supporting, and Securing Management Personnel such as URAs and Technical Staff

There are growing expectations from University Research Administrators (URAs) to manage overall research activities at universities and public research institutions. Earlier, research activities were conducted through the collaboration of researchers who conducted research and administrative staff who assisted; however, in recent years, the social responsibility demanded of universities has increased, requiring joint implementation of projects by stakeholders from various fields and initiatives for social implementation. This has brought a significant change to the nature of research.

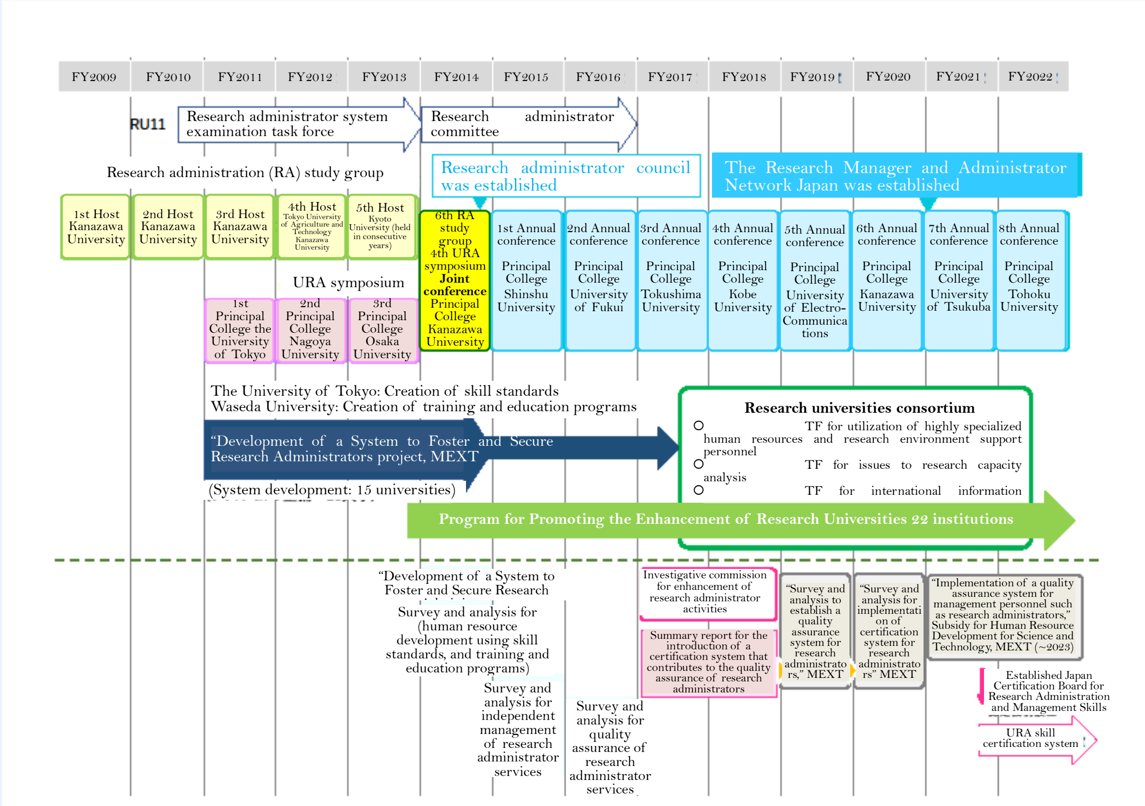
As the environment surrounding universities and other institutions is changing significantly, such as the COVID-19 pandemic and the need to promote research DX[1] (see Chapter 3, Section 3), it has become essential to effectively implement various research support activities, such as obtaining external research funds due to diversification of research funding, research project planning, development of the research environment, management tasks such as administrative work, use of intellectual property generated during research, contracts, P.R., and other such tasks, and professionals who support research so that universities and public research institutions can demonstrate their strengths, have come to play an active role.

The "Development of a System to Foster and Secure Research Administrators" was started in FY2011, and since then, the assignment of URAs to universities and other institutions has progressed. In the "Program for Promoting the Enhancement of Research Universities" started in FY2013, the selected universities were required to take initiatives to foster the URAs, which further entrenched the system. Currently, over 1,500 URAs are active in important positions at various institutions across Japan. In addition, from FY2021, a quality assurance system for URAs was launched to further foster and assign management personnel such as URAs.

While it has become increasingly important to utilize and systematically maintain and operate the latest research facilities and equipment, the importance of technical staff as personnel directly involved in the maintenance, management and operation relating to the sustainable infrastructure and usage environment of the facilities and equipment has been growing. Technical staff possess advanced and specialized knowledge and skills. They are expected to contribute in various ways, including participation in formulating management strategies related to research facilities and equipment, to make the most of their competencies and expertise as partners of researchers in problem-solving. Also, the scope of their activities is expected to expand with improvement in their treatment and expansion of their career paths. The "Guidelines for the Promotion of Shared Use of Research Facilities and Equipment" (March 2022, Study Group on the Development of Guidelines, etc., for the Shared Use of Research Facilities and Equipment Between Universities, etc.) (see Chapter 3, Section 3), call for the promotion of maintenance and utilization considering the research facilities and equipment and the personnel supporting them as an integrated unit, to make the most of the research facilities and equipment.

1 Digital Transformation

■ Figure 1-3-8/ Mechanism of the URA system in Japan




Provided by: The Research Manager and Administrator Network Japan

## Section 3 Strengthen Measures to Establish Research Environments

### 1 Promotion of Research DX

The COVID-19 pandemic has accelerated the trend toward digital transformation of research activities (Research DX), along with the digitalization of society as a whole. Both software and hardware aspects of Research DX must be addressed to create research results with higher added value. For software, data generated in the research process is strategically collected, shared and utilized. For hardware, initiatives are being made to make research facilities and equipment remote and smart and to develop next-generation digital infrastructure.

#### (1) Strategic collection, sharing and utilization of research data

As it becomes easier to collect and analyze diverse types of data, such as big data, data-driven research (a research method to advance the search for truth by automatically and statistically generating, analyzing, and verifying hypotheses from large amounts of data, unlike the conventional method in which researchers manually identify and verify hypotheses (hypothesis-driven research)) that utilizes simulations using supercomputers or AI is expanding. In addition, the Open Science movement, which aims to create research results with higher added value by publishing and sharing research data, is gaining momentum worldwide.

To create high-impact research results in Japan, the NII Research Data Cloud, a research data infrastructure system of the National Institute of Informatics (NII) , has been positioned as a core platform for managing and utilizing research data and a system for strategically collecting research data from public funds and making searchable for various data is being built. While taking advantage of the characteristics of each research field, efforts are being made to collect high-quality research data, build data platforms for strategic data sharing, develop and secure human resources, and promote pioneering AI and data-driven R&D that makes effective use of the data.

#### (2) Making remote and smart research facilities and equipment

To enable research activities to be carried out without being bound by distance or time, efforts are being made to encourage initiatives such as smart laboratories that realize remote research activities, automation of experiments through the introduction of robots, and virtual experiments in virtual spaces backed by abundant experimental data at all research sites, from large shared facilities to research laboratories.

#### (3) Development of next generation digital infrastructure

SINET is being constructed as an infrastructure to support digital transformation for research across Japan.[1] SINET is an ultra-high-speed, high-capacity information network designed and operated by NII as an academic information infrastructure that supports educational and research activities of universities, research institutions, etc., across Japan. To support community formation by a large number of people engaging in education/research and to facilitate the distribution of a wide variety of academic information, including a large volume of data, SINET has covered all 47 prefectures, including more than 950 universities/research institutions and has connected the United States, Europe and Asia for global collaboration. This has enabled joint experiments with institutes in distant places

1 Science Information NETwork

in Japan and overseas and data collection/sharing, which contribute to efficiency improvement and vitalization of R&D.

Operations of SINET 6, an extension of the previous SINET 5, began in April 2022. The connection speed has been enhanced in SINET 6 from the previous 100-Gbps (Gigabits per second) to 400-Gbps, the highest speed in the world, and international lines have also been enhanced, etc.

In addition, to support AI-driven and data-driven research and development, initiatives are being implemented to develop and operate high-performance and large-scale computational resources, including the supercomputer "Fugaku," ranked No. 1 in the world in four supercomputer rankings for four consecutive terms according to the supercomputer rankings of November 2021, and to accelerate the creation of further results by thoroughly utilizing these resources.



COLUMN 1-5

**Through AI analysis, the strength (product of maximum energy [2]) of a neodymium magnet on a laboratory scale [1] improved by about 1.5 times compared to before and after conventional analysis in about 40 experiments.**

To improve the efficiency and energy saving of motors, which account for about 50% of the world's electricity consumption, expectations are high for developing high-performance permanent magnets used in electric vehicle motors. Powerful neodymium magnets, a type of permanent magnet, are used in various electronic devices such as smartphones and electric vehicles. Although National Institute for Materials Science (NIMS) has been conducting R&D into neodymium magnets, there are approximately 66 million production process conditions (the number of conditions determined by NIMS studies), and it was deemed impossible to conduct an exhaustive search for improving the performance of the magnets using conventional experimental methods. Therefore, by utilizing data-driven research methods and proceeding with experiments based on optimal production conditions derived from AI analysis, the strength (product of maximum energy) of a neodymium magnet was successfully improved by about 1.5 times compared to before using AI analysis in only about 40 experiments. The results of this research are expected to lead to super-energy-efficient motors for electric vehicles, thereby contributing to the realization of carbon neutrality.

Thus, the goal of Research DX is not merely to digitize research activities but to revolutionize research methods. Even in the development of new materials, where previously it was necessary to conduct a vast pattern of experiments, the R&D cycle is being accelerated through the use of experimental data and AI These are expected to streamline the research process and significantly expand the scope of materials search in R&D and lead to new scientific discoveries and understanding beyond human capabilities.

← Hot extruded neodymium magnet

Source: National Institute for Materials Science (Press release dated November 15, 2021)

## 2 Shared Use of Research Equipment

### (1) Guidelines for the Promotion of Shared use of Research Facilities and Equipment

Research facilities and equipment at universities and other research institutions are important resources that serve as the driving force for all academic research activities and science, technology and innovation activities and are indispensable for science and technology to contribute to society at large.

To strengthen Japan's research capacity and improve research environments, it is essential to keep developing research facilities and equipment

1 Experiments in small-scale systems such as laboratories within the scope of application of basic research using small-scale equipment, rather than manufacturing with efficient methods using large-scale equipment such as those used by companies in their production processes.

2 One of the indicators for performance of permanent magnets. This value indicates the maximum amount of magnetic flux that a magnet can produce per unit volume, and represents the strength of a magnet.

and to continuously secure and improve the quality of human resources with expertise as key to their operation. Research facilities and equipment and the human resources that support them can only demonstrate their capabilities to the fullest together with many researchers. However, young researchers who do not necessarily have ample research funds are unable to freely pursue their research because they do not have access to the research facilities and equipment they require. Tighter budgets make installing new research facilities and equipment or upgrading them problematic. While there has been some progress in initiatives for the shared use of expensive equipment or equipment purchased with Fundamental funds, many research facilities and equipment are still dedicated only to specific laboratories.

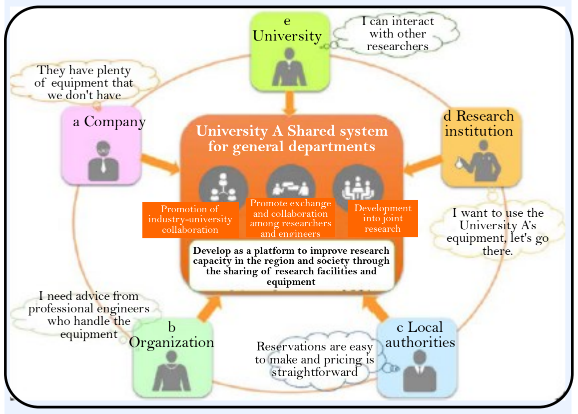
To ensure that all researchers have access to the necessary knowledge and research resources at all times and that their research activities are not hindered, it is important to strategically and systematically establish and upgrade research facilities and equipment and to operate them effectively and efficiently together with the human resources that support them. In March 2022, the "Guidelines for the Promotion of Shared Use of Research Facilities and Equipment" was established to promote strategic management of research facilities and equipment that are intended for limited use in specific laboratories, including shared use of research facilities and equipment based on management strategies, by establishing a system that enables wide-ranging use of research facilities and equipment within an institution and which also allows their use by third parties outside the institution at the discretion of the institution. The guidelines present the following approach.

<Significance and benefits of being a research institution that promotes shared use>

◯ If many research facilities and equipment are being managed and operated in specific laboratories, the researchers in each laboratory are often responsible for managing their respective equipment, which takes up a certain amount of their research time. Shared use allows for organized management and systematic maintenance and operation of facilities and equipment, which leads to more time for researchers to focus on their research.

◯ Shared use of research facilities and equipment both within and outside the institution will encourage new joint research with researchers in other fields. Shared use outside the institution also serves as a hub for collaboration with industries, communities and society. It also leads to the acquisition of external funds through usage fees.

■Figure 1-3-9/ Development of collaboration with external research institutions (conceptual image)




Document: Prepared by MEXT

<Key points of the shared use system>

◯ For every institution to maximize its research results, it is essential to make maximum use of the institution's research facilities and equipment. Research facilities and equipment are regarded as important management resources. Therefore, the management mindset of the institution's management strategy must be reformed to strategically utilize research facilities, equipment and the human resources that support them.

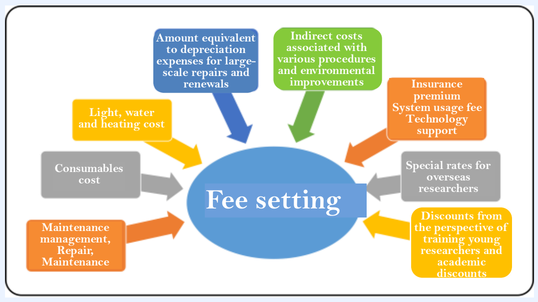
◯ Usage of research facilities and equipment requires reform of the shared use system to realize operations that consider research facilities, equipment and the human resources that support them as an integral part of the system. It is important to promote "Team Sharing," where diverse professionals such as executives, researchers, technical staff, administrative staff and URAs work together to promote shared use, and to establish "supervising departments" that are responsible for management of research facilities and equipment for the entire research institution.

○ It is important to analyze the current conditions of research facilities and equipment and formulate strategic facility maintenance and operation plan based on management strategies. Understanding and analyzing the condition and usage history of facilities, needs for equipment required in the future and financial resources for their operation, and making strategic decisions on which research facilities and equipment to maintain and upgrade and which to dispose of or reuse will enable not only the effective use of current resources but also of future resources, creating a virtuous cycle of limited resources.

○ Technical staff have advanced, and specialized knowledge and skills concerning the maintenance and management of research facilities and equipment and are important partners in solving challenges with researchers. By operating research facilities and equipment in a focused manner through shared use, technical staff can maximize their abilities and expertise and improve their technical skills by expanding their sphere of activities across the board, rather than being involved only in the management of specific facilities.

○ It is also important to review usage fees. While some fees may be reserved from the perspective of strengthening research capacity for researchers who need them, from the perspective of operational independence, appropriate usage fees may be set for the maintenance and management costs of research facilities and equipment, costs for supplies associated with their operation, and technical fees related to support. In setting usage fees, it is important to regard them as necessary for the sustainable maintenance and development of research facilities and equipment at each institution rather than profit.

■ Figure 1-3-10/Examples of approaches used to set usage fees



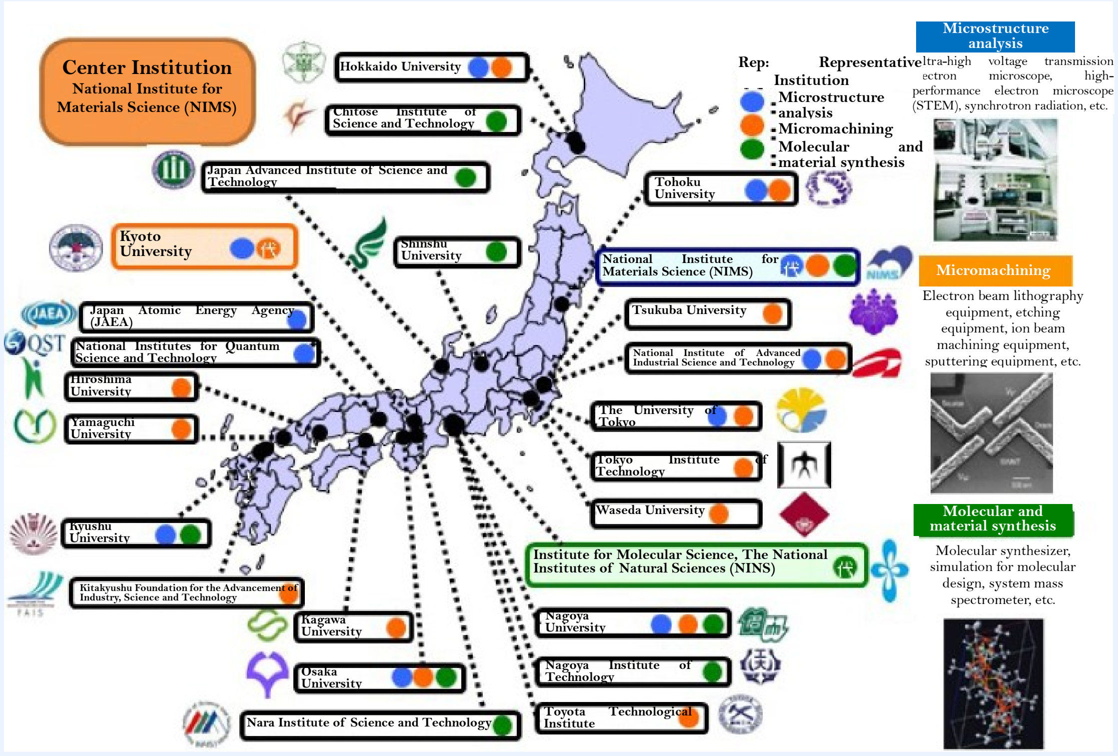

Document: Prepared by MEXT

## (2) Initiatives in the fields of nanotechnology and materials science and technology

Nanotechnology is a fundamental technology that manipulates and controls atoms and molecules at the nanometer scale (one billionth of a meter). Creating new functions utilizing the characteristics unique to nano-scale materials opens up new areas of science and technology and leads to technological innovation in a wide range of industries. The "Nanotechnology Platform Japan" (FY2012 to FY2021) provided many users in industry and academia with advanced technical support and opportunities to use cutting-edge facilities by building a nationwide shared system (see Figure 1-3-11) between universities and other research institutions that have cutting-edge nanotechnological research facilities.

This project created an indispensable research platform for R&D in nanotechnology and materials and has especially contributed to young researchers at universities and other research institutions as well as in private companies that cannot establish large research facilities independently. Through the system of granting job titles and commendations according to skill level, the program contributes to developing technical support personnel who support shared use at universities and other research institutions and promoting industry-university-government collaboration through technological development by joint research between participating institutions and user companies.

■ Figure 1-3-11/“Nanotechnology Platform Japan” Promotion System



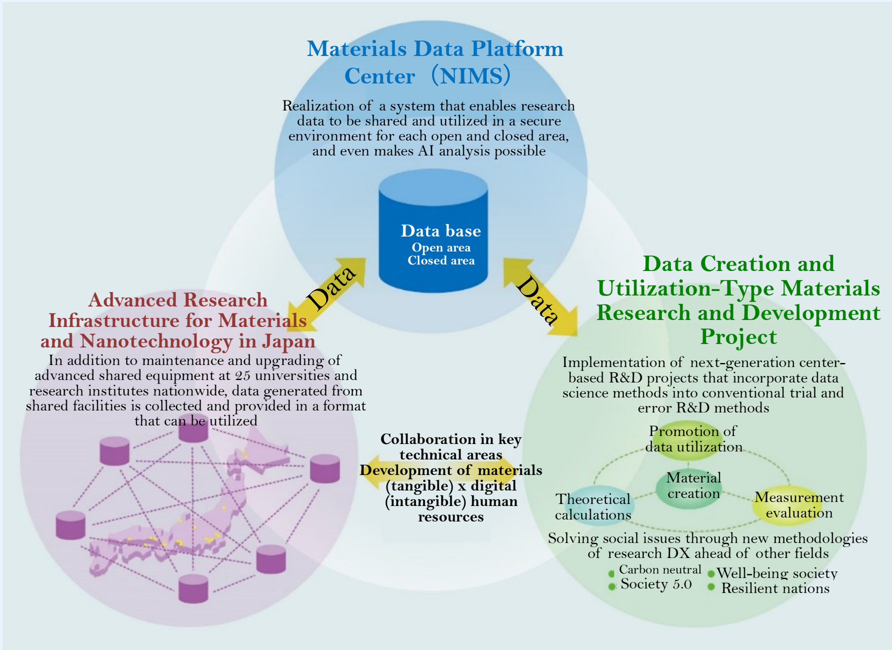

Source: Nanotechnology Platform Japan website

The Advanced Research Infrastructure for Materials and Nanotechnology in Japan (ARIM[1]) project began in FY2021, on the basis of nationwide facility sharing system established in the Nanotechnology Platform Japan. In addition to the nationwide sharing of cutting-edge equipment and technical support from highly specialized engineers, this project also strives to provide materials data[2] created from the use of the equipment to researchers throughout the country in a structured[3] and easy-to-use form.

In addition to this project for creating materials data, initiatives are taken to establish the Materials DX Platform (see Figure 1-3-12), which will form a trinity with the Materials Data Platform Center (NIMS) that integrates and manages data, and the Data Creation and Utilization-Type Materials Research and Development Project that creates innovative materials through the utilization of data. This scheme strives to promote data-driven research nationwide by utilizing materials data created from advanced shared facilities nationwide.

1 Advanced Research Infrastructure for Materials and Nanotechnology
2 Data on materials. In particular, data on organization, characteristics and performance.
3 Converting data into a form that can be analyzed.

■ Figure 1-3-12/ "Materials DX Platform" concept




Source: ARIM brochure

## 3 Establishment of Large Research Facilities

While large, state-of-the-art research facilities that support general science and technology activities require a large amount of money for their maintenance and operation, their value is maximized when they are utilized for R&D in a wide range of fields, from *basic research* to the development of industrial technologies, such facilities are expected to produce world-class results in R&D. Therefore, the government must take the initiative in strategically developing large research facilities and encouraging their shared use.

Among the large research facilities, below is a description of the next-generation synchrotron radiation facility (provisional name), which is currently being constructed.

### (1) The next-generation synchrotron radiation facility (high-brightness 3GeV-level radiation light source for soft X-rays)

A next-generation synchrotron radiation facility is a "super microscope" that uses high-brightness intense soft X-rays (the low-energy, long-wavelength part of X-rays) that can sensitively observe light elements (elements with small atomic weights such as hydrogen and helium), enabling not only the structural analysis of materials but also the visualization of the electronic state that influences the function of materials.

While next-generation synchrotron radiation facilities have been built successively since the beginning of the 21st century in other parts of the world, there are not many synchrotron radiation facilities geared toward soft X-rays in Japan, resulting in a significant performance gap. The next-generation synchrotron radiation facility will close this performance gap at once, enhancing the international competitiveness of Japan's R&D.

The facility is under construction through a new framework of public-private-regional partnership (involving the National Institutes for Quantum Science and Technology (QST), the Photon Science Innovation Center (PhoSIC), Miyagi Prefecture, Sendai City, Tohoku University and Tohoku Economic Federation), toward completion in FY2023.

This facility will make it possible to elucidate the functions of nano-scale materials, which has been difficult until now. This will lead to technological breakthroughs in the development of compact, lightweight, high-power and long-lasting battery materials, next-generation solar cells that exhibit high conversion efficiency, energy-saving power devices and environmentally friendly smart materials, which will contribute to solving social issues facing Japan, such as the realization of a decarbonized society.

**Next-generation synchrotron radiation facility (under construction)**
Provided by: Photon Science Innovation Center

Keyword

## What is synchrotron radiation?

Synchrotron radiation is the light produced when electrons accelerated to near the speed of light are forced to travel in a curved path by a magnet. The light is characterized by high brightness and high directionally (the direction and properties of the light are uniform), like a laser, making it possible to visualize nano-level structures, functions, etc.

# Section 4 Specific Measures for the Strategic Promotion of International Development of Science and Technology

## 1 Strategic Promotion of the International Development of Science and Technology

Promoting international development of science and technology, such as international brain circulation and international joint research, expands many possibilities. Various measures are being pushed to allow collaboration between researchers across borders, from Japan to overseas and from overseas to Japan.

### (1) International brain circulation (Outbound) - Dispatch of Researchers -

In the U.S. and other countries, students and young researchers from overseas are employed by researchers (P.I.[1] s) as postdoctoral fellows, research assistants (RAs), teaching assistants (TAs), etc., and engage in activities such as conducting research or obtaining a doctorate while earning a salary. To address this and promote international mobility, in addition to the fellowship-type (scholarship-type) med- to long-term overseas dispatch conventionally conducted by Japan, the government will promote a "new transfer-type mobility mode for young researchers entering the international brain circulation," in which researchers can engage in research and obtain a degree while earning a salary in the destination country.

### (2) International brain circulation (Inbound) - Acceptance of Researchers -

The international research bases formed under the World Premier International Research Center Initiative (WPI) Program (see Chapter 2 Section 2 5) are highly regarded worldwide. As a leading example in Japan, they are expected to disseminate their experience within and outside the universities. The following “Five Common Factors for Successful Internationalization of WPI Bases,” which were obtained through analysis of the initiatives undertaken by each center, can be considered important for universities and the National Research and Development Agency seeking to promote internationalization. Using these points as a basis for dissemination, further internationalization efforts for bases at universities and the National Research and Development Agency are encouraged.

[Five Common Factors for Successful Internationalization of WPI Bases]

- Establishment of an administrative system that can respond to inquiries in English
- Acceptance of a certain number of foreign researchers (Achievement of critical minimums)
- Appointment of an administrative department head with a “research background” who understands the research field
- Establishment of a governance structure that enables flexible operation of various systems within the university
- Support including the provision of information on living and research environment in English

### (3) Promotion of international joint research

International joint research with partner countries that have significant scientific and technological capabilities is research cooperation beneficial for researchers and expected to have a significant diplomatic effect.

For example, most of the budget of €95.5 billion for 7 years under the R&D support framework of the E.U. Horizon Europe is allocated to the international joint research budget through international joint call by 3 or more countries, and international joint research is proactively taking place on a large scale. To further strengthen such overseas collaborations, it is important to aggressively promote international joint research in various research and development projects through cooperation between the government, funding agencies and research teams. International

1 Principal Investigator

joint research has been conducted since around 2018 through domestic research programs such as the Strategic Basic Research Programs. This initiative will be continued in other programs to promote international joint research with top-level researchers. Additionally, in FY2021, the "International Leading Research" program under the Grants-in-Aid for Scientific Research (KAKENHI) aggressively promotes international joint research (see 3 Chapter 2, Section 2).

### (4) Promotion of Joint Degree Program

The Joint Degree Program, started in 2014, is a single educational program jointly established by multiple universities including at least one which is a Japanese university. Upon completion of the program, the student is awarded one diploma under the name of 2 or more universities.27 programs have been implemented at 12 universities in Japan.

The further utilization of this system is important as one way for students to gain international perspectives from the undergraduate/graduate school level. The program was amended in August 2022 to encourage more participation of universities by relaxing the requirements for approval of the establishment of the international collaborative curriculum system, abolishing the admission capacity limit and allowing more universities' participation (by lowering the requirement for the number of credits to be earned), etc., while ensuring the quality of education and research.

### (5) Contribution to internationalization by supporting doctoral students

Based on the 6th Basic Plan and "Comprehensive Package to Strengthen Research Capacity and Support Young Researchers" (Council for Science, Technology and Innovation, January 2020), financial support is significantly increased, such as the number of doctoral students who receive an amount equivalent to living expenses has been doubled, initiatives are taken to establish guidelines to improve the treatment of research assistants (R.A.s).

Such support for doctoral students is expected to contribute to the internationalization of Japan's research environment, such as enhancing opportunities for excellent Japanese doctoral students to study abroad and improving the attractiveness of Japan for overseas students to obtain degrees and conduct research.

## 2 Promote International Student Exchange and International Exchange at Universities, etc.

Promoting the internationalization of universities, etc., encouraging Japanese students to study abroad, and accepting international students are required to advance the globalization of Japan. Initiatives are being implemented in Japan to promote international student exchange and to achieve higher quality international mobility.

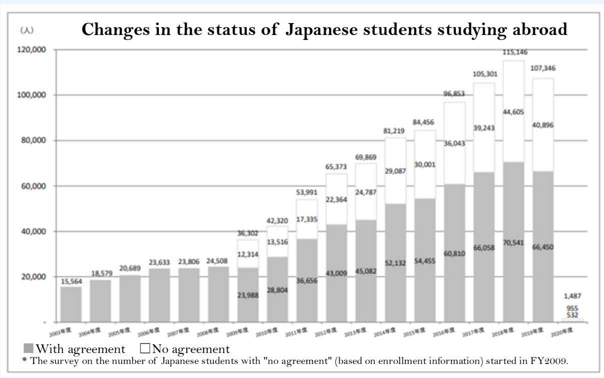
Initiatives are being implemented, such as promoting university reforms through the Top Global University Project, which contributes to the internationalization of universities, and realizing high-quality education through the Inter-University Exchange Project, which strategically promotes collaboration and student exchange with quality assurance to enhance the quality of international mobility.

For sending Japanese students abroad, the society as a whole is working to encourage young people to study abroad with scholarship support for overseas study, etc., such as the "Study Abroad Support Program" by the Japan Student Services Organization (JASSO) and "Tobitate! (Leap for Tomorrow) Young Ambassador Program" by a Japanese public-private partnership based on the "Tobitate! (Leap for Tomorrow) Study Abroad Initiative." Although the number of Japanese students studying abroad in 2020 declined by 98.6% from the previous year to 1,487 due to the impact of the COVID-19 pandemic, support for overseas study scholarships is being resumed in stages by the Japan Student Services Organization (JASSO) from November 2020, etc. We will continue to support young people with ambition and ability to get opportunities to study abroad, and the building of momentum for them to study abroad will be promoted.

Furthermore, accepting international students is important not only from the perspective of education but also from the perspective of diplomacy, as it fosters human resources that can act as a link between Japan and their home countries. For example, the Japanese Government (Monbukagakusho) Scholarship Program invites international students who want to study at Japanese universities, etc., to promote international student exchange between Japan and other countries and mutual friendship and goodwill, and contribute to the development of human resources in other countries and provides scholarships to the students who are selected. This system has produced many human resources who have worked as government officials or ambassadors to Japan or who have become university faculty members or presidents of local universities after returning to their home countries, thereby contributing to enhancing exchanges between Japan and foreign countries. On the other hand, acceptance of international students was affected by the immigration restrictions due to border control measures related to the COVID-19 pandemic, and the number of international students who enrolled peaked at 312,214 on May 1, 2019, dropped to 242,444 on May 1, 2021. In the future, while promoting the acceptance of international students, we will shift our focus to the quality of acceptance with a greater emphasis on the exit, such as improving the degree to which excellent international students who have received a high-quality education in Japan integrate into Japanese society, and enhancing friendly relations with other countries by utilizing international students who have returned home as pro-Japanese or Japan experts and by strengthening their networks.



■ Figure 1-3-13/ Changes in the status of Japanese students studying abroad




Source: JASSO, "Results of the survey on the status of the Japanese students studying abroad, 2020"

■ Figure 1-3-14/Examples of prominent Japanese Government Scholarship students (1,595 in total) who are active (survey conducted in November 2019)

**Examples of prominent Japanese Government Scholarship students (1,595 in total) who are active (survey conducted in November 2019)**

○ Former Minister of Mining, Mongolia
(1985-1989, Kyoto Institute of Technology)

○ Minister, Ministry of External Economy, Autonomous Republic of Karakalpak, Uzbekistan
(2011 to 2013, Tokyo University of Agriculture and Technology)

○ Ambassador of the Republic of Macedonia to Japan, Former Yugoslav Republic of Macedonia
(1983 to 1986, Sophia University)

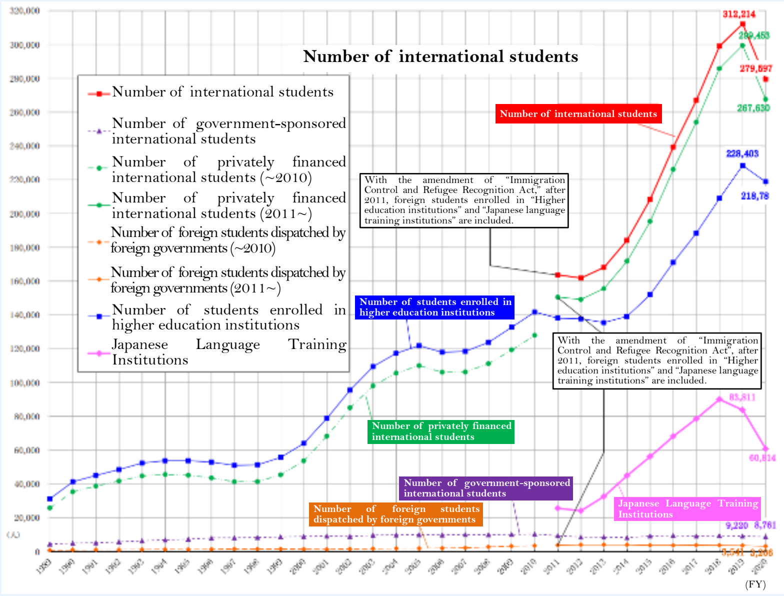
○ Rector, Pathein University, Myanmar
(1994 to 1997, Hokkaido University)

○ President, Andong University, Korea
(1985 to 1989, Nara Women's University)

○ President, Vietnam National University of Agriculture, Vietnam
(2003 to 2007, Yamaguchi University/Miyazaki University)

Document: Prepared by MEXT

■ Figure 1-3-15/Changes in the number of international students




Source: JASSO, "Result of International Student Survey in Japan, 2021"