Section 3 The Development and Securing of the Human Resources That Will Contribute to a Super Smart Society

Human resources are the key to realizing a super smart society before the rest of the world.

Section 3 focuses on the necessity of fostering and securing the following human resources that can contribute to a super smart society.

(1) Artificial intelligence engineers who are knowledgeable about the latest technologies

(2) Data scientists

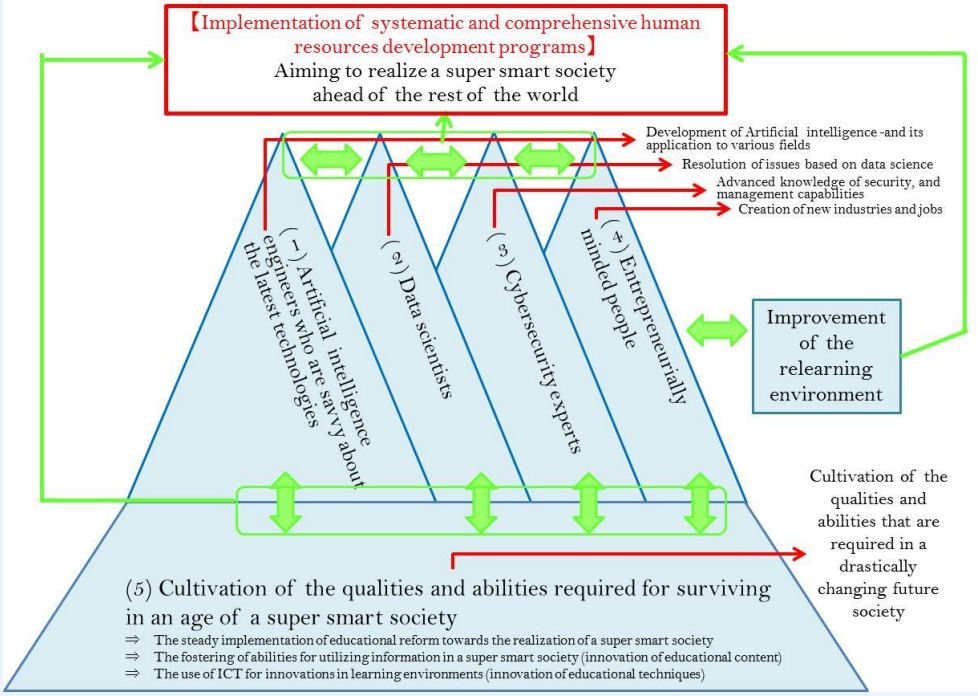
(3) Cybersecurity experts

(4) Entrepreneurially minded people

Additionally, this section looks at the qualities and abilities that each and every citizen needs to have to survive in an age in which change is difficult to predict. Thus, in addition to items (1)-(4) above, item (5) below will also be considered

(5) Cultivation of the qualities and abilities required for surviving in an age of a super smart society (Figure 1-2-23).

■ Figure 1-2-23 / Human resources contributing to a super smart society



Source: MEXT

To lead the world in the development of a super smart society, measures for fostering (1) - (5) above should be undertaken in a systematic and comprehensive manner.

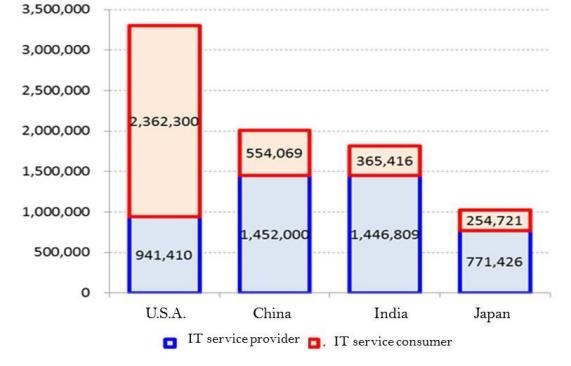
1 Human Resources Necessary for Realizing a Super Smart Society

(1) Artificial intelligence engineers who are knowledgeable about the latest technologies

① Current situation

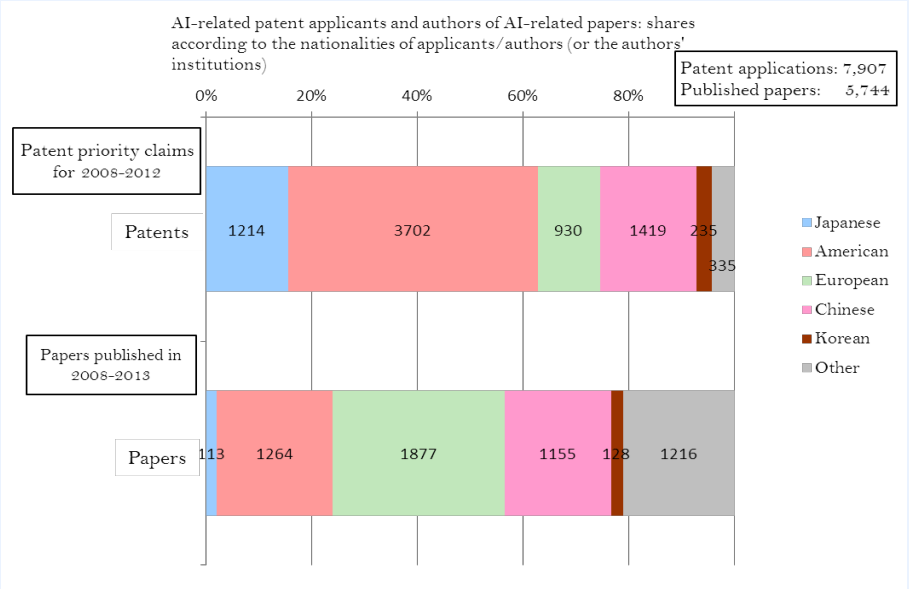
Japan has about one million IT engineers, and this number is one third that of the U.S.A. and half that of China (Figure 1-2-24). Regarding the nationalities of AI-related patent applicants, American, Chinese and European nationals respectively account for 50%, slightly less than 20% and slightly more than 10% of such applicants. The share for Japanese nationals is 15%, which is an acceptable figure in comparison with other countries. In contrast, of the total number of published scientific papers related to artificial intelligence, Japanese authors account for 2% (i.e., about 100 papers), one order of magnitude smaller than the share of European authors (slightly more than 30%), American authors (20%) and Chinese authors (20%) (Figure 1-2-25). As shown in Figure 1-2-26, concerning the total numbers of AI-related patent applications and scientific papers, the majority of patent applications are filed by companies and scientific papers are chiefly presented by universities (Figure 1-2-26).

■ Figure 1-2-24 / The number of IT engineers in Japan and other countries



Source: *White Paper on Manufacturing Industries* (Monodzukuri), 2015.

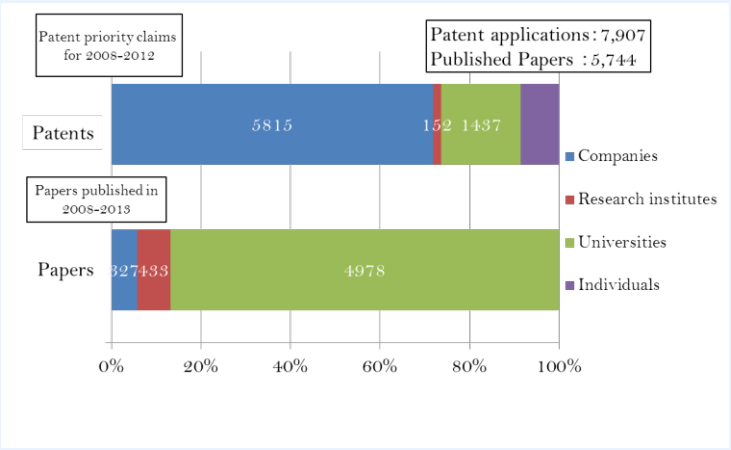
■ Figure1-2-25 / AI-related patent applicants and authors of AI-related papers: Shares according to the nationalities of applicants/authors (or the authors' institutions)



Note: Data for 2011 and the following years may not necessarily be the data on all patent applications due to delays in listing in the database or each country's timing of international patent application under the Patent Cooperation Treaty (PCT).

Source: *Report on FY 2014 Patent Application Trend Survey in Technology* (summary): *Artificial Intelligence Technology* (Japan Patent Office, March 2015).

■ Figure1-2-26 / The numbers of AI-related patent applicants and of AI-related papers: According to the types of applicants/authors (or the authors' institutions)



Note: Data for 2011 and the following years may not necessarily be the data on all patent applications due to delays in listing in the database or each country's timing of international patent application under the Patent Cooperation Treaty (PCT).

Source: *Report on FY 2014 Patent Application Trend Survey in Technology (summary): Artificial Intelligence Technology* (Japan Patent Office, March 2015).

From 1982 through 1992, the Japanese government implemented the Fifth-generation Computer Project for R&D on advanced computer technologies. Researchers and students who worked on that project are now top researchers at universities and companies, and many patent applications owe much to their research. However, in the late 1980s, researchers faced challenges concerning the industrial application of artificial intelligence technologies, which put a damper on research into artificial intelligence technologies in Japan. The insufficiency of fostering artificial intelligence researchers at Japanese universities seems to be the reason for the decline in the number of AI-related papers published by Japanese researchers[1].

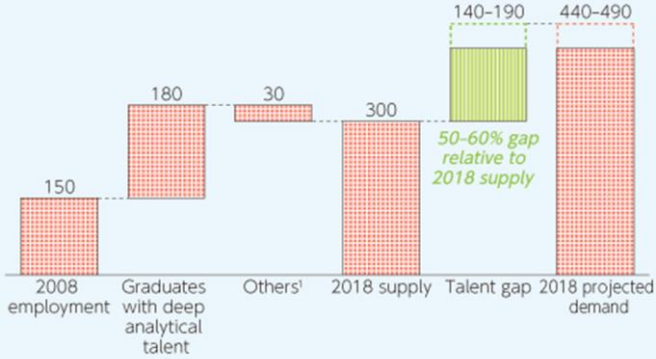
② Future direction

The number of published scientific papers, which is fewer for Japan than for other countries, suggests the need to foster and increase young scientists who research leading-edge artificial intelligence technologies. It is critical to combine the strengths of excellent researchers who have various abilities. Because basic technologies and the application of these technologies differ from industry to industry, researchers should be able to secure opportunities for exchanging and discussing various views on a daily basis over a long period of time, in order to develop diverse scientists who are knowledgeable about specific technologies. The government's efforts to foster artificial intelligence researchers are shown below.

Under the AIP Project[2], which started in FY2016, MEXT intends to foster artificial intelligence engineers who can support the development of innovative artificial intelligence technologies and the application of these technologies in various fields. Specifically, the AIP Project helps foster the following people so that they can become artificial intelligence engineers: doctoral and master's students, and people who have a broad vision, the required level of knowledge and experience, and the willingness to learn skills related to leading-edge artificial intelligence technologies as well as to develop necessary expertise for contributing to AI-related industries and research. A one-year program under the AIP Project includes schooling and seminars. It provides aspiring artificial intelligence engineers with opportunities to learn

1 Source: Report on FY 2014 Patent Application Trend Survey in Technology (summary): Artificial Intelligence Technology (Japan Patent Office, March 2015).
2 AIP: Advanced Integrated Intelligence Platform Project

state-of-the-art techniques and to take part in research activities related to the application of artificial intelligence technologies, so that they can have firsthand experience of problem-solving based on artificial intelligence technologies.



Outlook for data scientists in the U.S.A.

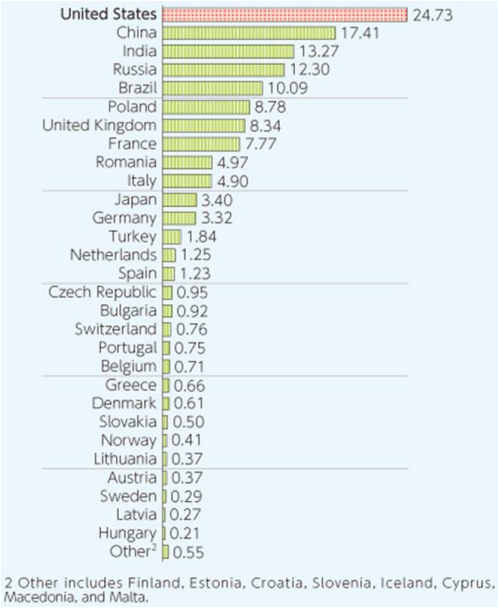
Source: *Big data: The next frontier for innovation, competition, and productivity* (McKinsey Global Institute)

(2) Data scientists

① Current situation

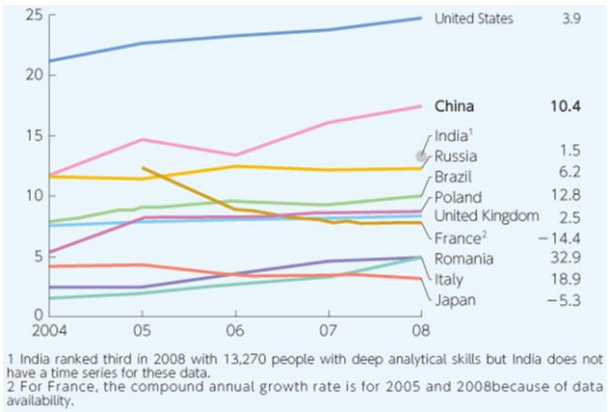
The rise of platformers as part of the changes to the industrial structure, as well as the revolutionary changes in techniques related to scientific and technological innovation, suggests the need to foster data scientists who are familiar with data processing techniques necessary for analysis, data visualization and data analysis methods.

Private companies have a high need for these scientists, and that need is expected to grow. The McKinsey Global Institute of the U.S.A. estimates that by 2018, the United States alone could face a shortage of 140,000 to 190,000 people with deep analytical skills. Japan is also facing a shortage of people with high data analytical skills. In 2008, Japan had only 3,400 university graduates with advanced training in statistics and machine learning and with data analytical skills. In the five years from 2004 through 2008, the number of scientists with analytical skills continued to decline.



The number of university graduates with training in data analysis, 2008 (Unit: 1,000 people)

Source: *Big data: The next frontier for innovation, competition, and productivity* (McKinsey Global Institute)



Changes in the number of human resources with data analytical skills (Unit: 1,000 people)

Source: *Big data: The next frontier for innovation, competition, and productivity* (McKinsey Global Institute)

② Future direction

Japan needs to foster data scientists who are familiar with the data processing techniques that are necessary for analysis, as well as with data visualization and analytical techniques. Although there is no clear definition of "data scientist," they are those who are familiar with the following techniques: big data processing techniques (necessary for the processing of petabytes of distributed data); data visualization techniques (for making vast amounts of high-dimensional data and computation results understandable to people); and data analysis techniques (indispensable for acquiring deep knowledge from big data; and these techniques are related to statistics, machine learning, data mining, and Bayes' Theorem). Additionally, data scientists need to have abilities and qualities related to the following.

- Security management and research ethics
- Strategic planning, problem identification, planning for problem determination, and problem solving
- Data collection
- Reading truth in data, and finding relevant data
- Curating (i.e., selecting, pre-processing, and cleansing data)
- Translating data analysis results into businesses and services
- Collaborating with researchers and business operators from different fields

In other words, data scientists are researchers with data literacy[1].

The government's efforts for the development of data scientists are explained below.

Under the AIP Project, MEXT has been working to foster high-level data scientists who can take the initiative in utilizing data within an organization. Specifically, in cooperation with The Institute of Statistical Mathematics, a one-year program consisting of schooling and seminars is provided to doctoral and postdoctoral students with advanced skills in data science. Under the program, PBL is used to give students opportunities to learn about cutting-edge techniques through hands-on experience. Case studies are also used for learning about the latest research results related to the application of artificial intelligence technologies.

The IoT Acceleration Lab (i.e., Advanced Model Business Promotion WG under METI) has been holding an online algorithm development contest in which participants, including students and other citizens, compete to achieve analytical precision by using big data provided by private companies. Because the participants work on analyzing industrial data and issues that they rarely have an opportunity to deal with, this contest helps find excellent data scientists and match these scientists with companies, where they can further develop their skills.

Big Data Analysis Contest

Source: IoT Acceleration Lab

1 "Development of Scientists for the Age of Big Data." Recommendations by the Subcommittee on E-Science and Data-Centric Science, Committee on Informatics, Science Council of Japan. September 11, 2014.

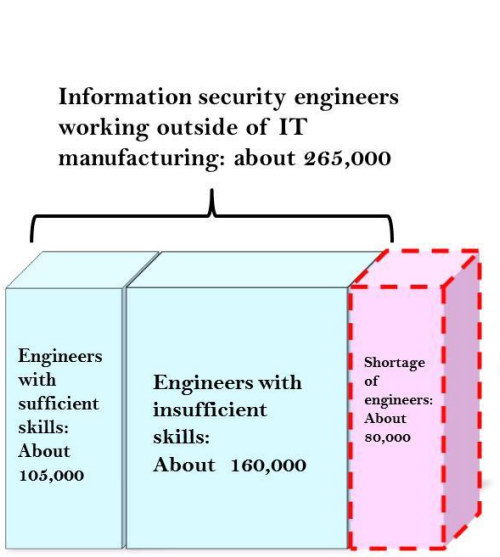
(3) Cybersecurity experts

① Current situation

As stated in Section 2 of Chapter 2, the Internet of everything will benefit our lives in many ways, but will also lead to increases in malicious cyberattacks. Thus, the fostering of cybersecurity experts is imperative.

In Japan, 265,000 information security engineers are employees of corporations that rely on IT. It is estimated that these companies will need an additional 80,000 information security engineers. The corporations that suffer from the severe shortages of such engineers are not information-related companies, but are businesses in the manufacturing, wholesale, retail, medical and welfare sectors. Among the 265,000 in-house information security engineers, about 160,000 are estimated to lack the technical skills necessary for their jobs; thus, they need advanced training (Figure 1-2-27)[1].

■ Figure 1-2-27 / Shortage of information security experts



Breakdown of the 80,000-engineer shortage by industry

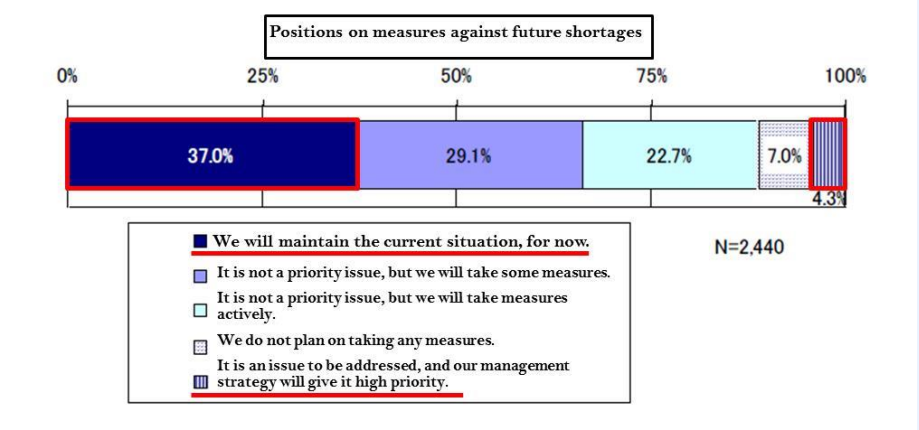
Industry	(People) Shortage
Agriculture, forestry, fishery, mining	256
Construction, civil engineering, industry	2,764
Electronic parts, device, electronic circuit manufacturing industry	1,403
Telecommunication machinery and apparatus manufacturing industry	605
Electrical machinery and apparatus manufacturing industry	
Other industry	15,853
Electricity, gas, heat supply, water industry	81
Telecommunications industry	683
Information services industry	1,885
Other telecommunication industry	1,717
Transportation and postal industry	
Wholesale and retail industry	14,480
Financing and insurance industry	4,957
Real estate and goods rental and leasing services	1,547
Academic research and professional engineers	1,014
Accommodations and food services	3,535
Living-related and personal services, and amusement services	3,301
Education and learning support	2,084
Medical services, public health and hygiene	8,473
Compounding services	614
Other services	8,462
Total	**81,590**

Source: Created by METI based on an analysis of the shortage of information security experts estimated by the IPA in the *Basic Survey on the Fostering of Information Security Experts*. (The IPA survey results for 2012 were further analyzed in 2014.)

In the face of a shortage of information security experts, Japanese society lacks awareness of the importance of information security and the need for measures to improve the situation (Figure 1-2-28). Measures should be taken to raise concerns over information security as well as to proactively foster experts.

1 "Basic Survey on the Fostering of Information Security Experts." Information-technology Promotion Agency (IPA). April, 2012.

■ Figure 1-2-28 / Willingness to remedy the shortage of information security experts within the company



Source: *Basic Survey on the Fostering of Information Security Experts.* Information-technology Promotion Agency. April, 2012.

② Future direction

To secure measures against increasingly blatant and serious threats to information security and sophisticated, ingenious cyberattacks, and for the purpose of ensuring information security for the 2020 Olympic and Paralympic in Tokyo, the fostering of cybersecurity experts is urgently needed. Toward that end, elementary and secondary education will be improved by increasing opportunities to learn programing and information ethics. Practical education networks will be built at universities, and education programs for learning about information security will be developed for national technical colleges. Industry-university-government collaboration is important in efforts to foster cybersecurity experts who can contribute to society. The Japanese government has been working on fostering these experts as described below.

MEXT has been reviewing the Curriculum Guidelines. In August 2015, the Special Committee on Curriculum Planning summarized issues requiring attention ("Summary of Issues"). Technical reviews are under way for each specific subject and school type. In the "Summary of Issues," Item #13 ("Information") states that opportunities to learn about information security, information ethics and programming will be increased according to the student's stage of development. For national technical colleges, "KOSEN Security Experts Incubation Centers" are being developed nationwide to provide technical college students with shared environments for information security exercises.

For universities, the Education Network for Practical Information Technologies (enPiT) is used for fostering information security experts (cf. Column 1-10). In cooperation with the National Institute of Informatics, the AIP Project offers a one-year program to doctoral students and persons with experience in information security management at a company or an organization. Under this program, SINET[1] is utilized for cyberattack simulations in which real data on cyberattacks are used to get an overview of such attacks and to assess the situation regarding them.

The National center of Incident readiness and Strategy for Cybersecurity (NISC), which serves as the secretariat of the Japanese government's Cybersecurity Strategy Center, has formulated the

1 SINET: The Science Information NETwork, provided and operated by the National Institute of Informatics

"Cybersecurity Strategy." This strategy describes the need to enrich education regarding cybersecurity and related matters as well as to find, foster and secure experts with outstanding abilities and skills. The "Cybersecurity Strategy" was approved at a Cabinet meeting in September 2015. On the basis of the Cybersecurity Strategy, the "Policy on the Comprehensive Enhancement of the Fostering of Cybersecurity Experts" was formulated for accelerating the fostering of cybersecurity experts. This policy was determined by the Cybersecurity Strategy Headquarters in March 2016.

The Cabinet Office is implementing the Strategic Innovation Promotion Program (SIP) to enhance the abilities and skills of security experts who are now managers at organizations responsible for operating key infrastructure or who are engineers working in various infrastructure sectors such as the machine control sector.

Column 1-10

Education Network for Practical Information Technologies (enPiT)

To lead the world in the realization of a super smart society, it is critical to foster human resources with high technological skills in applying information and communications technology to solutions of diverse social problems.

MEXT has been providing support to the Education Network for Practical Information Technologies (enPiT). This is a national network of industries and 15 universities, and it was built for the purpose of conducting and spreading practical education methods, including problem-based learning. Specifically, enPiT is used for developing world-class specialists with practical abilities. Toward that end, master's students nationwide are given opportunities to engage in group work during short-term study camps and problem-based learning sessions. Specialists described below are fostered in the following four fields.

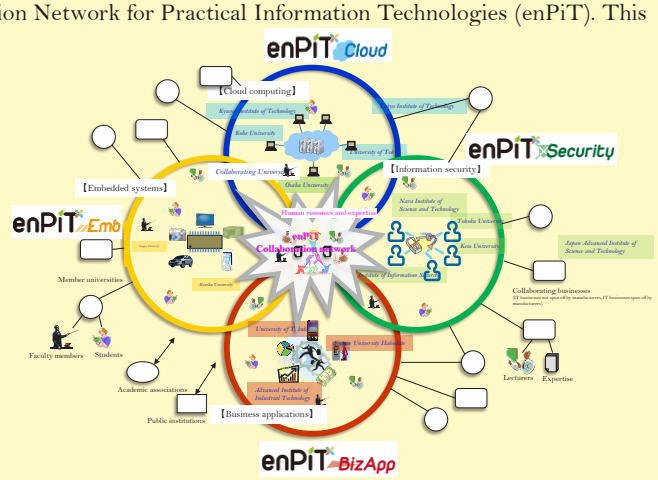


Figure Outline of enPiT

Source: MEXT

【Cloud computing】

Specialists who can utilize cloud computing technology to solve social issues such as the need to create big data analysis techniques and new business domains.

【Information security】

Specialists who can lead the efforts to find solutions by addressing both technological and administrative aspects of security issues that are related to information distribution and information assets and that affect the basis of socioeconomic activities.

【Embedded systems】

Specialists who can build high-value-added cyber physical systems in which embedded systems are among the core components.

【Business application】

Specialists who understand advanced element technologies in the ICT field, and who can apply these technologies to the creation of solutions that satisfy customer needs; additionally, specialists who are able to create human-centric total designs and develop applications, so that they will be able to create business innovations in the future.

Of the various projects that are implemented by using enPiT in the four fields above, the enPiT-Security project is explained below.

The enPiT-Security project is called "SecCap" and is implemented by cooperating universities. Under this project, students learn up-to-date technologies and knowledge about information security through hands-on experience so that they can develop practical abilities. SecCap provides wide-ranging courses consisting of the following: lectures on security technology for web servers and networks, and on social sciences, including legal systems and risk management; and exercises in system defense against cyberattacks, hardware security, incident response and CSIRT basics. Each student independently and proactively formulates his or her own learning program by selecting from the subjects in SecCap according his or her career developmental goals.

Students learning in an enPiT-Security course

Source: Institute of Information Security

(4) Entrepreneurial human resources

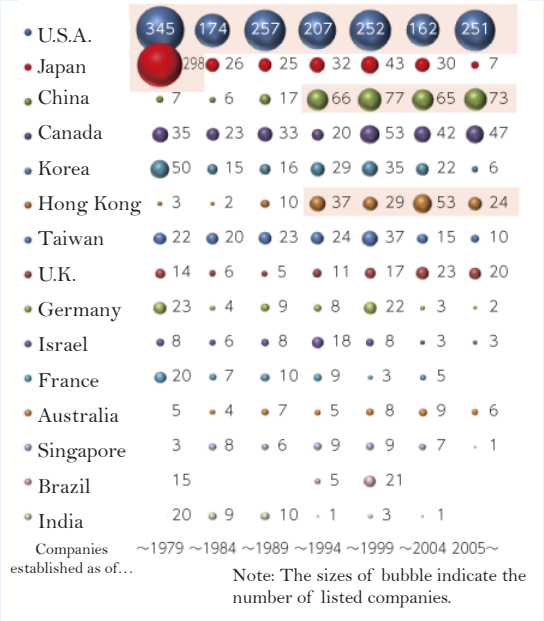
① Current situation

The spread of cloud computing and Social Networking Sites (SNS) have made it possible to create new value and new businesses that depend on the use of big data and low-cost ICT infrastructure.

In the current social environment that offers increasing entrepreneurial opportunities, it is necessary to foster human resources with an entrepreneurial attitude and the daring to launch new businesses and services. While a growing number of ICT companies have been listed on a stock exchange since 1980 in the U.S.A. and since 1990 in China and South Korea, the majority of existing Japanese ICT companies were listed before 1980. This suggests that ICT businesses in Japan are innovating more slowly than in other countries (Figure 1-2-29).

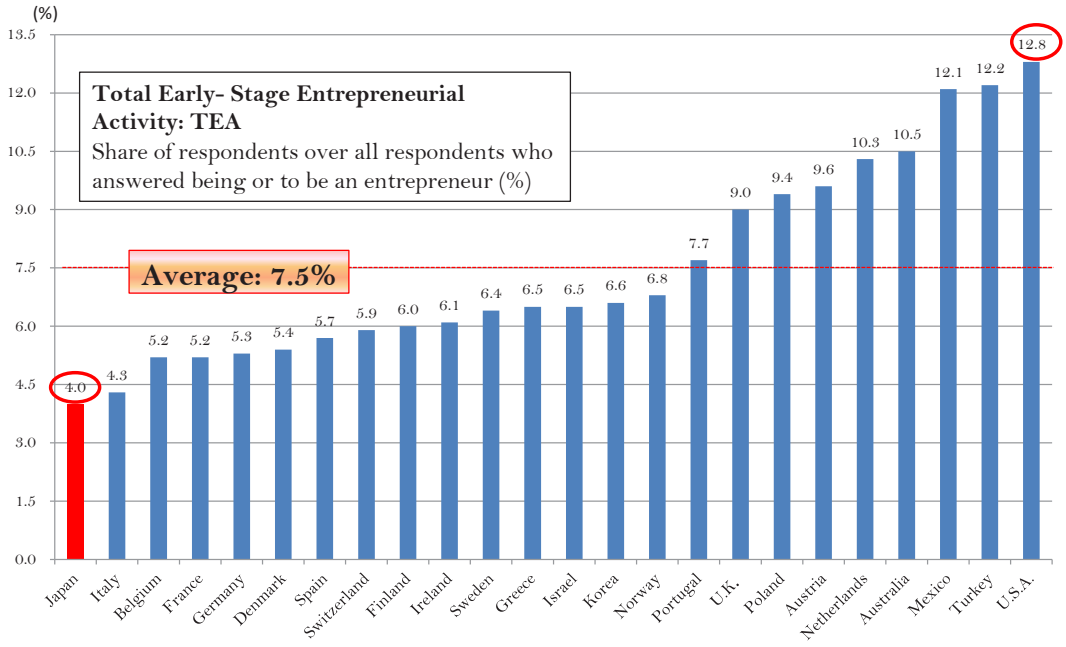
The reasons for this situation include the difficulty for entrepreneurs to raise money, as indicated by the fact that venture capital investment as a percentage of GDP is smaller in Japan than in other countries. Additionally, the Total Early-stage Entrepreneurial Activity (TEA) Rate[1] is lower in Japan than in any other surveyed country. Thus, efforts are necessary to cultivate entrepreneurship in Japan.

■ Figure 1-2-29 / Changes in the number of listed ICT companies (according to corporate nationality)



Source: White Paper 2014: Information and Communications in Japan. Ministry of Internal Affairs and Communications.

1 The percentage of questionnaire respondents who reported being entrepreneurs or planning to start a business



Entrepreneurial activity in various countries

Source: Global Entrepreneurship Monitor 2012 (GEM). Venture Enterprise Center. February 2013.
(OECD member countries were selected from the monitored countries.
The latest data from 2011 or 2012 were used.)

② Future directions

With the aim of increasing the number of potential entrepreneurs and enhancing the social acceptability and status of entrepreneurship and ventures, diverse human resources should be fostered through elementary, secondary and higher education. It is important that gifted young students, who will be the major players in the next generation, become familiar with entrepreneurship and consider working in a venture business as an option for their future career. For this purpose, opportunities should be increased for young students to communicate with entrepreneurs and to experience other cultures by studying abroad, so that they will learn to enjoy challenges and to appreciate unconventional ideas and approaches. Universities need to promote entrepreneurship education, support interchanges among students aiming at starting businesses, and provide opportunities and networks that students can use to communicate with excellent entrepreneurs and supporters. Government efforts to foster entrepreneurial human resources are described below.

MEXT has been implementing the Enhancing Development of Global Entrepreneur Program (EDGE Program). The EDGE Program supports various projects that aim at developing human resources with practical abilities and that provide graduate students and young researchers with opportunities to learn entrepreneurship and know-how for starting a business. In July 2015, the Edge Innovation Challenge Competition was held. Participants were required to compete over not only ideas but also over processes for creating ideas and plans for translating ideas into practical applications. The topic of the competition was "Realizing better communication between working mothers and their children". About 200 people visited the competition venue, and some 1,200 people used the School WEB-campus service to view the competition broadcast live and provided more than 1,000 comments online.

METI, in cooperation with MEXT, held meetings of the Panel on the Promotion of Entrepreneurship Education in Elementary, Junior High, and High Schools. Based on an analysis by the Panel of the current situation, the issues, and the future direction related to entrepreneurship education, a booklet was created that included ideas about, and specific examples of, entrepreneurship education. It is hoped that practical entrepreneurship education is introduced and enhanced nationwide based on the understanding of educators and the cooperation of regional communities and private companies.

EDGE Innovation Challenge Competition 2015

Source: MEXT

The IPA, which is under the jurisdiction of METI, implements the Exploratory IT Human Resources Project (The MITOH Program) in order to actively identify outstanding persons and develop these persons into creators of innovations in software-related sectors with the support of Project Managers (PM). Under the MITOH Program, infrastructure for providing information on the activities and achievements of young IT specialists is developed and networks with people in all industries are expanded in order to encourage a broader range of industries to take advantage of this program.

The National Institute of Information and Communications Technology (NICT), under the control of MIC, has launched the ICT Mentor Platform. Funds, human resources and commercialization are the three factors critical for starting an ICT business. To help connect these factors, human resources from ICT businesses serve as mentors on the ICT Mentor Platform and work together with regional communities and young human resources. Additionally, networking with supporting organizations, universities and communities is expanded nationwide in order to find outstanding talent and companies. The commercialization of ICT businesses is promoted through mentoring that is provided to young entrepreneurial people who aim to participate in a contest and a matching event (i.e., "NICT Entrepreneurs' Challenge 2 Days") held every March.

Examples of Practical Entrepreneurship Education Introduced in Elementary, Junior High, and High Schools

Source: METI

2 The Fostering of Qualities and Abilities Necessary for Survival in a Super Smart Society

As described above, people's lives and jobs may be subjected to unexpected changes in a super smart society. The qualities and abilities required for survival in such a society are considered below.

(1) The steady implementation of education reform towards the realization of a super smart society

To survive in a super smart society where rapid change is expected, it is critical to be able to use everything one has to independently address various issues, even those that are unexpected or unknown of. Such ability is ensured on the basis of solid academic skills and physical strength. A well-rounded education is necessary for young people who seek higher, specialized education before starting their careers. Mathematical ways of thinking are necessary for arts students, and students majoring in math, science or engineering need to learn humanities and social science.

Because some predict that artificial intelligence will surpass all human intelligence, it is increasingly important for humans to enhance their unique qualities and abilities. For example, the following abilities and activities will be more highly valued in the future: the ability to work on problems that no one knows the right answers to and the ability to determine and address challenges; activities that require creativity and a high degree of professionalism; and activities for which sensitivity, emotion and compassion are necessary. Specifically, the qualities and abilities listed below are required in a super smart society.

<Ability, ambition and leadership to independently identify and solve problems>

<Creativity, willingness to take on challenging work, perseverance, and self-affirmation>

<Sensitivity, compassion, communication skills[1], and acceptance of diversity>

These were proposed by the Education Rebuilding Implementation Council[2].

The "Summary of Issues" released by the Special Committee on Curriculum Planning states as follows: "The qualities and abilities that children, who will develop society in the future, need in order to face the reality of the world and society and in order to lead independent lives should be based on the three important elements of school education ("knowledge and skills", "thinking ability, judgment and expressiveness" and "a positive attitude toward independent learning") that are stipulated in Section 2, Article 30 of the School Education Law (Act No.26 of 1947). At the same time, such qualities and abilities can be understood according to the following three key points:

① What children know and can do (i.e., the knowledge and skills of individuals)

② How children use what they know and can do (i.e., the ability to think, judgment, and expressiveness)

③ How children interact with the world and society and create better lives for themselves (i.e., attitudes toward learning, and human qualities)

Far-sighted efforts should be made for educational reform by looking ahead at least 20 years. The ideas that current educators and children's parents have about education are based on the education they experienced more than 20 years ago, so they are 40 years older than the ideas that need to be conceived of for future education. Various changes will take place at an accelerating pace towards the realization of a super smart society, therefore educational reform should be steadily implemented.

1 On August 29, 2011, the Council on the Promotion of Communication Education (convened by the Senior Vice Minister of MEXT) released a report on its deliberations called "Towards the Enhancement of Children's Communication Skills". This report defines communication skills as the abilities to closely interact and empathize with people of different values and backgrounds, to develop personal relationships and teamwork, and to share information with others through discussions of problems to which no one knows the right answer or problems that no one has experienced before, think deeply about them, and exchange views about them to form a consensus and solve those problems.

2 Education Rebuilding Implementation Council. "The Seventh Draft Proposal: Qualities and Abilities Required in the Age to Come, and Education and Teachers Fostering These Qualities and Abilities." May 14, 2015.

① Fostering of abilities for utilizing information in a super smart society (Innovation of educational content)

It is desirable that children take an interest in conducting outstanding research or technology management when they think of their career in a super smart society where informatization is rapid. In this connection, efforts should be made to encourage children to learn math and science and to spark children's interest in these subjects. Because the rapid advancement of ICT has made children familiar with high technologies, it is important for children to acquire the scientific knowledge necessary for understanding and using these technologies.

In view of this, various efforts are being made for structural revisions to the National Curriculum Standards under the basic principle of achieving "a curriculum that is open to the public". These revisions include improvements to learning and instruction methods from the viewpoint of active learning, the strengthening of curriculum management, and the review of subjects and courses. Technical reviews are under way for each subject and school type on the basis of the "Summary of Issues" released by the Special Committee on Curriculum Planning in August 2015.

To help enhance children's skills in using information toward the realization of a super smart society, the ICT environment at school needs to be improved by securing a tablet PC for each student, large display devices such as electronic chalkboards, overhead cameras, and wireless LAN. Additionally, teachers' skills in utilizing ICT should be improved so that they can take advantage of the ICT environment at the school to provide favorable education. It is also necessary to secure postdoctoral fellows, graduate students and outside human resources with ICT skills, train them as technical support staff and assign them to ICT-related work at school according to the needs of the schools.

Column 1-11

First graders experience programming (Tama Municipal Aiwa Elementary School, Tokyo)

At Tama Municipal Aiwa Elementary School in Tokyo, some of the classroom hours for life environment studies and special activities are used to provide first graders with computer programming education. An iPad has been given to every student at this school, and up to 40 iPads a class can be connected to a Wi-Fi network at a time. Each first grader has his or her own stylus pen, and every classroom is installed with a large display screen.

In the programming class, students engage in the following tasks.

1. Get the inchworm to move (1): Learn the basics; move the inchworm on the iPad screen (1 hour)
2. Get the inchworm to move (2): Move the inchworm in many ways (1 hour)
3. Draw a picture and get it to move. (1 hour)

Computer program (Inchworm)

Source: Tama Municipal Aiwa Elementary School, Tokyo

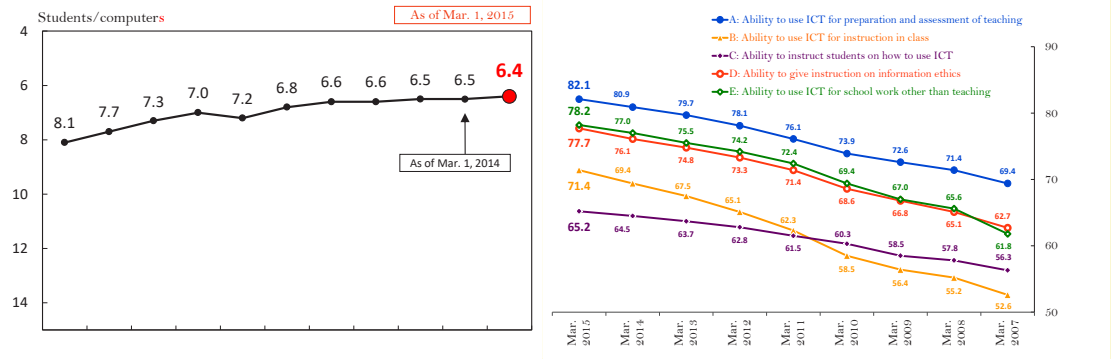
Computer programming education

Source: Tama Municipal Aiwa Elementary School, Tokyo.

In the class:

- After learning from their teacher how to use the iPad, students willingly tried various operations to get an inchworm and pictures to move. Students cooperated with each other and were willing to help other students who were at a loss about how to get the inchworm to move. Doing a presentation helped students to come up with new ideas, and they began to draw various pictures and get them to move.
- After familiarizing themselves with the iPad, the students worked more willingly on the tasks. They were motivated to create various pictures and tried to get them to move in different ways. The teachers' comments after the class are as follows.
- Teachers should try to ensure that it is fun for first graders to work on programming, and that they do not feel incapable of dealing with programming.
- In addition to computer programming education, contact with nature, such as with familiar plants and animals, is also important for first graders.

As the comments show, teachers need to understand the context and meaning of computer programming education.



Changes in the ICT environment at school

(Left: The number of students per computer at school; Right: Teachers' instruction abilities)

Source: FY 2014 Survey on the Informatization of School Education. MEXT. March 2015.

Column 1-12 What you never knew about cybersecurity (Information-technology Promotion Agency)

The Information-technology Promotion Agency published the educational comic book "Saibaasekyuriti no Himitsu" (What You Never Knew About Cybersecurity). This comic book is a guide that provides knowledge about cybersecurity to children. Public and school libraries nationwide have this comic for visitors to borrow and read. A digital version of this comic is available for free on Kidsnet "Manga Himitsu Bunko" of Gakken Plus Co., Ltd.

An educational comic on children's learning and enjoyment

Source: IPA

An educational comic on children's learning and enjoyment

Source: IPA

The target readers of the comic are fourth to sixth graders. By reading the comic, readers can learn about potential risks in using the Internet (i.e., risks associated with IDs and passwords), unauthorized access and cyberattacks by hackers. To help readers understand the importance of cybersecurity, the comic describes the organizations that protect Japan from cyberattacks, the Security Camp Project for fostering young security experts, and cyberbullying.

② The use of ICT for innovations in learning environments (innovation of educational techniques)

"The Seventh Draft Proposal: Qualities and Abilities Required in the Age to Come, and Education and Teachers Fostering These Qualities and Abilities" released by the Education Rebuilding Implementation Council in May 2015, states that educational content and techniques need to be drastically innovated through items (1) to (4) below in order to instill the above-mentioned qualities and abilities.

(1) Enhancing active learning, and establishing an educational system comparable to the systems in other advanced countries; (2) using ICT to innovate the learning environment, and developing skills in information utilization; (3) cultivating entrepreneurship and the power of creativity to generate new value; and (4) finding and fostering outstanding talent.

According to the "Summary of Issues" released by the Special Committee on Curriculum Planning, in order to ensure that students can acquire the necessary qualities and abilities, learning and instruction methods need to be improved on the basis of the three key points of active learning: "deep learning", "dialogic learning" and "voluntary learning".

Among the approaches listed above for innovating educational content and techniques. The focus below is on item #2 ("using ICT to innovate the learning environment, and developing skills in information utilization") because it is expected to have major implications for innovation in a super smart society.

<Massive Open Online Course (MOOC)>

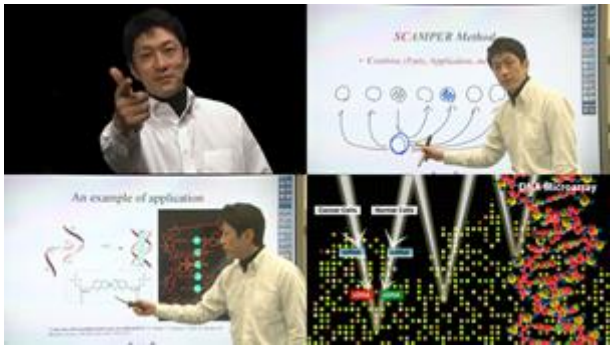
An increasing number of top universities and colleges worldwide offer Massive Open Online Courses (free online courses) in a wide range of subjects. MOOC became popular worldwide in the autumn of 2011 when Stanford University experimentally offered three courses free to the public. "Introduction to Artificial Intelligence" course drew more than 160,000 registrants from around the world. This suggested the potential of services that can surmount geographic borders in attracting excellent learners with a thirst for advanced knowledge.

Platform	Established	Operating body	Major participating university and the number of subjects offered	Cumulative enrollment
Coursera	Apr. 2012	Two Stanford University faculty members Established the company with US$16 mil. in venture capital funding.	• 117 universities and institutions from around the world (Stanford, Duke, Princeton, Penn, Yale, etc.) • More than 990 courses	More than 12 mil. people (as of Mar. 2015)
edX	May 2012	This non-profit project was established by MIT and Harvard University with an investment of US$60 mil.	• 70 universities and institutions from around the world (MIT, Harvard University, University of California Berkeley, etc.) • More than 400 courses	More than 3.5 mil. people (as of Mar. 2015)
Udacity	Feb. 2012	Three Stanford University faculty members Established the company with venture capital funding.	• Stanford University, University of Virginia other universities, individual faculty members • More than 60 courses	More than 1.6 mil. people (as of Apr. 2014)

Major global MOOC platforms in the U.S.A.
Source: Research on Educational Improvement Through the Use of MOOC.

In 2013, the Japan Massive Open Online Courses (JMOOC) was started to promote the use of MOOCs in Japan. The results of a questionnaire survey on the use of MOOCs were released by the Academic eXchange for Information Environment and Strategy (AXIES) in March 2015. As of March 2015, only four national universities and 15 private universities had produced and offered MOOC content. There were 54 schools (18 national universities, 30 private universities, two public universities, four junior or technical colleges) that were planning to produce and offer MOOC content.

Thus, only a limited number of universities and colleges have a positive stance toward MOOCs, and a majority of universities and colleges do not seem to have plans to create and offer MOOC content[1].



Lecture given at Kyoto University by using MOOC "The Chemistry of Life": lecture given at Kyoto University by using MOOC

Source: Kyoto University

The growth of MOOCs and other free online courses around the world helps expand the base of people who can benefit from good education. These courses attract excellent learners who are eager to acquire advanced knowledge across borders. Effective use of these courses is desirable for continuing education. In a super smart society, expertise required in the manufacturing industry, for example, will be more diverse than now. In this connection, online courses that are available anytime, anywhere, are expected to be effectively utilized by specialists who need to keep themselves up to date on information security, advanced technologies and system reforms.

<Optimized & customized learning (adaptive learning)>

In adaptive learning, data on the right and wrong answers given by learners are gathered and collated as big data. Artificial intelligence analyzes each learner's likelihood of giving wrong answers and estimates the knowledge and skills that the learner needs to acquire. Based on this analysis and estimation, the optimal learning content is automatically organized and offered. Adaptive learning is particularly well suited to subjects that require memorization. Learners learn by repeating predetermined processes to solve problems and get answers. Conversely, adaptive learning is not an optimal method for working on problems to which multiple answers are possible, because learners are required to think from a multilateral viewpoint through discussion and debate.

Thus, adaptive learning should be effectively used for subjects in which knowledge acquisition and memorization are important. Utilizing adaptive learning, learners can use their time efficiently. It is hoped that more time than previously is used for education on debating and creative thinking, as these are necessary for Japan to rank with other advanced countries in the wave of globalization.

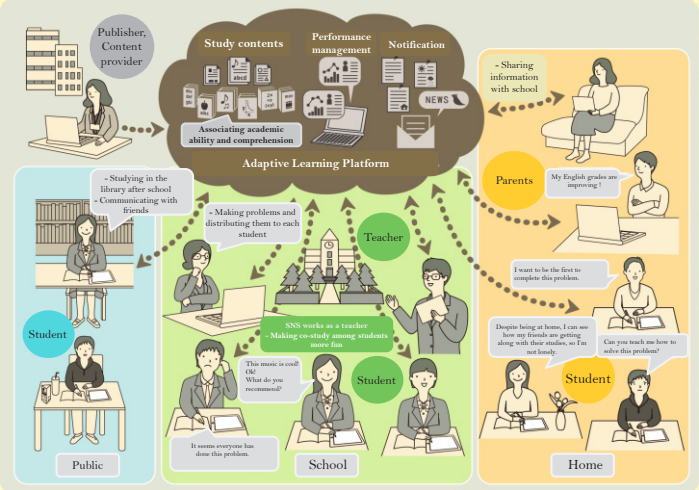
1 FY 2014 research supported by the Fund for Promoting Reform at Leading Universities, "Survey on the Use of MOOCs for Educational Improvement (4th edition)." AXIES. March 2015.

Column 1-13

Example of adaptive learning: Ritsumeikan Moriyama Junior & Senior High School

Ritsumeikan Moriyama Junior & Senior High School, one of the Super Science Schools in Japan, started the Ristumeikan Intelligent Cyber Space (RICS) project in May 2014 in collaboration with the Open Innovation Lab (Innolab) of Information Services International-Dentsu, Ltd. It is a learning support program utilizing cloud computing, SNS and adaptive learning. Adaptive learning is an education method for providing students with appropriate problems in a timely manner according to the needs of each learner.

This school was the first in Japan to adopt an educational program utilizing SNS and adaptive learning that depends on ICT infrastructure.



Adaptive Learning Platform

Source: Ritsumeikan Moriyama Junior & Senior High School

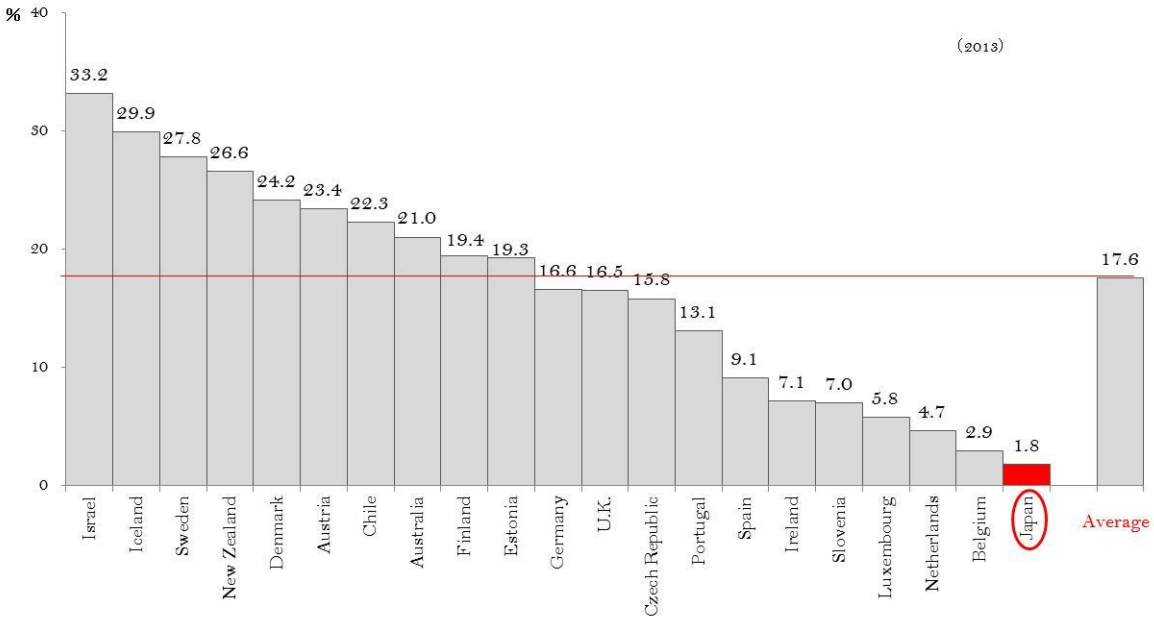
In the RICS project, an adaptive learning platform that is being developed by Innolab is used as the basic ICT infrastructure. From digital course materials (i.e., quizzes) that are accumulated as cloud data, teachers or students choose appropriate ones for learning in class according to the needs of each student. By linking "academic performance and depth of understanding" for each student to "learning materials" on the platform, students can select the optimal learning content. The RICS project aims at the implementation of adaptive learning, which is said to be a next-generation educational technique.

This project also aims to create a learning environment in which students make use of SNS for active learning in cooperation with other students. In such an environment, students can evaluate learning materials and recommend good ones to other students, and can solve problems by asking teachers and friends questions on unclear points.

(2) Improvement of the relearning environment for a super smart society

It is anticipated that people will increasingly focus on creative work in a super smart society. This suggests that the abilities and expertise that professionals need to acquire for career development will change in the future. Currently, the percentage of workers who undergo relearning in order to earn a degree is lower in Japan than in other countries (Figure 1-2-30). In preparing for a super smart society where change takes place rapidly and quick responses are required, university education should be reformed in many ways to ensure that there will not be mismatches between the human resources that companies need and the human resources that universities foster.

■ Figure 1-2-30 / The percentage of students 25 years of age or older who are enrolled in bachelor's degree programs in various countries



Source: *OECD Education at a Glance* (2015).
Note: International students are not included. The figure for Japan is based on Basic School Statistics and research by MEXT. It includes international students.

In this regard, the relearning environment should be improved for professionals who need to enhance their abilities and knowledge. It is also necessary that educational content at universities be enriched through the development of curricula in cooperation with industries and businesses in the information, science and technology sectors.

Among the initiatives that MEXT and MHLW need to work on immediately[1], major initiatives are described below.

① The creation of a system for certifying Brush-up Programs for Professionals at universities

○ To increase opportunities for professionals to enhance abilities necessary for their careers, a certification system was established in July 2015. Under the system, a practical and professional program that a university creates to satisfy the needs of professionals and businesses is certified as a Brush-up Program for Professionals (BP). In December 2015, MEXT Minister certified 123 university programs as BP programs[2].

○ Through the certification of BP programs, (i) options for relearning are visualized for professionals, (ii)

1 MEXT and MHLW announced that they need to start the following initiatives immediately, although these should be promoted on the basis of onsite verification from the viewpoint of the need for human resources development and for comprehensive reform, including institutional reform. These initiatives include the following: 1) the creation of a system for certifying "Brush up Program for Professionals" at universities, 2) the enrichment of internship programs at universities, 3) the establishment of new institutions of higher learning that provide practical vocational training, 4) the development of an educational system through cooperation between specialized training colleges and industries and 5) the drastic enhancement of the capacity of professional graduate schools to train advanced professionals. (Policy Package for the Enhancement of Human Resource Development for the Future: Employment and Education Policies. The 7th Meeting on a Specific Issue, the Industrial Competitive Council. June 4, 2015. (Material submitted to Minister Shiozaki of MHLW and Minister Shimomura of MEXT)).

2 "Education for Realizing a Society That Is Inclusive and Continuously Learning, and the Vitalization of Local Economies." Sixth Proposal of the Education Rebuilding Implementation Council. March 2015.

the attractiveness of university programs is enhanced and (iii) relearning by professionals is promoted because companies better understand the need for relearning, and MHLW's education and training benefit system is utilized.

② The establishment of new institutions of higher learning that provide practical vocational training

○ To help develop highly skilled professionals who can meet changing socioeconomic needs for human resources, and for the purpose of increasing relearning opportunities for graduates of specialized upper secondary school, deliberations have been conducted regarding the establishment of new institutions of higher learning that provide practical vocational training. These will be established as degree-granting institutions included in the university system[1].

○ Specifically, deliberations have been conducted on the following matters:

- The design of institutional arrangements that facilitate the development of highly skilled professionals in response to social needs for human resources, on the basis of the characteristics of each specific sector
- Institutional arrangements for securing the educational quality required of institutions of higher learning as well as for receiving due recognition domestically and internationally as institutions with satisfactory courses
- Arrangements for increasing career options for high school students as well as for facilitating relearning by active employees who aim at acquiring advanced technologies and expertise

After deliberations by the Central Council for Education, the specific design of institutional arrangements will be summarized by the middle of 2016, and a new system for institutions of higher learning will be introduced in FY 2019.

(3) The path toward a super smart society

A super smart society is defined in the 5th Science and Technology Basic Plan as follows:

"a society in which the various needs of society are finely differentiated and met through the provision of the necessary products and services in the required amounts to those who need them when they need them, and in which all people can receive high-quality services and can live comfortable, active lives regardless of differences in age, sex, region, language and other factors."

Such a society will be realized on the strength of science, technology and innovation. The advancement of the IoT has brought the age of big data. Innovations in artificial intelligence have made it possible to provide new services. Robots undertake dangerous tasks and physical work, and artificial intelligence supports knowledge-intensive professional services. In the future, robots and artificial intelligence will be people's partners in their everyday lives. Robots and artificial intelligence will help enhance productivity; thus, people will be able to allocate more of their time to creative work and communication with others.

Meanwhile, some predict that the "technological singularity," the point at which powerful super-intelligence will surpass all human intelligence, will occur in 2045. Will artificial intelligence surpass human intelligence? In trying to answer this question, we naturally consider what humans can do and artificial intelligence cannot.

1 "Future of the Japanese Education System." Fifth Proposal of the Education Rebuilding Implementation Council. July 3, 2014.

In the age of the IoT, data are collected from many areas into big data. In the future, innovative artificial intelligence will help us to find answers to all questions, and robots will help us to carry heavy loads and to work in dangerous places. In the future society, we will probably not have to think about many things because artificial intelligence will tell us what we need and how we should behave. Then, we will be able to spare more time for creative work and to create innovations.

The advent of such a society will be made possible by massive amounts of data that are generated by human activities. "If I had asked people what they wanted, they would have said faster horses," said Henry Ford, the auto baron. He meant that customers knew about horse-drawn carriages, but not about automobiles. In a super smart society realized by the innovative advancement of the IoT, big data, artificial intelligence and robots, who will have the imagination and creativity that were used to imagine and create automobiles as a replacement for horse-drawn carriages?

To create unexpectedly novel ideas out of nothing, great ambition is necessary. We need to be able to identify problems that arise from differences between the ideal and the real that we know from our experience of failures, successes, sorrows, joys, defeats and accomplishments.

This should be remembered when we think of the possibility that artificial intelligence will surpass all human intelligence. Artificial intelligence and other scientific and technological innovations that will be available in a super smart society should be regarded as useful tools that we can depend for fully exercising our creativity and for using time to enhance smooth communication with others.

With the advent of a super smart society, we'll be able to enjoy more comfortable and affluent lives. Then, we'll be able to spare the time to think more about human behavior and creative work, the meaning of life and ways of living as humans.

In aiming to realize a super smart society before the rest of the world, all those concerned need to consider the things stated above while working together to promote the necessary efforts.