[Column 6]

Concrete Achievements of 21st Century COE Program (Project for International Center of Research & Education for Materials, Tohoku University)

○ Outline of Research

Tohoku University has established a world-top-class center of research and education concerning special structured materials so as to exploit its potential academic research and educational capabilities regarding the field of materials science and engineering, in which it has been a world leader since its foundation, by establishing arrangements for enabling its research institutes, mainly the Institute for Materials Research, and researchers belonging to graduate schools to conduct joint research.

Technologies related to special structured materials that are developed at this center are ultimate technologies useful for realizing new properties on an atomic, molecular, or nanometer scale. Such technologies are expected to realize movements, toward the development of materials with a variety of characteristics, originating in Japan.

○ Human Resource Development through Research Activities

Tohoku University advocates the "Research First" principle and the university's Institute for Materials Research in particular conducts research and educational activities based on the policy that fostering excellent researchers is possible only in an environment in which top-level researchers are engaged in world-class research. Since its foundation, the Institute for Materials Research has enjoyed a virtuous circle of its pool of excellent researchers acting as a magnet for more researchers, which in turn helps to foster young researchers.

In this kind of research environment, Tohoku University has discovered young talents that dare to venture into uncharted territories of materials science, and enabled researchers to collaborate to further unique research with a free mind. It has promoted innovative exploratory research and endeavored to build a research center capable of realizing world-top-class research consistently.

Specifically, Tohoku University invited, from young researchers around the world, proposals concerning unique exploratory research themes such as the development of the process of fabricating special structured materials and investigation into the mechanism of new properties, and adopted 20 post-doctorals (hereinafter referred to as COE fellows) as a result. COE fellows have made substantial achievements in terms of both quantity and quality over the five-year implementation period of the 21st Century COE program, by delivering 70 presentations at international conferences and by being involved in the publication of 347 research papers, including 147 as first authors.

Moreover, the university's graduate school students have cultivated internationality and enhanced their own independence and research motivation through, for example, international student exchange seminars which were planned and organized by student themselves by contacting South Korean students. Cross-border friendship generated by such activities constitutes a precious asset not only for graduate school students themselves but also for Japan as a whole.

In addition, the perspectives of young researchers have been broadened and their research activities have been revitalized as a result of encounters with excellent researchers through joint research programs with Japanese and foreign research organizations and companies and through "schools for young researchers," which are summer seminar camps that enable students to mingle with top-level researchers invited from around the world.

Human resource development conducted through the above-mentioned research activities has fostered young researchers capable of undertaking original research concerning special structured materials and playing the central role in this field in the future, and these researchers have been employed by Japanese and foreign research organizations and companies. Particularly notable is that a quarter of the COE fellows have been employed by foreign universities. Tohoku University's success in making consistent institutional efforts to discover talented young researchers, foster their capabilities further and vault them to global prominence represents significant achievements of the 21st century COE program.

1.1.4.3 How to Develop and Retain Human Resources

Amid intensifying global competition for human resources, technologies and other elements essential for "knowledge," concern is growing about Japan's ability to secure sufficient human resources related to science and technology in terms of both quantity and quality as the country faces problems such as the aging of society and a population decline.

Therefore, it is very important for Japan to maintain and enhance its standard of R&D and the level of international competitiveness of the country as a whole in order to realize its goal of becoming an advanced science and technology-oriented nation. Another critical challenge Japan must tackle at the same time is how to develop and retain human resources that form the basis of science and technology and academic activities and enable them to play an active role in various sectors of society, so as to cultivate a safe, comfortable and high-quality living environment.

The Third Science and Technology Basic Plan points out the importance of implementing consistent comprehensive efforts from elementary and secondary education to undergraduate/graduate courses in universities and adult education through the following measures: enhancing science and mathematics education, cultivating a favorable working environment for young researchers, female researchers and foreign researchers, strengthening the human resource development function of universities and human resource development by

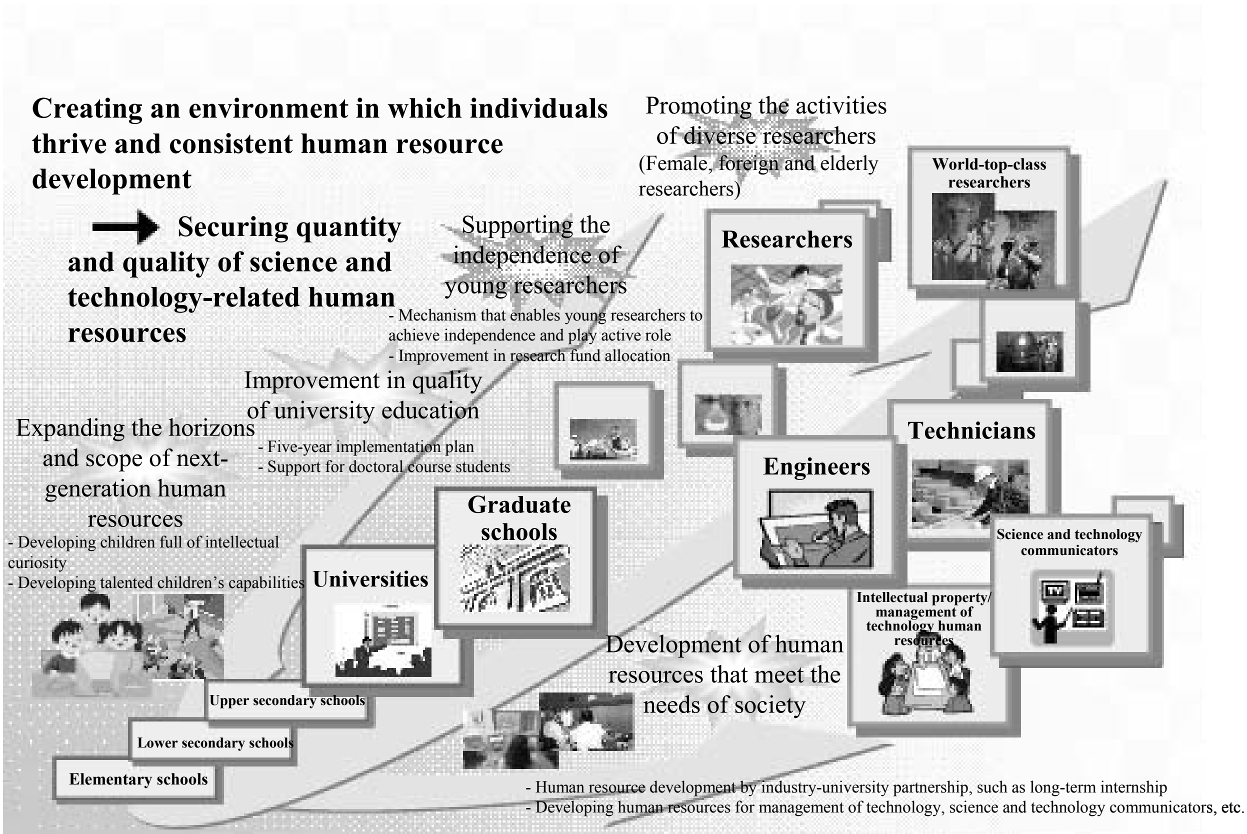


Figure 1-1-42 Development and securing of human resources and promotion of activity

Source: MEXT

industry-university partnership (Figure 1-1-42).

In this context, we will explain how we should seek to develop and retain human resources in the future, from the viewpoint that in order to secure sufficient human resources related to science and technology in terms of both quantity and quality, it is important to establish a system that enables the capabilities of individual young researchers to be effectively utilized, drastically enhance graduate school education, establish outstanding education and research centers and encourage, through industry-university partnership, science and technology-related human resources to contribute their expertise to various sectors of society in response to social needs. We will also explain how to cultivate an education/learning environment for children so as to broaden the base of next-generation human resources related to science and technology.

(1) Support for independence of young researchers (Increase in competitive funds for young researchers)

In order to support young researchers who have made no notable achievement in the past but who are recognized as talented and capable of conducting research based on their own ideas, it is effective to set aside a certain proportion of competitive funds as a quota for young talents. Table 1-1-43 shows competitive fund programs intended for young researchers in Japan.

In the United States, for example, a series of new programs aimed at providing targeted support for outstanding research in the field of biomedicine by young researchers was established at the National Institutes of Health after the National Academy of Sciences proposed a substantial expansion of support programs for early-career researchers. In Japan, although Grant-in-Aid for Scientific Research, which represents the country's most typical competitive fund program, had already been used to support research activities by young researchers, the category (S) funds were added to this aid program in fiscal 2007 to provide research grants worth about 100 million yen to researchers aged 42 or younger over a five-year period so as to enable them to lead their own teams and devote intensive efforts to advancing their research based on the achievements already made.

In order to further enhance efforts to foster young researchers who can think flexibly and have a spirit that enjoys challenge, it is effective to provide budding researchers with opportunities for becoming independent and venturing into new research areas and to establish a system that allows further development of the capabilities of researchers who have made achievements by taking

Table 1-1-43 Major competitive research funds for young scientists in Japan

Competent Ministry	Distributing Organ	Program Name		Target Researchers	Period
Ministry of Internal Affairs and Communications (MIC)	MIC	Strategic Information and Communications R&D Promotion Programme	Research and Development through Encouraging Researchers and their Collaborations (SCOPE-R) (Promotion of young advanced information technology researchers)	Up to age 35	Up to 3 years
Ministry of Education, Culture, Sports, Science and Technology (MEXT)	MEXT/ Japan Society for the Promotion of Science (JSPS)	Grants-in-Aid for Scientific Research	Grant-in Aid for Young Scientists (S)	Up to age 42	5 years
			Grant-in Aid for Young Scientists (A)	Up to age 37	2 to 4 years
			Grant-in Aid for Young Scientists (B)		
			Grant-in Aid for Young Scientists (Start-up)	Persons hired by a university, etc. as a researcher for the first time	2 years
			Grant-in-Aid for JSPS Fellows	JSPS fellows	Up to 3 years
	MEXT	Special Coordination Funds for Promoting Science and Technology	Support Program for Young Fixed-Term Researchers	Fixed-term researchers up to age 35	Up to 5 years during the fixed term
			Program to Create an Independent Research Environment for Young Researchers	Researchers who have earned a doctoral degree within the past 10 years	5 years
	MEXT	Innovative Nuclear Research and Development Program	Nuclear Science and Technology	Up to age 40	Up to 3 years
Ministry of Health, Labour and Welfare (MHLW)	MHLW	Health and Labour Sciences Research Grants	Promotion of young researchers	Up to age 37	1 to 3 years
	National Institute of Biomedical Innovation	Program for Promotion of Fundamental Research in the Health Science	Research by Young Individual Researchers Based on Creative Ideas	Up to age 37	Up to 3 years
Ministry of Agriculture, Forestry and Fisheries (MAFF)	National Agriculture and Food Research Organization	Program for Promotion of Basic Research for Creation of New Technologies and Sectors		Up to age 39	3 to 5 years
Ministry of Economy, Trade and Industry (METI)	New Energy and Industrial Technology Development Organization	Grant for Industrial Technology Research		Under age 39 (Under age 44 for researchers of social sciences, etc.)	4 years or 2 years
Ministry of the Environment (MOE)	MOE	Environmental Technology Development Fund	Feasibility study research area	Up to age 40	1 year
		Environment Waste Management Research Grant	Promotion of young researchers	Up to age 35	Up to 3 years
		Global Environment Research Fund	Domain of innovative research	Up to age 40	1 to 2 years

Reference Information: In addition to the programs shown in the table above, there is a program called "Precursory Research for Embryonic Science and Technology (PRESTO Type)" in the "Basic Research Programs" provided by the Japan Science and Technology Agency under the jurisdiction of the Ministry of Education, Culture, Sports, Science and Technology. It is not a system specifically targeting young researchers, but as a result of screening that did not take into account the researchers' backgrounds or accomplishments, the average age of the selected researchers was 36 (when selected in FY2006).

Source: Created by the Ministry of Education, Culture, Sports, Science and Technology based on materials prepared by the Cabinet Office advantage of such opportunities. To do so, it is necessary to expand the amount of research funds intended for young researchers.

(Creating an independent research environment for young researchers)

As explained above, although post-doctorals employed on the basis of competitive funds make great contributions to improving the standard of research in Japan and producing research results, they face problems such as instability of positions and uncertainty over their career path. Another problem is that in many cases, Japanese researchers are allowed to take charge of their own laboratories only when they reach the top of the career ladder by becoming professors after working as an associate following the completion of graduate courses. While this system provides a certain degree of stability to the positions of researchers, it has been pointed out that the current research environment does not ensure the independence of young researchers in their conduct of research and that it does not provide sufficient mobility and competition. Therefore, it is necessary to immediately implement personnel system reform at universities and other research organizations so as to establish a career path for post-doctorals and other young researchers, enhance the mobility of human resources and revitalize the research environment.

In the United States, the tenure system usually provides a career path for researchers. Under this system, an early-career researcher with postdoctoral experiences is employed for a fixed term at a certain university or research organization, and he/she may be awarded tenure, or the right to stay permanently, depending on the results of rigorous screening of their research achievements during this term. The fix-term position provided before the awarding of tenure is called a tenure track position. This system cultivates a fierce competitive environment and establishes a clear career path extending from post-doctoral to tenure track position to tenured position. The prospect of getting a tenured position provides a strong incentive for tenure-track researchers charged with operating their own laboratories, encouraging them to attain outstanding research achievements. The tenure system is also said to help to enhance the mobility of human resources, thus contributing greatly to the revitalization of the research environment at universities.

In fiscal 2006, Japan launched the Young Researchers' Independent Research Environment Support Program (Special Coordination Funds for Promoting Science and Technology). This program seeks to establish a tenure track system (a mechanism for allowing young researchers to gain experiences as an independent researcher in fixed-term employment before obtaining a steady position through stringent screening) at Japanese research organizations aiming to become world-class research centers by supporting efforts to introduce a mechanism that provides young researchers with opportunities for becoming independent and making successful achievements in a competitive environment.

In fiscal 2006, nine projects were selected as eligible for this program, and there are expectations that a model case of a tenure track system in Japan may be developed out of these projects, leading to the establishment of a fair and clear career path that enables young researchers to fully exercise their capabilities and cultivates a competitive research environment.

(Enhancement of financial support for doctoral course students)

In order to encourage talented students to proceed to doctoral courses, it is necessary to cultivate an environment that enables them to devote themselves to academic and research activities without worrying about financial conditions. According to a survey conducted by the Japan Student Services Organization on "FY 2004 Survey Results on Student Life" (April 2006), about 75% of the academic and living expenses of Japanese doctoral course students are covered by allowances provided by their families, scholarship funds and income from part time jobs, etc. Figure 1-1-44 shows the current status of Japan's financial support programs for graduate school students, including fellowship, teaching assistantship (TA), research assistantship (RA)[37] and scholarship. In the United States, meanwhile, many graduate school students are believed to receive non-repayable grant aid equivalent in amount to their living expenses through fellowship, research assistantship and other financial support programs (Figure 1-1-44).

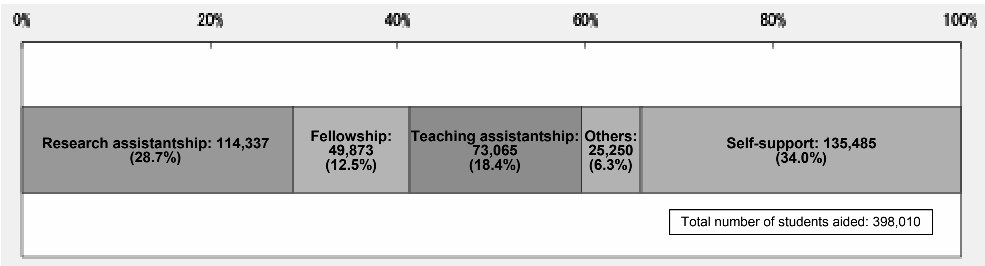
[37] Fellowship: Fellowship aid is usually granted directly to students and is sometimes called a "portable subsidy" because the recipient students may engage in research at the graduate school of their own choosing with the use of the funds provided. Fellowship requires the recipients to devote themselves to research and attain excellent achievements, but the recipients do not have to return the funds.
Teaching assistantship (TA): Under the TA program, graduate school students are employed as assistants to the teaching staff of the university and receive a certain amount of grants in exchange for providing seminar guidance, giving instructions concerning experiments and practical training, implementing examinations and providing lessens to undergraduates.
Research assistantship (RA): Under the RA program, graduate school students are employed as assistants for the research activities of the teaching staff of the university and receive salaries and funds to cover tuition fees in exchange for assisting such activities.

		Grant type					Loan type
Aid Type		Fellowship	Teaching assistantship (TA)		Research Assistantship (RA)		Scholarship
			National universities	Private universities	National universities	Private universities	
Program		JSPS Research Fellowship (Japan Society for the Promotion of Science)	National university special account(Before FY 2003)	Recurring expense subsidies for private universities	National university special account(Before FY 2003)	Recurring expense subsidies for private universities	Scholarship programs (Japan Student Services Organization)
Budget		¥8,254 million (FY2005)	¥4,414 million (FY2003)	¥1,500 million (FY2005)	¥1,843 million (FY2003)	¥800 million (FY2005)	¥111.1 billion (FY2005)
No. of students aided	Doctoral degrees	3,640 (Budgeted number in FY 2005) (5%)	9,281 (Budgeted number in FY2003) (13%)	9,091 (Budgeted number in FY2005) (4%)	4,267 (Budgeted number in FY2003) (6%)	678 (Budgeted number in FY2005) (1%)	28,363 (Budgeted number in FY2005) (39%)
	Master's degrees/ Professional degrees		4,384 (Budgeted number in FY2003) (3%)				65,573 (Number under budget in FY2005) (38%)

Figure 1-1-44 Status of financial support for graduate school students

Notes:
1. The percentage figures in parentheses in the column for the number of students aided represent the ratio relative to all students staying in the relevant programs at national, public and private universities (FY2004). (For reference: The total number came to 162,712 for students in master's degree programs, 7,866 for those in professional degree programs and 73,446 for those in doctoral programs (School Basic Survey 2004).
2. Students may receive two or more types of financial support in some cases.
3. TA and RA are funded not only by management expenses grants and recurring expense subsidies for private universities but also by the 21st century COE program.
4. The budget amount for RA at private universities includes financial support for post-doctorals.
5. Since FY2004, the expense of TA and RA against which measures are taken at the National university special account is transferred into the "management expenses grants for national university corporations" with incorporation and is operated at the discretion of each university corporation.

Source: MEXT



(For reference) Status of major financial support programs for graduate school students in U.S. (broken down by type of support)

Note: "Self-support" includes federal scholarship funds, etc.
Source: National Science Foundation, "Science and Engineering Indicators 2006," Appendix table 2-18

The Third Science and Technology Basic Plan aims to enable about 20% of doctoral course (latter stage) students to receive financial support equivalent in amount to their living expenses by enhancing fellowship programs like JSPS Research Fellowship for Young Scientists and expanding the provision of funds for research assistantship, while maintaining a competitive environment so as to ensure the selection of talented researchers.

In order to steadily implement objectives set forth by the Third Science and Technology Basic Plan, Japan must not only enhance the JSPS Research Fellowships for Young Scientists program but also implement financial support measures such as increasing the provision of competitive funds to students, expanding scholarship programs of the Japan Student Services Organization and exempting talented students from tuition fee payment.

(Developing human resources that meet the needs of society)

Japan, which aims to become an advanced science and technology-oriented nation, must cultivate an environment that enables doctorals, who should form the basis thereof, to play an active role not only at universities and research organizations but also in various sectors of society by taking advantage of their advanced expertise.

Here is a comparison of data on the employment status of Japanese doctorals and the status of their U.S. equivalents as broken down by employment sector. This shows that "four-year universities" are the biggest employment sector for doctorals, followed by "non-profit institutions" and "commercial companies". Although four-year universities are also the biggest employment sector for doctorals in the United States, "commercial companies" and "government agencies" are the second and third biggest employment sectors, respectively. Particularly notable is that the ratio of doctorals employed by commercial companies in the United States is almost double the ratio of doctorals in Japan (Figure 1-1-45).

Moreover, data on annual income by the type of degree earned shows that doctorals earn the most (Figure 1-1-46). According to a survey conducted by MEXT's National Institute of Science and Technology Policy and the Japan Research Institute, Limited[38], doctorals are highly appreciated at companies' R&D divisions in the United States, and such students employed by the industrial sector generally earn more than their equivalents hired by other employment sectors. This situation apparently provides a strong incentive for doctorals to obtain jobs at companies. U.S. companies recognize doctorals as persons who have acquired or are capable of acquiring the ability to act as leaders of activities such as cutting-edge research and coordination with internal and external organizations to facilitate research and as supervisors of the management of research programs. Therefore, U.S. companies are said to be strongly inclined to give precedence to doctorals in R&D job employment over students with bachelor's degrees and master's degrees.

On the other hand, a survey by Nippon Keidanren's Committee on Industrial Technology[39] shows that most Japanese companies have no employment quota for doctorals and that they make employment decisions based on their evaluation of the abilities of individual applicants.

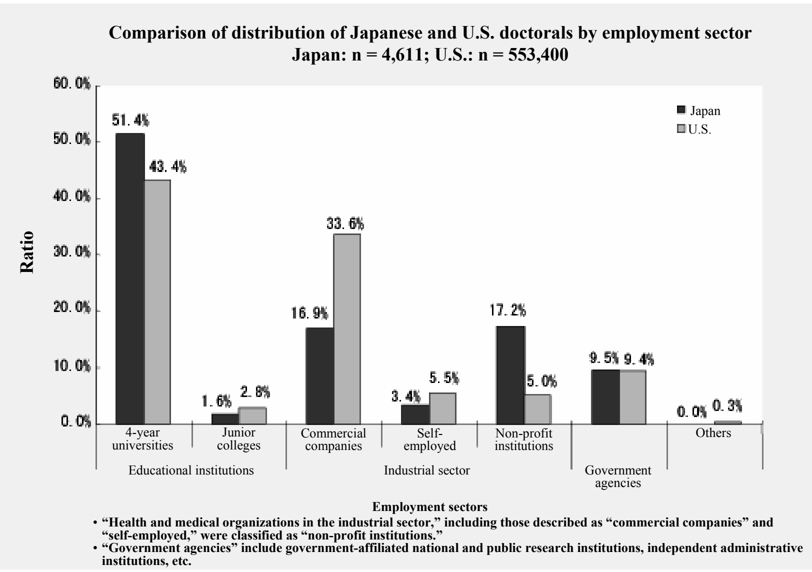


Figure 1-1-45 Comparison of activities of doctorals in Japan and U.S.

Source: "Research on Activities of Japanese doctorals" (March 2004), written by the Japan Research Institute on commission from MEXT

[38] "Study for Evaluating the Achievements of the S&T Basic Plans in Japan: Comparative Analysis on Abilities and Careers of HRST (Human Resources in Science & Technology) between Japan and the US - Career Paths for Doctoral Recipients - ("March 2005 National Institute of Science and Technology Policy and the Japan Research Institute, Limited)

[39] Results of Survey on Status of Doctorals at Companies (February 2007)

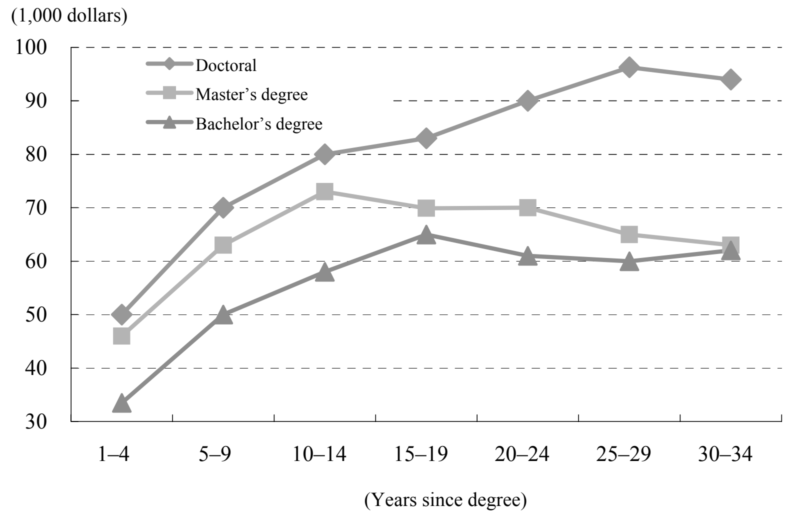


Figure 1-1-46 Median annual salaries by degree level and year (2003)

Note: The above is the median annual income for degree holders in science and engineering fields.

Source：National Science Foundation, "Science and Engineering Indicators 2006," Figure 3-22

When employing doctorals, companies subject applicants to a rigorous selection process, and about 80% of companies that have employed such students say they succeeded in securing "human resources they want." Factors regarding which doctorals are recognized by companies as excellent include "expert knowledge/skills," "ability to conduct research" and "logical thinking capability." On the other hand, factors regarding which problems are recognized include "communications skills," "cooperativeness" and "ability to perform business procedures." Attributes companies expect in doctorals include "leadership," "task-setting capability," "management capability" and "spirit that enjoys challenges."

It is important to take account of the viewpoints provided by companies in implementing measures for promoting human resource development.

(Human resource development by industry-university partnership)

As shown in the examples of industry-university-government joint research cited in the preceding section, such joint programs not only provide ideal opportunities for young researchers to improve their research skills but also help to foster new research leaders.

In addition, in both university and industrial sectors, awareness is growing that there is a pressing need to develop "advanced expert human resources" capable of understanding the position of their areas of specialty in relation to social activities as a whole, setting tasks in light of practical problems and tackling them. In order to meet this need, MEXT in fiscal 2005 launched the "Joint Internship Project for Advanced Human Resource Development", which mainly seeks to promote industry-university partnership for the purpose of human resource development.

This project aims to promote education programs that help to develop internship intended mainly to foster abilities needed in real-life society, such as abilities to set tasks in light of practical problems and understand the position of areas of specialty in relation to corporate activities as a whole. For example, MEXT is engaged in the development of education programs to have graduate school students identify and solve practical problems by arranging for them to participate in joint R&D programs with companies in advanced science and technology fields such as IT, biotechnology, medicinal chemistry and nanotechnology/materials. MEXT is also implementing a variety of other projects such as a pilot project to foster entrepreneurs in collaboration with R&D-oriented local venture companies. We pin high hopes on the future progress in these projects as part of fresh efforts to promote industry-university partnership with emphasis placed on human resource development.

(Promoting the activities of doctorals in industry)

Japan has been implementing the "Project to Promote Diversification of Career Paths for Science and Technology-related Human Resources" since fiscal 2006 in order to encourage people with advanced expertise such as doctorals to exercise their capabilities in various sectors outside universities and other research organizations. Under this project, universities, companies, academic societies, etc. form a network so as to provide organized support to and cultivate a favorable environment for post-doctorals and other young researchers with regard to career choice through the following steps: providing meeting places for companies and young researchers, offering career guidance, providing opportunities for capability development through internship and other measures and fostering awareness about diversification of the career path (Figure 1-1-47).

In fiscal 2006, eight institutions were adopted as the implementing agencies, and they are starting to implement a variety of measures such as the establishment of career support centers, the formulation of a network involving local companies and the provision of technology management guidance, and the provision of opportunities for young researchers to promote their own capabilities to companies. We hope this project will produce successful results.

(Expanding the horizons and scope of human resources)

In order to develop and retain next-generation human resources related to science and technology, it is essential to provide consistent education throughout the entire education cycle, from elementary and secondary education to graduate school education. The important thing to do is to expand the horizon and scope of human resources by providing opportunities to experience the wonder and delight of science and mathematics at elementary and lower secondary schools so as to encourage many children to be interested in science and technology and develop the capabilities of highly-motivated and talented children.

To this end, it is necessary to implement a consistent set of measures such as: to expand opportunities for first-hand learning such as observation and experiments at elementary and lower secondary schools, promote communication between students and researchers/engineers, provide support to upper secondary schools that attach importance to science and mathematics education as well as to universities that provide special education programs to a selected group of highly-motivated and talented students.

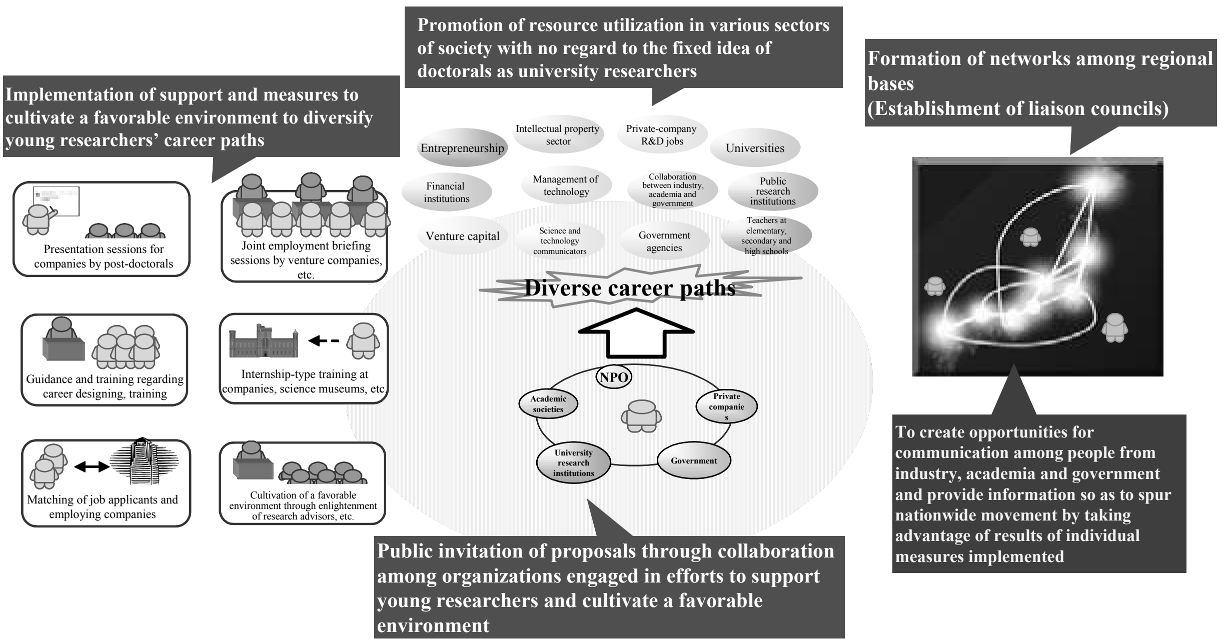


Figure 1-1-47 Project to diversify career paths of science and technology-related human resources

Source: MEXT