1.1.4 Development of Next-Generation Human Resources - Succession of Knowledge -

Summary

Science and technology are human activities that make cumulative development as they interact with society. People involved in science and technology discover "knowledge," which represents a body of achievements made by their predecessors, identify problems, and acquire the ability and habit of resolving problems while engaging in education and research activities conducted at universities and research organizations. Human resources developed through the promotion of science and technology further research and produce new "knowledge" and play an active role in various sectors of society, thereby feeding back the results of their research activities to society. This section will show the results of Japan's human resource development conducted through research activities at a time when a shift toward knowledge-based society is proceeding around the world and explain how we intend to promote human resource development in the future.

1.1.4.1 Importance of Development and Retention of Science and Technology-Related Human Resources

The Third Science and Technology Basic Plan features as a basic tenet "Emphasis on fostering human resources and competitive research environments - Shift of emphasis from 'hard' to 'soft' such as human resources; greater significance of individuals in institutions". It also points to the need to shift emphasis in science and technology policy from infrastructure building to investment in the development of excellent human resources, because human resources constitute the basis of the prowess in science and technology, and the future of creative science and technology in Japan depends on the capabilities of human resources that play an active role in the country. Moreover, the Basic Plan stipulates that Japan should aim to enhance its prowess in science and technology in the long-term and contribute to building trust with other countries by making efforts to establish

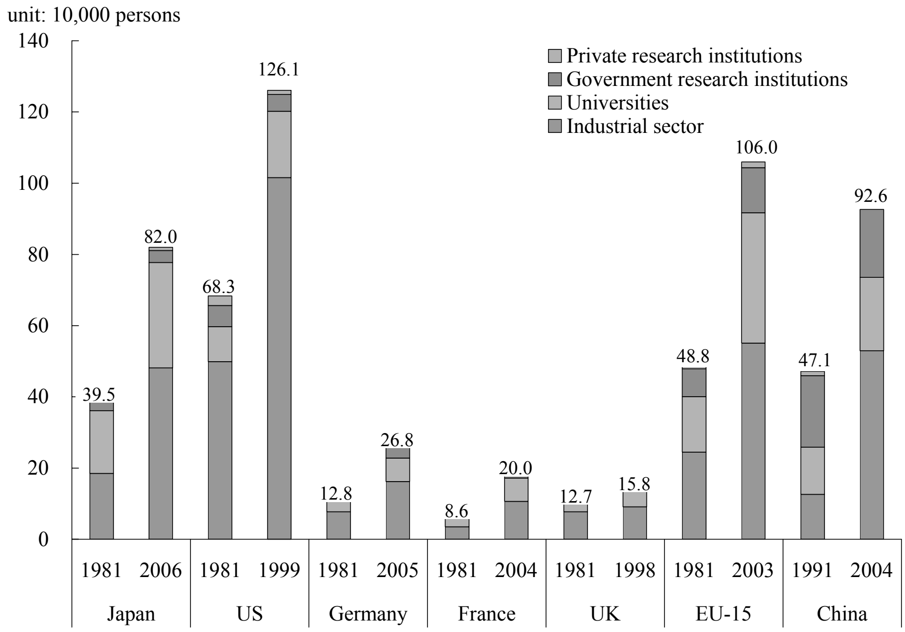


Figure 1-1-28 Trends in number of researchers in Japan and other major countries

Note: EU-15 comprises Belgium, Germany, France, Italy, Luxemburg, Netherlands, Denmark, Ireland, UK, Greece, Portugal, Spain, Austria, Finland and Sweden.

Source: Figures for Japan taken from "Report on the Survey of Research and Development" by the Ministry of International Affairs and Communications and those for other countries from "Main Science and Technology Indicators" by the OECD.

and improve facilities and equipment that form the basis of science and technology activities so as to attract excellent human resources from within and outside the country.

(1) Other countries' efforts to develop and secure human resources

The numbers of researchers in Japan and other countries have now risen sharply compared with the early 1980s, indicating that the role of researchers as the core human resources in the establishment of a knowledge-based society is expanding (Figure 1-1-28).

In this context, countries around the world regard the development and retention of excellent science and technology-related human resources as the centerpiece of their science and technology promotion policies and are implementing a variety of initiatives suited to their own circumstances and challenges.

In the United States, for example, the American Competitiveness Initiative, unveiled by President George W. Bush in his State of the Union Address in February 2006, seeks to develop and secure human resources by enhancing mathematics and science education and by reforming the immigration system in ways to attract excellent human resources from around the world and retain them. The United Kingdom also aims to increase the supply of scientists, engineers and technicians under a 10-year investment program for science and technology called the Science and Innovation Investment Framework 2004-2014, by enhancing the quality of science teaching staff and student performance in science and raising the ratio of high-performing students choosing R&D jobs.

Meanwhile, Germany in 2006 launched a funding program for university called Excellence Initiative in order to develop elite universities that have international clout and are capable of attracting excellent brain powers. Under this initiative, a project to support about 40 graduate schools is underway in order to foster young researchers. The EU is implementing the Marie Curie Actions, which are intended to enhance the mobility of researchers, under the Seventh Research Framework Program (2007-2013), and is considering a plan to establish a European institute of technology as an education and research center of the EU region.

China is implementing the 211 Project, which puts priority on aid for about 100 universities and aims to lay the foundation of science and technology, including human resource development, and promoting the policy of calling back Chinese students studying overseas and inviting researchers with international acclaim. Moreover, China launched the 111 Project (This project aims to invite more than 1,000 scientists from the best 100 universities in the world and establish 100 research

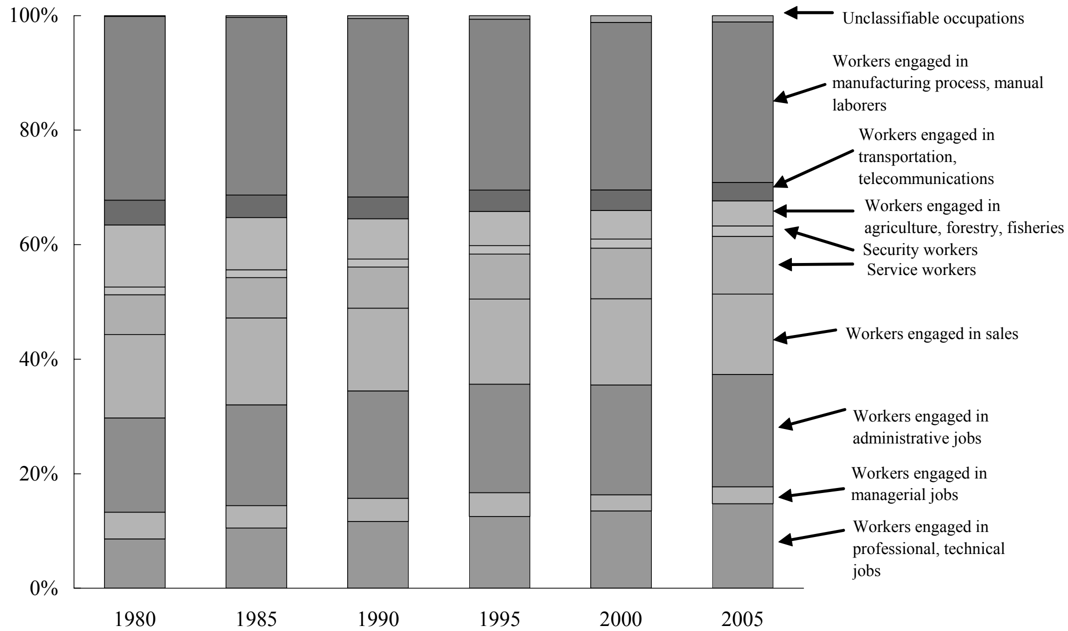


Figure 1-1-29 Percentage breakdown of employees by occupation type

Source: 2006 White Paper on the Labour Economy by the Ministry of Health, Labour and Welfare centers at Chinese universities for joint research by domestic and foreign scientists.), in an effort to establish world-leading research centers.

(2) Japan's viewpoint concerning human resource development and retention

The number of researchers in Japan stood at 820,000 in fiscal 2006, rising more than double from 395,000 in 1981. It is notable that the ratio of researchers working in the industrial sector to the total number of researchers increased particularly sharply (Figure 1-1-28). Moreover, the ratio of people engaged in specialist and technical jobs, including science researchers and engineers, to the total number of workers has been rising in Japan in recent years, with demand for human resources with higher-level knowledge growing in the labor market (Figure 1-1-29).

As the interaction between science and technology and society deepens and becomes diverse, people involved in research activities are increasingly required to play an active role not only at universities and research institutes but also in various sectors of society. In order to pass knowledge produced by academic research and achievements in science and technology onto future generations and ensure further development, it is necessary to promote the development and retention of excellent human resources suited to social needs.

In order to ensure the development and retention of human resources capable of supporting Japan's intellectual foundation, it is important to provide young researchers, who are the key to this challenge, with a variety of research opportunities suited to their aptitudes. It is thus desirable to further enhance programs for assisting young researchers in the future.

Many researchers attain great achievements while they are young, as shown by a survey on at what age Nobel laureates did the work for which they were commended

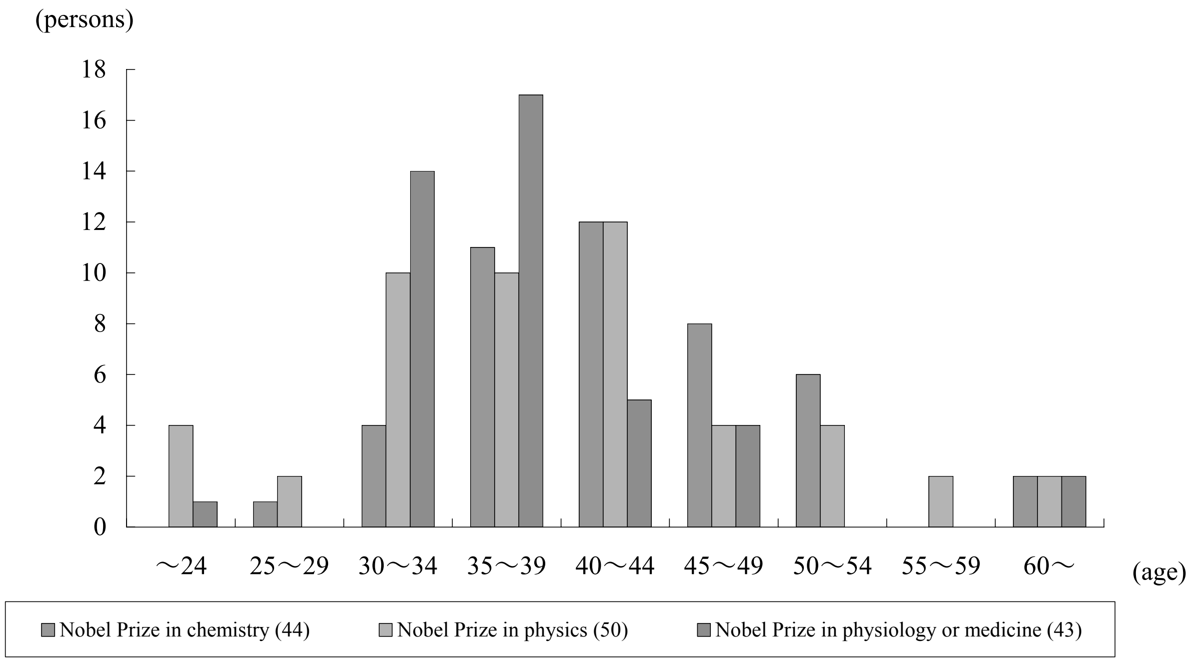


Figure 1-1-30 Distribution of Nobel Prize laureates by age of prize-winning work (1987-2006)

Note: The "age of prize-winning work" indicates the age of the Nobel laureate at the time of the publication of the research paper, etc. that led to the award. The following principles were applied to determine the age.

1) The age of the prize-winning work shall be equivalent to the number reached by deducting the number of the year of the Nobel Laureate's birth from the number of the year when the research paper, etc. that led to the prize award was published.
2) When two or more papers were cited in the commendation, the year when the earliest one was published shall be used in the calculation explained above.
3) When the publication date of the paper, etc. that led to the prize award cannot be precisely determined, the year of the prize-winning work shall be assumed as follows: Work done in the 1990s shall be dated to the year 1995, work done in the early 1990s to 1992, work done in the latter half of the 1990s to 1998 and work done in the mid-1990s to 1995.

Source: Survey by MEXT

(Figure 1-1-30). This survey covered a total of 137 scientists who won Nobel Prizes in the natural science fields of physics, chemistry and medicine/physiology between 1987 and 2006. It is evident from Figure 1-1-30 that in any science field, Nobel prize-class achievements are mostly attained when the scientists are in their 30s to 40s.

With regard to Japanese Nobel laureates, please refer to Table 1-1-31. Among them, Hideki Yukawa and Koichi Tanaka were commended for work done at the youngest age, 28, and most others were honored for work done when they were between the late 20s to 40 years old.

With due consideration of the above, this section describes the research results achieved by young researchers in particular and explains how Japan intends to promote human resource development in the future.

1.1.4.2 Results of Human Resource Development Conducted through Research Activities

Research activities at university are conducted as one with education, an arrangement that enables graduate school students and other young researchers to inherit knowledge obtained as a result of their predecessors' research and engage in research activities themselves in pursuit of new knowledge, thus acquiring the ability and habit of identifying problems and finding solutions.

Such education and research activities have the function of not only training academic researchers but also developing human resources capable of playing an active role in various sectors of society. Intellectual assets thus created are returned to society and contribute to social development through human resource development conducted by universities and other institutions of higher education.

Table 1-1-31 Japanese Nobel Prize laureates (natural science fields), work commended, and age of prize-winning work

Prize Winner	Work commended	Year of research publication (Age)	Year of award (Age)
Hideki Yukawa	Theory of mesons	1935 (28)	1949 (42)
Sin-itiro Tomonaga	Renormalization theory	1946 (40)	1965 (59)
Leo Esaki	Discovery of tunneling phenomena in semiconductors	1957 (32)	1973 (48)
Kennichi Fukui	Frontier orbital theory	1952 (34)	1981 (63)
Susumu Tonegawa	Research on the immune system from the viewpoint of molecular biology	1976 (37)	1987 (48)
Hideki Shirakawa	Discovery and development of conductive polymer	1977 (41)	2000 (64)
Ryoji Noyori	Work on chirally catalyzed hydrogenation reactions	1980 (42)	2001 (63)
Masatoshi Koshiba	Pioneering contributions to astrophysics, in particular for the detection of cosmic neutrinos	1987 (61)	2002 (76)
Koichi Tanaka	Development of methods for identification and structure analyses of biological macromolecules	1987 (28)	2002 (43)

Source: Survey by MEXT

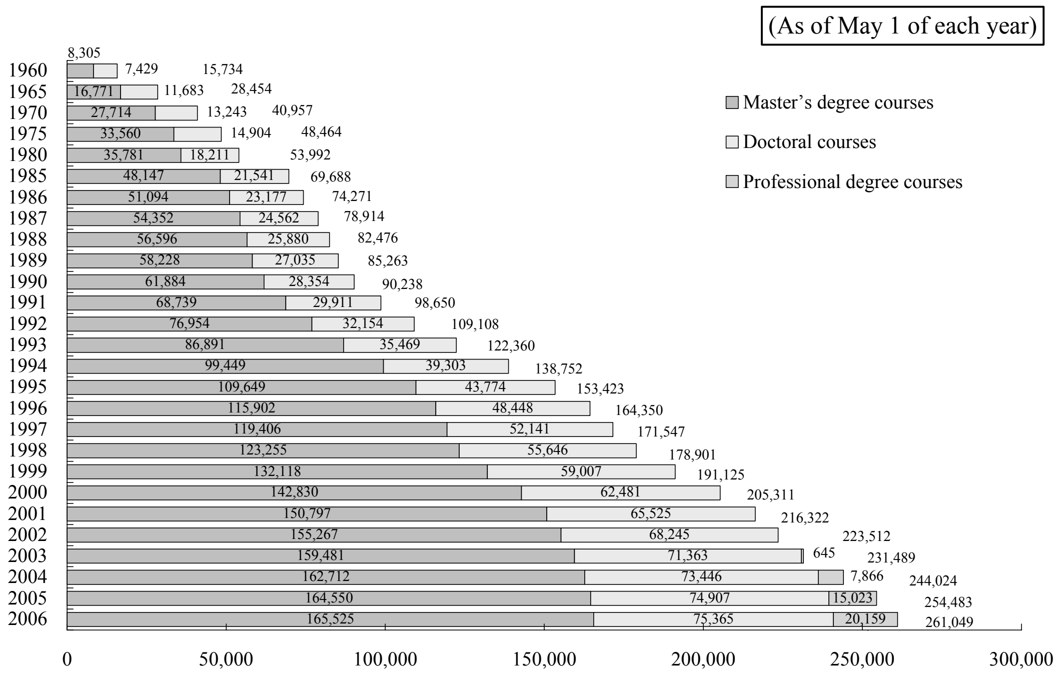


Figure 1-1-32 Trends in number of graduate school students in Japan

Note: The number of graduate school students enrolled in "master's degree courses" include those in master's degree courses, two-stage doctoral courses (two-year first stage) and five-year integrated doctoral courses (first and second year). The number of graduate school students enrolled in "doctoral courses" include those in two-stage doctoral courses (three-year second-stage), in doctoral courses of medical, dental and veterinary sciences and five-year integrated doctoral courses (third to fifth year).
Correspondence-based programs are excluded.

Source: MEXT

(1) Reform of graduate schools

In order to satisfy diversified social needs, it has become necessary for Japanese graduate schools to provide opportunities for education and research in a variety of ways. In addition, international exchanges and competition in the field of education and research have increased against the background of the realization of a borderless economy and a society based on advanced communications technologies. As a result, demand has grown for human resources equipped with advanced expert knowledge and abilities and capable of playing an active role across national borders.

In light of this situation, reform of the graduate school system has been vigorously promoted, leading to the establishment of new types of institutions such as those dedicated entirely to graduate courses, correspondence-based graduate schools and professional graduate schools. The reform has also injected flexibility into the university entrance criteria and the duration of academic programs, allowing the introduction of an early entrance system, one-year master's degree course programs and long-term stay programs, and helped to diversify the methods and arrangements of education, enabling the adoption of the linked graduate school program and the establishment of graduate schools offering evening or day/evening courses. Meanwhile, the number of graduate school students in Japan has risen about 3.5 times over the past 20 years, although the number is still small compared with the numbers in the United States and Europe (Figure 1-1-32).

In recent years, Japanese universities have also been promoting reform measures such as prioritized allocations of funds intended to revitalize research activities, the provision of support for young teaching staff and the introduction of arrangements for enabling flexible implementation of research programs.

Many universities are implementing measures for revitalizing research activities, including the introduction of campus-wide public invitations of research proposals with the use of president's discretionary expenses, differential budget allocations among departments and prioritized allocations of funds intended to revitalize research activities. More specifically, some universities extend public invitations of research proposals throughout the campus with an offer of research grants provided out of the discretionary expenses of the university president. Others are seeking to revitalize research activities by varying the amounts of funds allocated to departments according the adoption ratio with regard to Grants-in-Aid for Scientific Research, for example.

Meanwhile, there are universities that promote the development of human resources capable of forming the basis of academic research through the provision of support to young teaching staff and graduate school students. For example, some universities seek to enhance assistance for graduate school students by earmarking funds for research assistantship (RA) intended mainly for graduates in the second stage of the doctoral program. Others have introduced a system of commending young teaching staff with innovative ideas and allocating to them research funds totaling tens of millions of yen.

Moreover, there are moves to promote the establishment of a system that enables flexible or effective research activities by taking advantage of the recent corporatization of national universities, which allowed them to make their organizations more flexible. More specifically, some research organizations have started collaboration with other institutions concerning specific themes such as "Imaging Science" after establishing an internal committee in charge of planning research collaboration and an organization in charge of implementing plans. Such collaboration aims to promote joint inter-disciplinary research activities involving researchers from several inter-universities and other research organizations and universities and create and develop new academic fields.

The above-mentioned reform measures have contributed to the revitalization of education and research activities at universities and the development and retention of human resources that form the basis of science and technology and academic activities.

(2) Fostering young researchers (Support for post-doctorals)

Young researchers' experiences as post-doctorals[36] are important for fostering their creativity and independence

"In what way are post-doctoral experiences significant for researchers?"
(Research mangers, post-doctorals, doctoral course students)

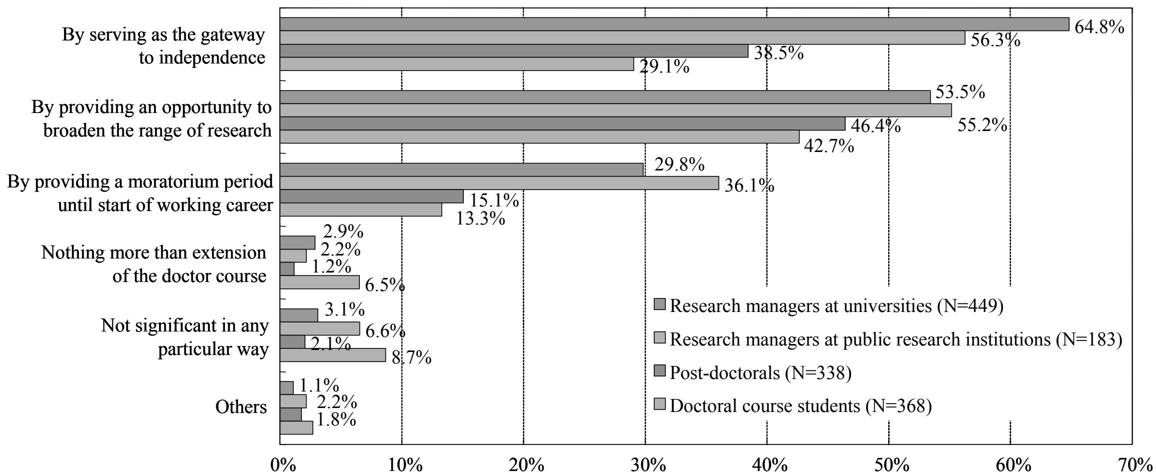


Figure 1-1-33 Significance of post-doctoral experiences

Note: "N" indicates the number.

Source: "Achievements and Issues of Major Policies for S&T Human Resources Training Program March 2005" by National Institute of Science and Technology Policy/Mitsubishi Research Institute, Inc.

[36] Post-doctorals: Those who, after having completed doctorates, (1) engage in research activities at a research organization such as a university, not as a professor, an associate professor, an assistant professor, or the like, or (2) engage in research activities at a research organization such as an independent administrative agency, assigned to the position for a fixed term and are not in a position such as a leader or a senior researcher of their research group. Both (1) and (2) include those who have terminated their student status but have been a graduate student for a period exceeding the required number of years for completing a doctoral course and have obtained the required credits (generally referred to as "withdrawals upon obtaining required credits").

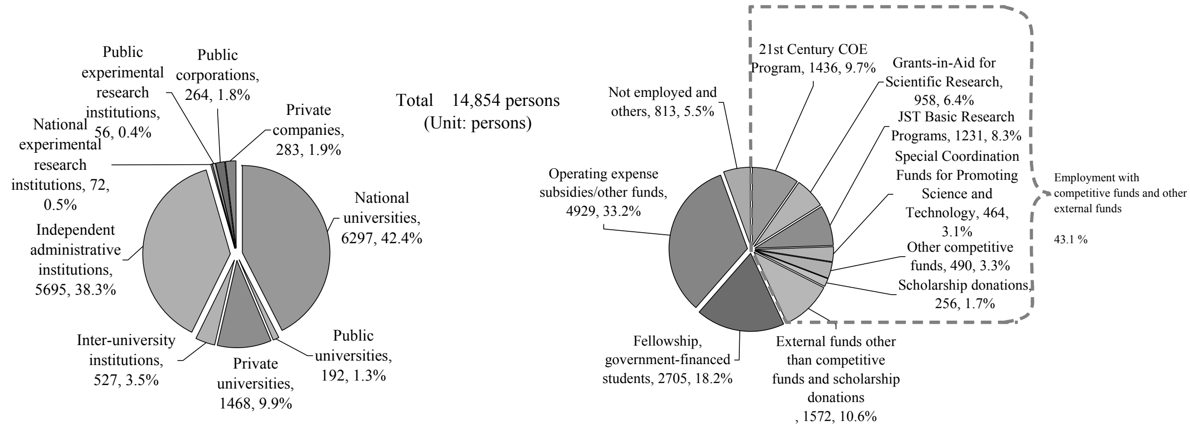


Figure 1-1-34 Employment status of post-doctorals by type of institution and funding

Source: "Survey on Post-doctoral Fellows and Research Assistants (FY2005) August 2006" by National Institute of Science and Technology Policy/MEXT

as they engage in research activities under a variety of advisors, get to know what kind of research environment is the most suited to themselves and broaden the range of their research and tackle new fields during the post-doctoral period. When the National Institute of Science and Technology Policy conducted a survey with regard to the significance of the post-doctoral period, many respondents characterized this period as the gateway to independence or an opportunity to broaden the range of their research (Figure 1-1-33).

In order to foster and retain excellent researchers, it is necessary to enhance the independence of young researchers and create an environment that enables talented young researchers to fully exercise their capabilities. To this end, the First Science and Technology Basic Plan (which started in 1996) proposed a plan to provide support to 10,000 post-doctorals and other young researchers, and this proposal led to the establishment and implementation of a variety of aid programs for post-doctorals. The numerical goal of this plan was achieved in fiscal 1999, helping to expand the pool of young researchers in Japan and establish an environment that enables post-doctorals to devote themselves to research activities.

On the other hand, the uncertainty over the career paths of post-doctorals remains a problem. In order to resolve this problem, it is important to enhance the transparency over the process of employing young researchers, help them become independent and promote career-support efforts, such as providing post-doctorals with career options other than academic research jobs (For specific measures, see page 63 and 67).

According to a survey conducted by MEXT in fiscal 2005, a total of 14,854 post-doctorals and the like were employed as of fiscal 2004, with 57% of them working at universities and 38% at independent administrative institutions. The breakdown by the type of funding showed that 43% were supported by competitive funds and other outside funds and 33% by management expenses grants and other internal funds (Figure 1-1-34).

(Enhancing quality of young researchers through JSPS Research Fellowships for Young Scientists)

The JSPS Research Fellowships for Young Scientists (sponsored by the Japan Society for the Promotion of Science) is intended to provide talented young researchers in Japan with opportunities to devote themselves to research activities concerning themes selected by themselves with a free mind in order to foster and retain researchers. Under this fellowship program, which started in fiscal 1985, doctorate program students and doctorals who are recognized as having excellent research capabilities and who wish to devote themselves to research activities at universities and other research organizations may be adopted as fellows and be eligible for research grants.

In fiscal 2006, as many as 5,032 researchers were adopted as fellows, indicating that this fellowship program constitutes the centerpiece of researcher training. In particular, this program has contributed to remarkable improvement in the capabilities and potentials of promising, next-generation researchers by enabling them to make a living without engaging in part time jobs and devote themselves to research activities concerning themes of their own choosing and at institutions of their own choosing.

With regard to the employment status of researchers adopted as fellows under JSPS Research Fellowship (PD), about 40% obtained permanent research jobs immediately after the completion of their fellowship term, with the ratio rising to about 50% one year later, to 70% four years later and to more than 80% 10 years later. These figures indicate that some researchers get permanent research jobs by continuing research activities as post-doctoral fellows after the completion of their term of the JSPS Research Fellowship and by eventually achieving excellent research results (Figure 1-1-35).

As explained above, the JSPS Research Fellowships for Young Scientists has played a significant role in Japan's efforts to foster researchers by securing a career path to permanent research jobs for talented young researchers.

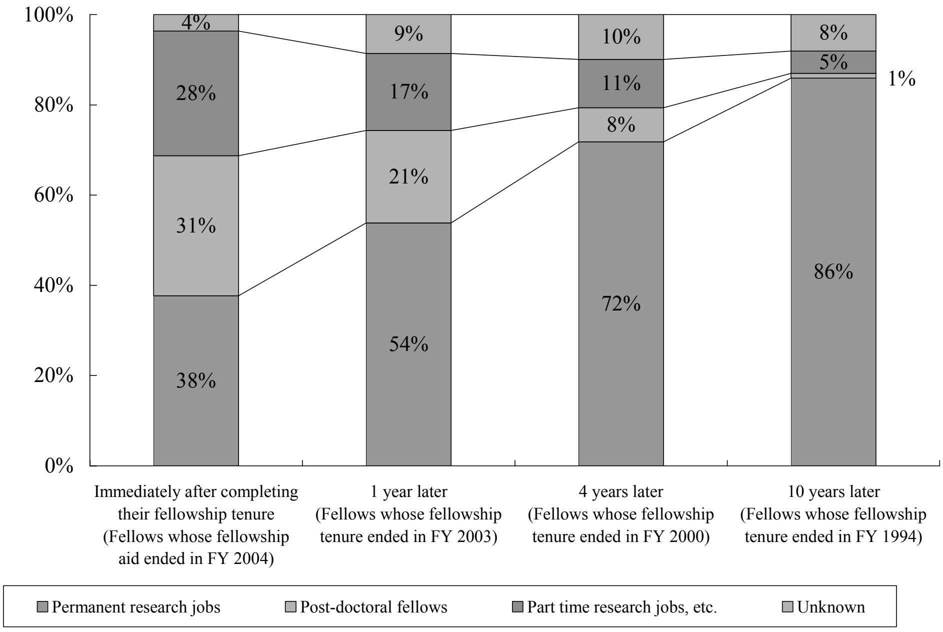


Figure 1-1-35 Employment status of researchers accepted by JSPS Research Fellowship (PD) program

Source: Date compiled by MEXT based on "Results of Employment Status Survey on JSPS Research Fellows (PD) (as of April 1, 2005)" issued in May 2006 by the Japan Society for the Promotion of Science

[Column 5]

Liberal Research Environment and Consistent Support are Important for Fostering Young Researchers

What is necessary for fostering young researchers? We asked Hiroshi Takayanagi, professor of cellular physiological chemistry at Tokyo Medical and Dental University, who has won international acclaim as a pioneer in an inter-disciplinary field called osteoimmunology, about what is a desirable research environment for young researchers and what kind of public support should be provided to them in light of his own experiences.

Starting Point for My Current Research Work

After graduating from the Faculty of Medicine, University of Tokyo, I worked as an orthopaedic surgeon at hospital for about six years and engaged in the treatment of rheumatoid arthritis patients. Although there were many excellent drugs to treat the pains and swelling caused by rheumatism at that time, surgery was the only way to prevent the progress of the bone destruction caused by the disease, and I felt that a more fundamental treatment was necessary. At Tokyo Metropolitan Geriatric Hospital, where I worked, there was an arrangement for allowing its clinical doctors to conduct research at the Tokyo Metropolitan Institute of Gerontology, which was attached to the hospital, and so I started research on osteoclast, which is a type of cell that destroys bones, because I was interested in the mechanism of bone destruction. As I wanted to further my research, I decided to return to my university to continue research as a graduate. Looking back now, I think the fact that I was in an environment where I could relate my interest as a clinical doctor to basic research gave me a huge impetus to go on to engage in basic research later.

Stint at Graduate School Taught Me Essentials of Both Clinical Study and Basic Research

When I enrolled in the doctorate program, I was worried about my financial situation. However, as I had my research paper prepared, I was adopted as a fellow of the Japan Society for the Promotion of Science's JSPS Research Fellowship (DC), and so I was able to devote myself to my research. At the graduate school, I studied orthopedic surgery. Since rheumatism is an immunity-related disease, I thought it was necessary to relate my research to immunology and took advantage of an arrangement provided by the graduate school at that time to allow graduate school students to participate in basic research seminars while engaging in clinical study. In the latter two years of my doctoral course, I was allowed to join the laboratory of Prof. Tadatsugu Taniguchi (Faculty of Medicine, University of Tokyo), and Prof. Taniguchi was kind enough to permit me to continue my research related to osteoclast and immunology. I was very lucky in that I was in an environment which allowed me to receive support for my research work without regard to the conventional boundaries of academic fields and frameworks as long as the research theme looks interesting. Besides, from my experiences in basic research at this laboratory, I learned a harsh truth of the world of research: that even if I grasp a certain thing as a phenomenon, my achievements would not be recognized in the international arena unless I make thorough investigations into the working mechanism and fully explain it. As I explained above, I was able to conduct research combining elements of both orthopedic surgery (clinical study) and immunology (basic research) because I received guidance from experts in both fields. I believe that the fact that I was in an environment that allowed me to choose research themes I like led me to publish a research paper in the Nature journal (Note) in 2000, when I completed my doctoral course.

(Note) This paper drew acclaim as heralding the dawn of the new research field of osteoimmunology.

As Independent Researcher

It is often difficult for researchers to continue basic research after completing their graduate school course, but I was able to do so because I applied for the JSPS Research Fellowship (PD) and was adopted as a fellow. After a while, I obtained the post of an associate at the Department of Immunology, Graduate School of Medicine, University of Tokyo. At the same time, I also applied for the Japan Science and Technology Agency's "PRESTO (Precursory Research for Embryonic Science and Technology)" program and my application was accepted. As this program provides a relatively large amount of research grants compared with other funding programs for individual young researchers, it allowed me to employ post-doctoral fellows and strengthen my own laboratory and greatly helped to further my research.

Around the time when I started to feel like becoming independent and beginning my own research, I received an invitation for the post of a specially appointed professor from Tokyo Medical and Dental University, which had been adopted with the research theme of "destruction and reconstruction of bones" under the 21st Century COE Program. This was a lucky opportunity for me, because there were few institutions willing to accept researchers engaged in bone-related research. Even if we obtain a post, it would be difficult to set up our own laboratories without receiving sufficient funds. In my case, I was able to secure sufficient funds to operate my own laboratory by obtaining consistent support from the Japan Science and Technology Agency's "PRESTO" program, "SORST (Solution Oriented Research for Science and Technology)" program, etc.

In 2005, I became a professor at Tokyo Medical and Dental University, and I am now conducting research on the mechanism of the interactions between bones and the immune system, mainly with the support of Grant-in-Aid for Creative Scientific Research. I hope this research will pave the way for new treatments of rheumatism and other bone and articular diseases. In the aging society, it is particularly important to enhance the quality of life. From the viewpoint of enabling people to live long while remaining as active as possible and maintaining good health conditions, I believe that osteoimmunology research has an important role to play in society.

What Is Necessary to Foster Young Researchers?

It is relatively easy for young researchers to obtain Grants-in-Aid for Scientific Research (B) and (C), but these grants are insufficient for them to set up their own laboratories and further their research. Young researchers need funds for research more than anything else. I hope research grant programs for young researchers will increase further. I think it is important to establish a mechanism that enables them to receive funds consistently, on condition that their research results are evaluated appropriately.

In order to enable young researchers to proceed with their research without obtaining a large amount of research grants immediately, it is necessary to cultivate a favorable research environment through measures such as expanding and strengthening equipment rooms for common use and reducing the burden for the use of other commonly-used facilities such as mouse-breeding rooms. Such measures also help to increase the mobility of human resources. The recent increase in commendation programs for young researchers is useful for stimulating their research motivation, but it is also desirable to establish programs that link commendations with the provision of grants. Moreover, it is also necessary to enhance programs for inviting foreign researchers to Japan because inviting foreign post-doctorals for interactions with Japanese researchers so as to revitalize laboratory activities is important for fostering researchers capable of winning international acclaim.

Advice to Young Researchers

To fulfill your dream, you should further your research by setting research themes for yourself and by thinking with your own mind, without being swayed by the fashion of the time.

It is also necessary to communicate your original ideas to the world in English in a convincing manner. To do this, you must work hard to acquire language skills. I want you to recognize at an early stage in your career that even in science research, how your achievements are evaluated depends largely on your ability to communicate your ideas to the world.

* Hiroshi Takayanagi (Professor, Department of Cell Signaling, Tokyo Medical and Dental University), born in 1965; graduated from the Faculty of Medicine, University of Tokyo in 1990; completed a doctoral program (orthopedic surgery) in 2001 at the Graduate School of Medicine, University of Tokyo, where he had a PhD in medicine. He is now a professor at the Department of Cell Signaling, Tokyo Medical and Dental University, after previously serving in the following posts: JSPS fellow (PD), associate at the Graduate School of Medicine, University of Tokyo; researcher under Japan Science and Technology Agency's Sakigake 21 program; specially appointed professor at the Department of Cellular Physiological Chemistry, Tokyo Medical and Dental University.
Awards received include: Amersham Biosciences and Science Prize for Young Scientists (2002), Japan College of Rheumatology Award (2004), Japan Society for the Promotion of Science Prize (2005), Japan Academy Medal (2005), The Commendation for Science and Technology by the Minister of Education, Culture, Sports, Science and Technology, The Young Scientists' Prize (2005), NISTEP AWARD 2005 of the National Institute of Science and Technology Policy, Ministry of Education, Culture, Sports, Science and Technology (2005), etc.

(3) Cultivating uniqueness and international competitiveness of universities

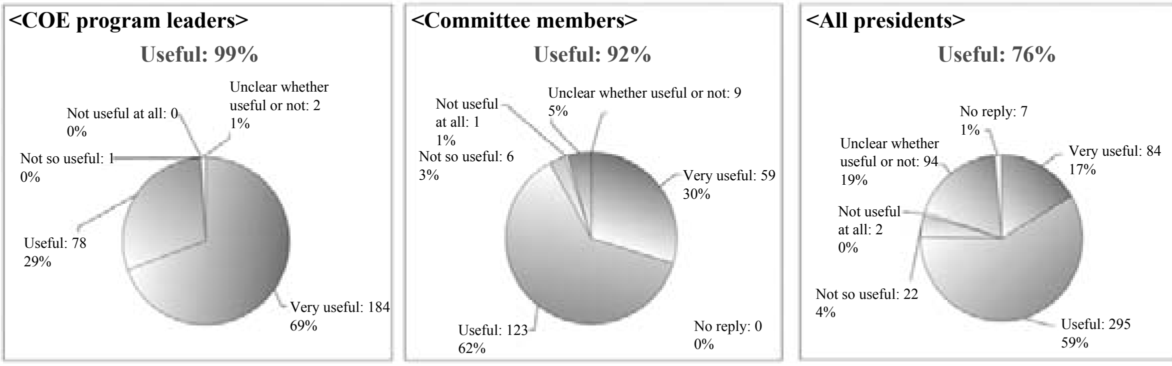
In order to enable Japanese universities to compete with world-leading universities in education and research activities on an equal footing, it is important to further cultivate a competitive environment in Japan by introducing the principle of competition based on third-party evaluation so as to revitalize competition among all domestic universities including both public and private ones. In this context, Japan has been implementing the 21st Century COE program (grants for the establishment of research centers) since fiscal 2002 under the sponsorship of MEXT, based on the "A Policy for the Structural Reform of Universities" (June 2001), which seeks to promote efforts to cultivate the uniqueness and international competitiveness of Japanese universities. The 21st Century COE program aims to establish world-top-class research and educational centers at Japanese universities so as to raise the standard of research and develop creative human resources capable of making world-leading achievements by providing targeted support in this regard.

In December 2005, MEXT sent questionnaires to the presidents of all universities to which graduate schools are attached (There are 558 such universities.) regarding the 21st Century COE program. At the same time, MEXT implemented evaluations and verifications of projects adopted under the program based on a survey conducted at the 21st Century COE program committee on research center leaders and committee members in charge of screening and evaluation. We will explain the achievements of these projects below based on the evaluation and verification.

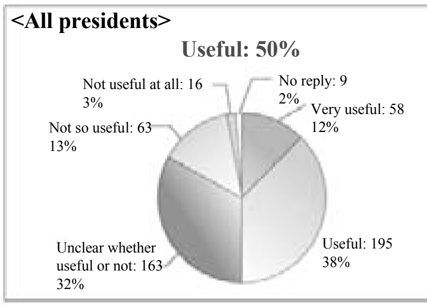
○ More than 90% of COE program leaders and screening and evaluation committee members replied that the 21st Century COE program contributes to the revitalization of the education and research environment in Japan as a whole. The presidents of more than three quarters of all universities, including those that do not have projects adopted under the COE program, have replied that the program contributes to the revitalization of the education and research environment in Japan as a whole (Figure 1-1-36).

○ Many respondents said the 21st Century COE program has contributed to human resource development by playing a significant role in enhancing financial support, promoting internationalization, improving the education and research environment and raising the standard of research. Specifically, each COE program has made efforts to promote research activities by students themselves, enhance students' research motivation through experiences gained abroad, promote student

○Contribution to revitalization of education and research environment



○Contribution of internal debate on COE application to organizational revitalization



	Very useful	Useful
Presidents of universities having COEs	48 (53%)	41 (45%)
Presidents of universities not having COEs	10 (2%)	154 (37%)
All presidents	58 (12%)	195 (38%)

Figure 1-1-36 Achievements of the 21st Century COE Program: Contribution to revitalization of education and research environment

Source: MEXT

○Specific effects/results in terms of human resource development

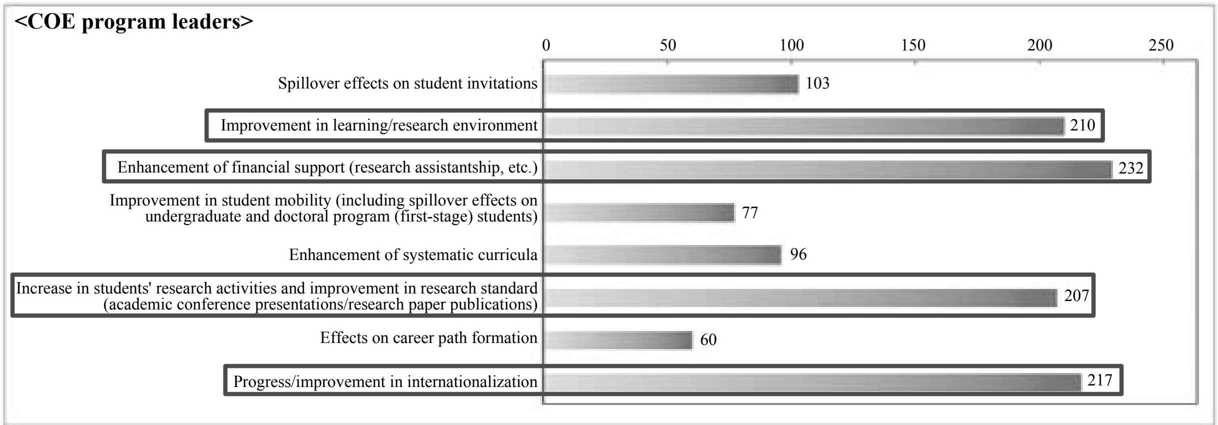


Figure 1-1-37 Achievements of the 21st Century COE program: Effects/results in terms of human resource development (COE program leaders)

Source: MEXT

intercourse across the boundaries of the fields of majors and laboratories, provision of joint guidance to students on multidisciplinary fields based on teacher collaboration, and to cultivate internationality through the introduction of tasks such as writing papers and making presentations in English (Figure 1-1-37).

○ With regard to the enhancement of financial support, the number of students adopted as research assistants increased by 2.6 times at the selected COEs compared with when the application was made. In addition, the number of post-doctorals employed increased by 2.2 times. In particular, the number of foreigners employed increased by 2.6 times and the number of people employed from other research organizations increased by 3.2 times, facts that indicates that the 21st Century COE program is helping to improve the level of internationalization and the mobility of researchers. (Figure 1-1-38).

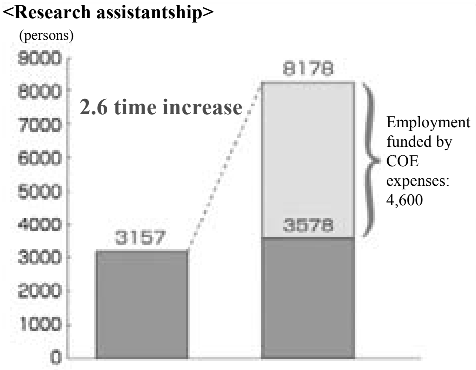
○ With regard to improvement in the standard of research conducted by graduate school students and the level of internationalization, the number of research papers contributed to academic journals by doctorate course students at the selected COEs increased by 1.3 times from 12,000 to 16,000. About three quarters of those papers were contributed to refereed journals of global standards, indicating that high levels of research are conducted in doctorate programs. The number of presentations made at academic conferences increased by 1.3 times, with the number of those made at conferences held abroad rising as much as 1.5 times (Figure 1-1-39).

○ With regard the status of graduate school students after completing their courses, the number of graduate school students employed by R&D divisions of companies increased by 1.3 times compared with before the COE program, indicating that the program helped the development of human resources capable of contributing to industry (Figure 1-1-40).

○ With regard to the implementation status of joint research activities, the number of joint research programs with Japanese and foreign universities, research organizations and companies increased 1.5 times, indicating that industry-university partnership and internationalization have proceeded in research activities (Figure 1-1-41).

○Employment status of doctoral program students and post-doctorals

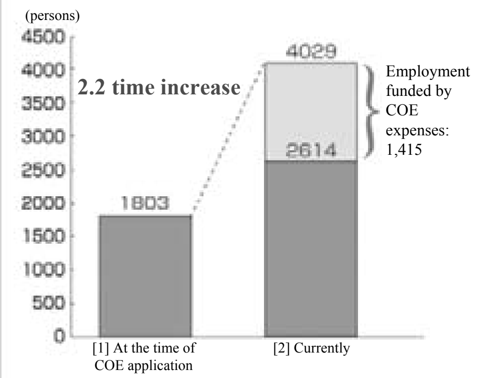
<Research assistantship>



<Number of foreign students> *Figures in parentheses indicate the number of students whose employment was funded by COE expenses.

[1] At the time of COE application	[2] Currently	Grow rate
515	1,299 (617)	2.5-time increase

<Post-doctorals>



<Number of foreign students> *Figures in parentheses indicate the number of students whose employment was funded by COE expenses.

[1] At the time of COE application	[2] Currently	Grow rate
312	813 (348)	2.6-time increase

<Number of people employed from other research organizations > *Figures in parentheses indicate the number of students whose employment was funded by COE expenses.

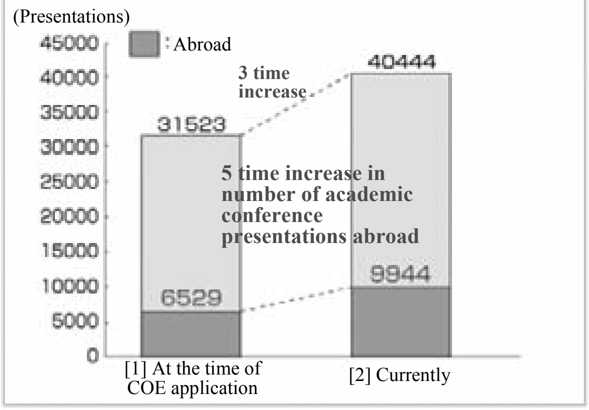
[1] At the time of COE application	[2] Currently	Grow rate
605	1,908 (763)	3.2-time increase

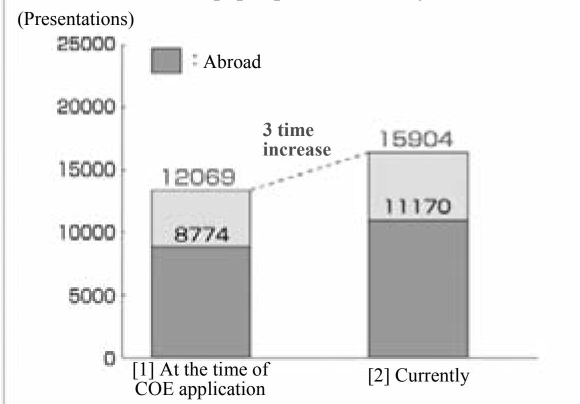
At the time of COE application: Status in the year preceding COE adoption
Currently: Status in FY 2004

Figure 1-1-38 Achievements of the 21st Century Program: Employment status of doctoral program students and post-doctorals

Source: MEXT

○Number of academic conference presentations and research paper publications in journals made by doctoral program students





Adopted fields			Life sciences	Chemistry, materials sciences	Information sciences, electrical and electronic engineering	Humanities	Interdisciplinary, combined fields, new disciplines	Medical sciences	Mathematics, physics, earth sciences	Mechanical, civil, architectural and other fields of engineering	Social sciences	Interdisciplinary, combined fields, new disciplines	New scientific fields	Total
Number of academic conference presentations		[1] At the time of COE application	3660	4601	5718	763	1877	4100	3188	2463	306	1893	2954	31523
		[2] Currently	4357	6166	7364	1682	2482	4522	4203	3203	531	2273	3661	40444
		Growth rate ([2] / [1])	119%	134%	129%	220%	132%	110%	132%	130%	174%	120%	124%	128%
	Abroad	[1] At the time of COE application	583	905	1708	101	372	734	662	510	27	356	571	6529
		[2] Currently	860	1460	2420	309	611	867	1078	762	92	528	957	9944
		Growth rate ([2] / [1])	148%	161%	142%	306%	164%	118%	163%	149%	341%	148%	168%	152%
Number of research paper publications in academic journals		[1] At the time of COE application	1253	2217	1672	551	899	1286	1119	800	313	664	1295	12069
		[2] Currently	1529	2121	2857	1161	1228	1547	1402	1023	553	950	1533	15904
		Growth rate ([2] / [1])	122%	96%	171%	211%	137%	120%	125%	128%	177%	143%	118%	132%
	Number of research paper publications in refereed academic journals	[1] At the time of COE application	1028	1956	1108	249	613	1008	800	514	130	509	859	8774
		[2] Currently	1273	1649	1808	543	927	1244	1031	676	268	734	1017	11170
		Growth rate ([2] / [1])	124%	84%	163%	218%	151%	123%	129%	132%	206%	144%	118%	127%

*Research papers written by students as representative or first authors

At the time of COE application: Status in the year preceding COE adoption
Currently: Status in 2005

A foreign researcher giving a science English lesson
"Functional innovation of molecular informatics" Kyushu University

Figure 1-1-39 Achievements of the 21st Century COE Program: Number of academic conference presentations and research paper publications in journals made by doctoral program students

Source: MEXT

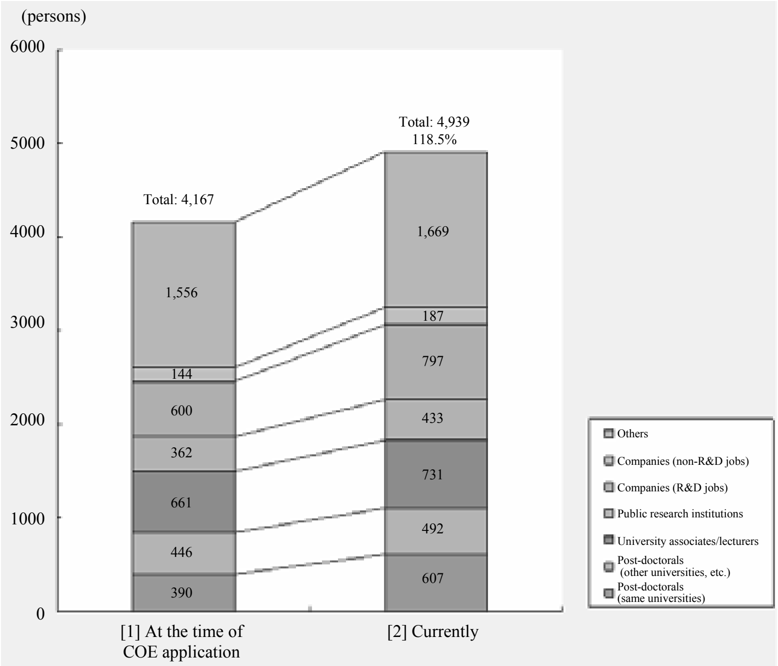
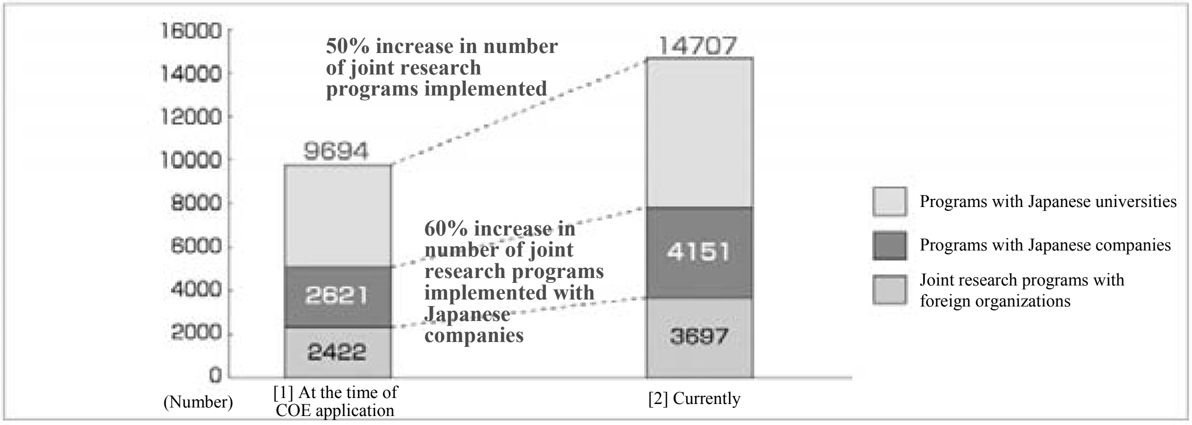


Figure 1-1-40 Achievements of the 21st Century COE program: Employment status of graduate school students, etc.

Note: The above numbers represent students 1) who completed the doctoral program and 2) who have terminated their student status but have been a graduate student for a period exceeding the required number of years for completing a doctoral course and have obtained the required credits. "%" indicates growth rate.

Source: MEXT

○Implementation status of joint research



Year of adoption		2002					2003					2004	Total
Adopted fields		Life sciences	Chemistry, materials sciences	Information sciences, electrical and electronic engineering	Humanities	Interdisciplinary, combined fields, new disciplines	Medical sciences	Mathematics, physics, earth sciences	Mechanical, civil, architectural and other fields of engineering	Social sciences	Interdisciplinary, combined fields, new disciplines	New scientific fields	
Joint research programs with Japanese organizations (number)	[1] At the time of COE application	896	998	722	121	565	1366	683	570	253	331	764	7269
	[2] Currently	1465	1723	1187	257	834	1932	863	863	380	509	974	10987
	Growth rate ([2] / [1])	164%	173%	164%	212%	148%	141%	126%	151%	150%	154%	128%	151%
Programs with Japanese companies	[1] At the time of COE application	214	453	510	20	176	406	88	295	66	138	255	2621
	[2] Currently	367	836	804	36	270	600	127	498	96	198	319	4151
	Growth rate ([2] / [1])	172%	185%	158%	180%	153%	148%	144%	169%	146%	144%	125%	158%
Programs with foreign organizations (number)	[1] At the time of COE application	350	249	92	42	153	537	476	108	67	123	225	2422
	[2] Currently	531	462	189	125	248	688	652	180	138	208	276	3697
	Growth rate ([2] / [1])	152%	186%	205%	298%	162%	128%	137%	167%	206%	169%	123%	153%
Total (number)	[1] At the time of COE application	1249	1247	814	163	718	1903	1159	678	320	454	989	9694
	[2] Currently	1996	2185	1376	382	1105	2620	1515	1043	518	717	1250	14707
	Growth rate ([2] / [1])	160%	175%	169%	234%	154%	138%	131%	154%	162%	158%	126%	152%

At the time of COE application: Status in the year preceding COE adoption
Currently: Status in FY2006

Figure 1-1-41 Achievements of the 21st Century COE program: Implementation status of joint research

Source: MEXT