Section 2 Toward the Construction of New Relationship of Society with S&T

1 Cultivating S&T Literacy

(1) The Importance of S&T Literacy

As mentioned in the previous section, S&T has permeated in all aspects of our daily lives in modern society, and whether we like it or not, we have to accept both the positive effects such as convenience and benefits of S&T as well as the negative effects. In particular, the uncertainty of scientific assessments and the risks of S&T, are things of concern for not only specialists like researchers and technicians, but more so for the Japanese public who are non-experts.

In such a society, there are times when in our social and working lives, all Japanese people have no choice but to make scientific assessments. (Table 1-2-4). To effectively cope with S&T related issues in various aspects of our social and daily lives, universal S&T literacy[1] is necessary as a basic grounding for all generations, males and females, science and non-science students.

Furthermore, the improvement of S&T literacy is indispensable to the progress of S&T communication mentioned in the next section.

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1 "Scientific Literacy" in the OECD PISA looks at the knowledge and skills of fifteen-year-olds who have completed the compulsory education and how much they are using these in the various real-life situations under the following respective abilities.

1) Scientific literacy is the capacity to use scientific knowledge, to identify questions and to draw evidence-based conclusions in order to understand and help make decisions about the natural world and the changes made to it through human activity.
2) Understanding the various characteristics of science as part of human knowledge and pursuit of knowledge
3) Recognize how science and technology is shaping our material, intellectual and cultural environment
4) Proactively involve oneself in problems related to science and think scientifically as a thoughtful citizen

In addition, in "Creating Science Literacy Activities – Developing a program for all generations" (National Museum of Nature and Science, Mar 2010) defines "scientific literacy" as having adequate knowledge, a scientific perspective and attitude toward nature and science and technology, and a comprehensive set of talents and abilities to evaluate and act logically and appropriately in response to changes in the natural world and human society.

"Scientific Literacy" used in this chapter is based on these concepts.

Table 1-2-4/Examples of Situations where S&T Literacy is Required in Society

(In general social life)
- Using high-tech telecommunications devices such as the mobile phones, Internet, etc. (with an understanding of the attendant ethical problems)
- During a pandemic of emerging infectious diseases such as novel influenza, etc. or when suffering from diseases which require advanced medical help
- Determining the safety of processed foods, etc., analyzing the risks of various new financial products.
- Calm response toward emergency information and appropriate evacuating procedures during emergencies.

(In occupations apart from S&T related occupations)[1]
- Judicial related personnel: For example, to assess whether the scientific evidence in a criminal case is admissible or not, basic knowledge and judgment about the most advanced science, which is often ambiguous, is necessary.
- Business people: As a part of business judgment, it is vital to evaluate and assess one's company's technology.
- Bankers and financial related personnel: For example, it is vital to assess a start-up's R&D ability when deciding whether to approve a loan to it or not, it is necessary to have knowledge of mathematics and science when developing financial products.
- Firefighters, etc: It is necessary to have knowledge of how to save lives and remove dangerous items during an emergency.
- Cooks: It is necessary to have knowledge about chemical reactions and the latest cooking utensils.

Source: Created by MEXT

To produce a concrete image of S&T literacy expected, the Sub-committee of Promoting Science Capability of the Science and Society Committee, Science Council of Japan initiated a survey research using the Special Coordination Funds for Promoting S&T, and implemented the "Scientific Literacy for all Japanese[2] " outlining the S&T grounding expected of all adults in Japan in 2030. This project recognizes that S&T is not only for researchers and technicians, but should be considered with all its advantages and shortcomings in relationship with society, the economy and politics, and aims to clearly define the S&T knowledge required of each individual in a society in order to assess and act in unity to create a sustainable democratic society. About 150 researchers, educationists, media personnel, and industrialists from various circles and occupations who are worried about the worsening situation concerning S&T in Japan participated in the same project, and in March 2008, they produced a report[3] defining the type of knowledge, skills and opinions on science, mathematics and technology that all adults should have in the seven new knowledge fields of "Mathematical Sciences", "Life Science", "Materials Science", "Informatics," "Universe, Earth and Environment Science," "Human and Social Sciences" and "Technology" to replace the existing frameworks of academic fields and subjects. The report opined that in order to analyze and solve

1 The International Standard Classification of Occupations (ISCO88) classifies science and technology related occupations according to the four categories below.
(A) Physical, Mathematical and Engineering Science Professionals (2100 Group)
(B) Physical, Mathematical and Engineering Science Associate Professionals (2200 Group)
(C) Life Science and Health Professionals (2200 Group)
(D) Life Science and Health Associate Professionals (3200 Group)

2 Representative: Professor Kazuo Kitahara, College of Liberal Arts, International Christian University, (then-professor of the current Tokyo University of Science) (Project website: http://www.science-for-all.jp/). Preceding models for this project include "Science for All Americans" published by AAAS' "Project 2061" in 1989. This report was published as part of the science education reforms, and recommended the scientific literacy all Americans should have amidst the backdrop of a science education crisis in the 1980s.

3 The Japan Science Foundation has been conducting survey research since Oct 2010 which aims to rewrite difficult contents in reports in different fields into simple and easy-to-understand contents, thus making science more accessible to the public through schools and social education.

real-life problems, it is not enough to stay within the existing scientific framework of physics, chemistry, biology, and earth sciences, but also necessary to include fields like mathematics (mathematical sciences), Informatics, Technology, and also to a wider aspect, Human and Social Sciences too, when thinking about how S&T affects society and human beings.

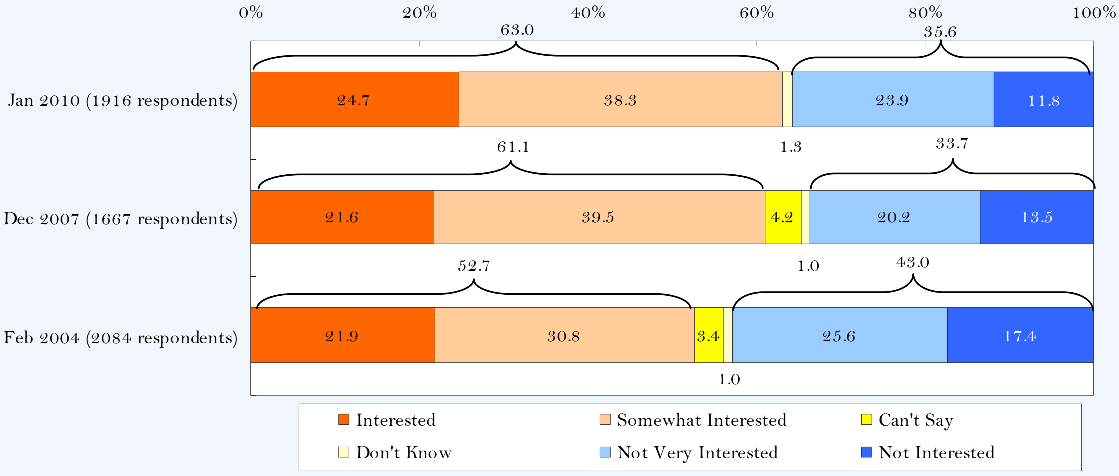
(2) Current Situation of S&T Literacy in Japan

So, what is the current situation of S&T literacy in Japan? We shall analyze the opinion poll results of adults and children respectively, on their interests in and concerns about, and their recognition and understanding of S&T.

First, in the "Public Opinion Poll on Science and Technology and Society" conducted by the Cabinet Office, Government of Japan, the percentage of positive responses to the question, "Are you interested in news or topics about S&T?" rose from 52.7% in 2004 to 63% in 2010. However, while the percentage of "Interested" responses rose from 21.9% in 2004 to 24.7% in 2010, it was still less than a quarter of the total responses. (Figure 1-2-5).

Figure 1-2-5/General (Adult) Interest of Society toward S&T

Question: Are you interested in news or topics about S&T?



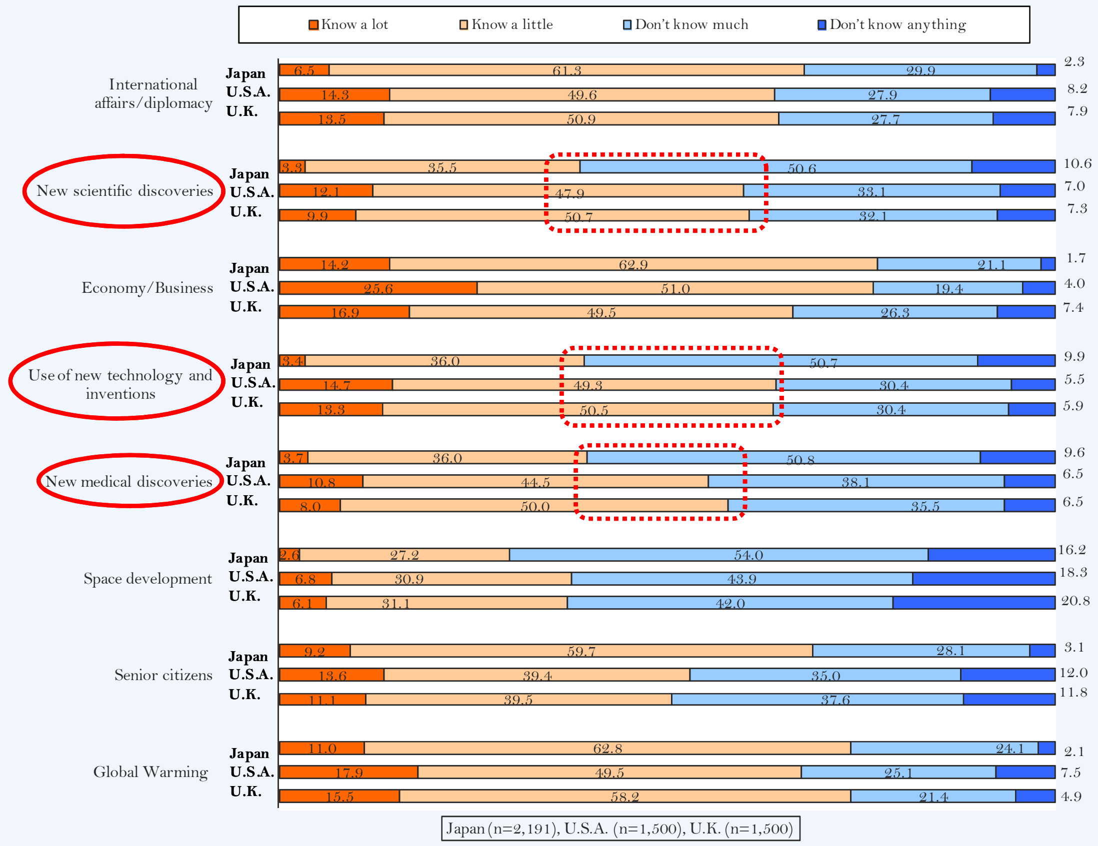
Notes: In the Jan 2010 Survey, "Can't Say" was not available.
Source: Cabinet Office, Government of Japan "Public Opinion Poll on Science and Technology and Society" (January 2010 Survey)

When comparing the adult's recognition of S&T among three countries (Japan, USA and U.K.), it was found that Japan had a very low score in scientific issues such as new scientific discoveries in comparison to USA and U.K. (Figure 1-2-6). Furthermore, the average percentage of correct responses with regard to 10 questions on basic S&T concepts was very much lower for Japanese males when compared to British males, with the same results for females compared to their American and British counterparts. In addition, although Japan had higher percentages of correct answers for some items, with regard to "Sizes of Electrons and Atoms," "The Synchronicity of Humans and Dinosaurs," "Virus Replication Suppression Ability of Antibacterial Medicine," "Relationship Between Laser and Sound Waves," the correct response ratios were considerably lower than the USA and U.K.'s results (Figure 1-2-7).

Therefore, it can be said that Japanese adults' recognition and understanding of S&T is low compared to their American and British counterparts.

Figure 1-2-6/Recognition of Social and Scientific Issues

Question: How much do you know about the recent trends with respect to each of these issues?

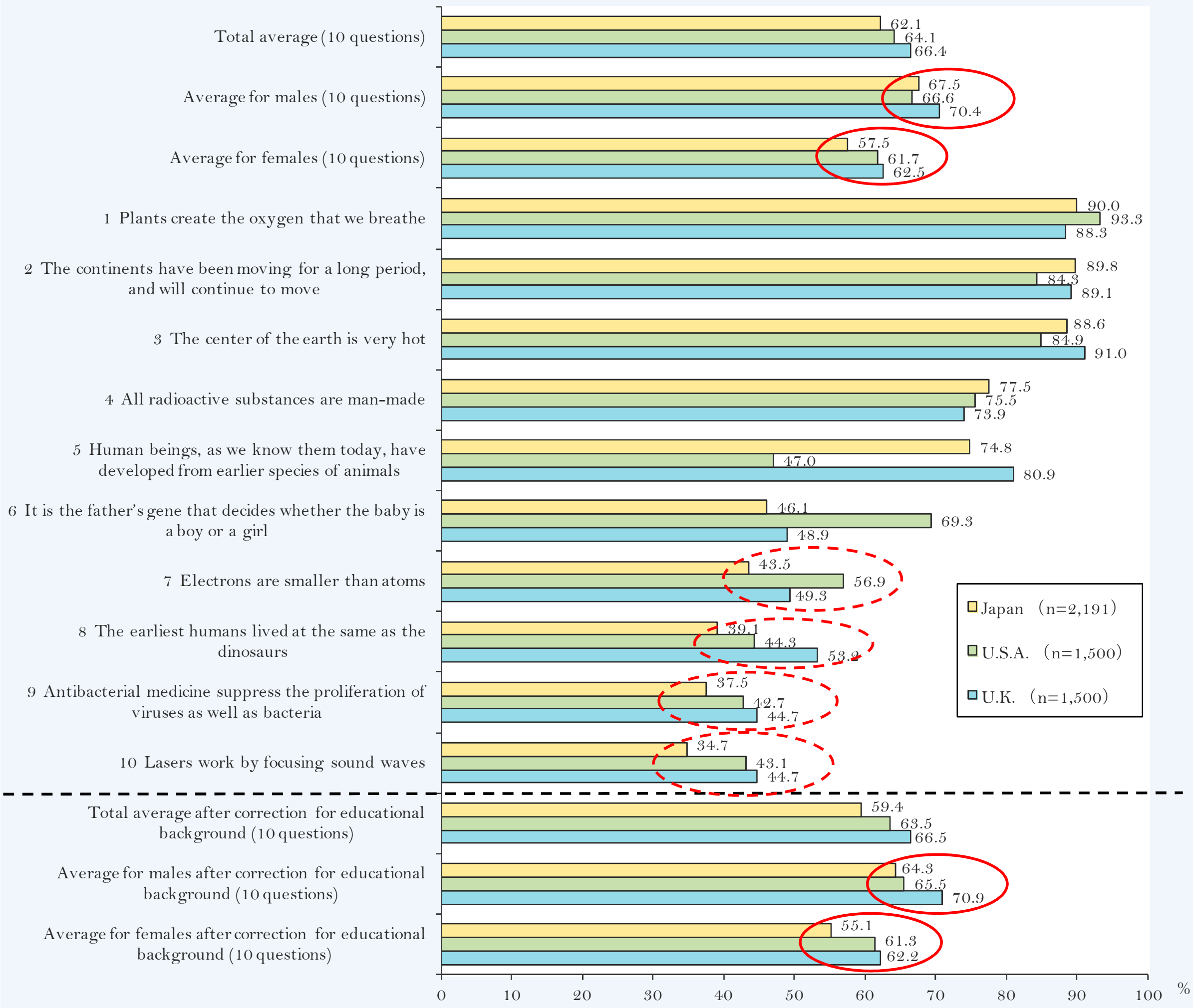


Notes: 1. This survey was conducted on participants in Japan, USA and U.K. who have registered with an Internet research company and was carried out from end Feb to early Mar 2009 through the Internet.
2. The participants were randomly chosen from registered members in their 20s to 60s to approximate the population distribution of the respective countries according to male/female ratios and age group categories captured in the respective National Census. Other characteristics such as occupation and education level were based on the characteristics of the participants registered with the research company.

Source: National Institute of Science and Technology Policy "International Comparison of the Public Attitudes towards and Understanding of Science and Technology -Comparative Study of Internet Survey in Japan, the United States of America, and the United Kingdom" (March 2011)

Figure 1-2-7/Understanding of Basic S&T Concepts (ratios of correct responses in 2009 comparison survey)

Question: Please answer “True” or “False” for the following items. If you do not know or are not sure, answer “Don’t Know.”



Notes: 1. Same as Notes 1 & 2 for Figure 1-2-6.

2. The correct answers (hereinafter indicated as “T” for correct and “F” for wrong) for the respective items are 1-T, 2-T, 3-T, 4-F, 5-T, 6-T, 7-T, 8-F, 9-F, 10-F.

The percentage of correct responses is derived from dividing the number of correct responses by the total number of respondents (including people who had answered “Don’t Know”).

3. In all three countries, the percentage of respondents who were university graduates or postgraduates was higher than the respective national census (this was especially true for Japan). Therefore, values “after correction for educational background” are also shown for each country. These values were obtained by adjusting the percentage of educational background to agree with the results of the statistical survey of each country (for the total correct responses rate and the correct rates by gender).

Source: National Institute of Science and Technology Policy “International Comparison of the Public Attitudes towards and Understanding of Science and Technology -Comparative Study of Internet Survey in Japan, the United States of America, and the United Kingdom – Comparative Survey Using the Internet” (March 2011)

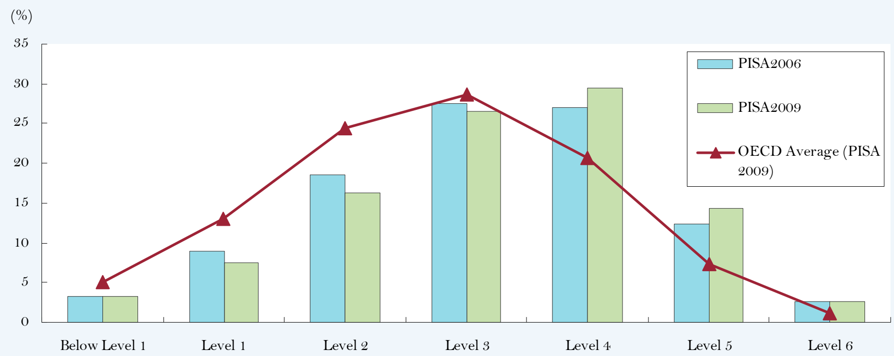
Next, we consider the children’s basic grounding of S&T based on the results of the “Organization for Economic Co-operation and Development (OECD)’s PISA[1] and TIMSS[2].”

1 Program for International Student Assessment

2 Trends in International Mathematics and Science Study

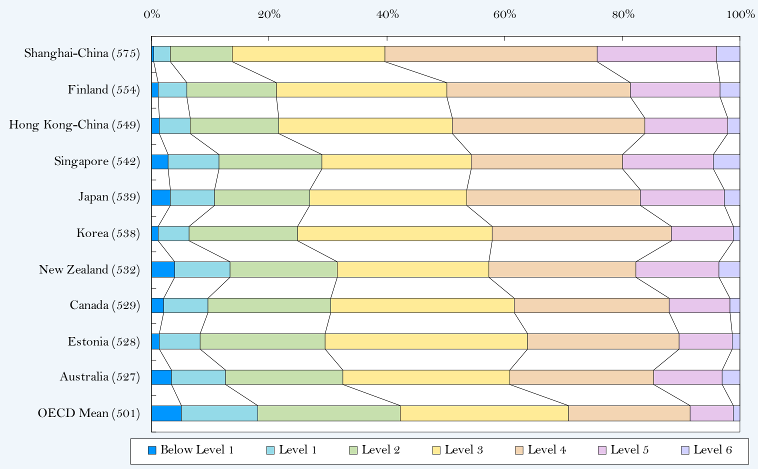
In PISA 2009, the mean scientific literacy score of Japan's first graders in senior high school (fifteen years old) was 539, and was statistically not significantly different from the mean score of 531 in PISA 2006. Based on student distribution according to proficiency levels, there were lower student distributions for Levels 1 and 2 and higher student distributions for Levels 4 and 5 in PISA 2009 compared to PISA 2006 (Figure 1-2-8). The mean score for scientific literacy was within the top group internationally, but there was a rather high ratio of students with low proficiency, as indicated in the higher distribution of Level 1 proficiency compared to other top countries such as Korea (Figure 1-2-9). As for Mathematical literacy[1], the mean score of 534 in PISA 2003 dropped to 523 in PISA 2006. In PISA 2009, it was 529, statistically not significantly different from PISA 2006. This showed that issues remain on how to utilize knowledge and skills in actual situations.

Figure 1-2-8/Japan's Scientific Literacy According to Proficiency Levels



Notes: PISA divides students into 7 levels of proficiencies based on their scientific literacy scores.
Source: Created by MEXT based on "OECD'S PISA 2009 Results."

Figure 1-2-9/Distribution of Proficiencies in Scientific Literacy (PISA 2009)



Source: National Institute for Educational Policy Research "OECD Programme for International Student Assessment (PISA) – Analysis of OECD PISA 2009"

1 PISA defines "Mathematical Literacy" as an individual's capacity to identify and understand the role that mathematics plays in the world, to make well-founded judgments and to use and engage with mathematics in ways that meet the needs of that individual's life as a constructive, concerned and reflective citizens.

Turning to the interest and concern for S&T of Japanese children, in the aforementioned PISA 2006, it was found that the percentage of children who had interest in and cared about S&T and found it fun was extremely low compared to other countries. The average OECD percentage for positive responses to “Joys of Studying Science” was 57%, but only a low of 45% in Japan. However, when the National Institute for Educational Policy Research asked third year junior high school students the same question from PISA 2006 (which targeted 15-year-old first year senior high school students), the percentage of positive responses was 58%, closer to the OECD average (Figure 1-2-10).

Furthermore, in PISA 2006, the percentage of students who did not feel the meaning of the importance of studying science was very high compared to other countries, and even the percentage of positive responses to the question “I am studying science because I understand that it is useful to me” was only 42%, 25 points lower than the OECD average of 67%. Similar results were observed in TIMSS 2007, where the mean score of “I strongly agree” and “I agree” responses to the statement, “Studying science is useful to my daily life” was only 53% compared to the international mean score of 84% for second year junior high school students.

Figure 1-2-10/Do You Enjoy Studying Science? (From the results of PISA 2006 and junior high school third graders in Japan)

Countries	Percentage of students who answered "I think so", "I absolutely think so" in the following items (%) Question 12 Joys of Studying Science (1) Usually fun to learn about scientific topics (2) Enjoy reading books on science (3) Fun to solve science problems (4) Fun to get knowledge on science (5) Interested in learning about scientific topics					
	Mean	(1)	(2)	(3)	(4)	(5)
Mexico	83	94	82	60	92	85
Turkey	73	79	75	53	78	78
Portugal	73	73	66	52	87	84
Hungary	65	75	61	46	71	72
Italy	65	61	59	57	73	73
Canada	64	73	54	49	73	72
Finland	64	68	60	51	74	68
France	63	73	48	43	75	77
Greece	60	62	59	40	71	69
New Zealand	59	62	43	55	71	65
Belgium	58	61	45	53	64	68
Norway	58	64	48	47	69	62
Japan (3rd year high school students from national sample)	58	69	43	44	71	62
OECD Mean	57	63	50	43	67	63
USA	57	62	47	41	67	65
Slovakia	56	70	51	34	71	57
U.K.	56	55	38	53	69	67
Iceland	56	60	53	45	66	56
Australia	56	58	43	49	67	61
Czech Republic	55	59	47	36	70	62
Luxemburg	54	67	48	42	59	55
Switzerland	54	67	45	42	60	55
Denmark	53	63	48	37	55	63
Ireland	53	48	45	39	68	64
Spain	53	59	45	27	63	69
Sweden	53	62	49	34	61	57
Germany	51	63	42	38	52	60
Korea	49	56	45	27	70	47
Austria	47	58	42	39	51	44
Poland	46	44	47	37	60	44
Japan	45	51	36	29	58	50
Netherlands	44	46	41	33	56	46

Notes: Only OECD countries were selected from the participating countries and regions in PISA 2006.

Source: Created by MEXT based on the National Institute for Educational Policy Research’s “Survey Results of 3rd year Junior High School Students based on Survey Questions in PISA”

As shown above, the current S&T literacy level poses some issues: for adults, in addition to a low interest and concern for S&T, there is also less recognition and understanding of S&T compared to the USA and the U.K., and the percentage of children who are interested and care about science is low.

In the future, as fewer babies are born and the population continues to dwindle, every Japanese needs to acquire the ability and sense to logically evaluate issues regarding S&T and decide the course of action for themselves in order to create a sustainable society into the future. They also need to continue to nurture talented children who will lead future generations. From this point of view, it is necessary to have a S&T literacy cultivation plan for children to adults.

(3) Enriching Science Education

Science education in schools involves learning activities like organizing results of experiments and observations, thinking and explaining things with scientific concepts, and discovering new things. Through such activities, children can develop their thinking ability and nurture not only their expression ability but also the required S&T literacy. It has a very important meaning and therefore it is vital to enrich it.

With this view, the Revised Course of Study indicated clearly the importance of "Utilizing Scientific Knowledge and Concepts" and the relationship of science education to society and daily lives based on results from surveys such as PISA, and expanded teaching contents accordingly. In particular, from the viewpoint of the relationship between S&T and society, parts of the curriculum guidelines for "Science Technology and Humanity" for third year junior high school science, in which students deepen their understanding of energy resource utilization and the relationship between the development of S&T and human lives, and nurture their ability to think and evaluate scientifically the preservation of our natural environment and utilizing S&T, have been changed from optional to mandatory (Table 1-2-11). Lesson hours for science in elementary and junior high schools have also been increased from 350 hours to 405 hours (16% increase) for elementary schools (four years from third grade to sixth grade) and from 290 hours to 385 hours (33% increase) for junior high schools (three years), in order to adequately secure the time necessary for observation, experiments and reports, and natural living experience.

Table 1-2-11/Examples of Expansion of Teaching Contents in the Revised National Curriculum Standards

Elementary Science
- 3rd year: Objects and weight, observation of familiar environment
- 4th year: Structure and movement of the human body
- 5th year: Weather change
- 6th year: Regulatory of a lever, use of electricity, structure and functions of the human body, the moon and the sun

Junior High Science
- 1st year: Force and stretch of the spring, difference between mass and weight
- 2nd year: Electric energy, heat value, the periodic table, transformations and evolution of living things, characteristics of Japanese weather
- 3rd year: Ions, law of heredity, DNA, global warming, alien species, Science Technology and Humanity

Source: Created by MEXT

In addition to the contents of education, there is an issue to maintain and develop an educational environment that can respond to these changes. It was shown that approximately 50% of elementary school teachers felt it hard to teach science, while not a few junior high school teachers felt it hard to teach certain topics in a survey conducted on elementary and junior high school teachers. (Table 1-2-12). Furthermore, it raised issues concerning observations and experiments, such as inadequate time to prepare, clear and teach, and inadequate equipment and expendables. (Figure 1-2-13). All these issues point to the importance of raising teachers' ability and improving the actual environment for science education.

Table 1-2-12/Feelings of Elementary and Junior High School Teachers toward Science

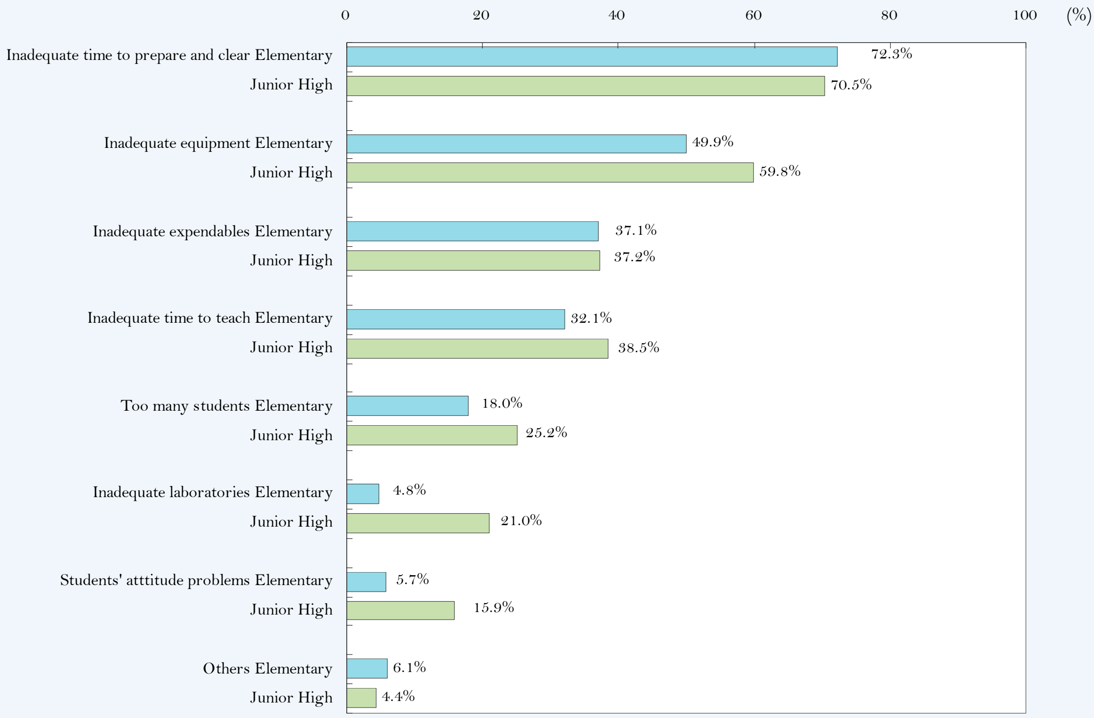
-Elementary School Teachers:
- -It is hard or somewhat hard to teach all the science contents 50%

-Junior High School Teachers:

-It is hard or somewhat hard to teach Physics	31%
-It is hard or somewhat hard to teach Chemistry	13%
-It is hard or somewhat hard to teach Biology	28%
-It is hard or somewhat hard to teach Earth Sciences	44%

Source: Created by MEXT based on the "2008 Fact-Finding Report on Elementary School Science Education and Junior High School Science Teachers" commissioned by the Japan Science and Technology Agency and the National Institute for Educational Policy Research

Figure 1-2-13/Obstacles Faced in Conducting Science Observations and Experiments in Elementary and Junior High Schools



Source: Created by MEXT based on the "2008 Fact-Finding Report on Elementary School Science Education and Junior High School Science Teachers" commissioned by the Japan Science and Technology Agency and the National Institute for Educational Policy Research

In order to respond to these issues and with a view to raise the ability of teachers, the Japan Science and Technology Agency started the project "Establishing Training Centers for Core Science Teachers" from 2009 to nurture key teaching staff in science and mathematics education in their respective regions. Teachers trained under this project have started to play leading roles in science education in their regions. (Figure 1-2-14).