Situation and problems of decrease of Japanese students in Science and Technology fields

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The results of Japanese students in PISA 2003 showed their high level of achievements in the domains of mathematical literacy, scientific literacy, and problem solving. PISA tells us the situation of how well young people are prepared to meet the challenges of today's knowledge societies. It does not tell, however, the situation of preparation of young people who are coming to Science and Technology (S&T) fields to study and work and then engage in researches, developments or productions in S&T.

In many countries within OECD including Japan, there is a concern of declining interest among young people in studying S&T and then decreasing the number of young people who go on to S&T fields. Situations of and activities to this problem in various countries have been researched and discussed in GSF committee on 'Declining interest in science studies among young people'.

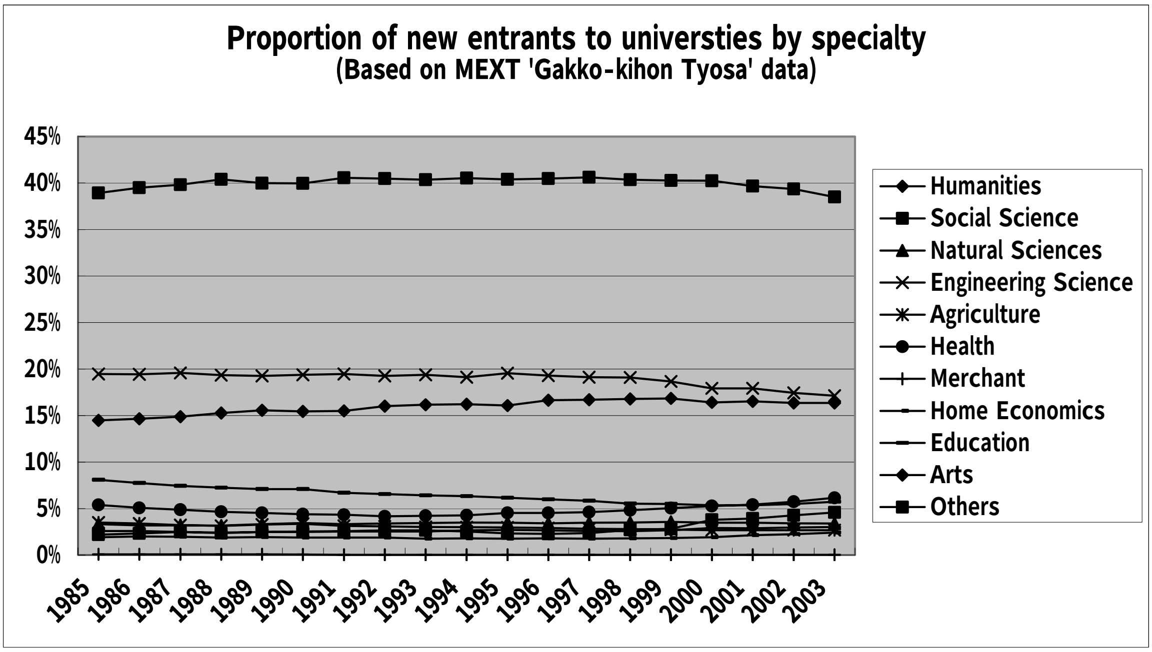
This presentation introduces some features of situation and effective results of activities in Japan.

1. Decrease of Japanese students in Science and Technology

Decrease of the number of young people in S&T fields will lead the lack of human resources in researches, developments or productions in S&T fields. It is predicted in Japan that the number of students who study in S&T fields will be rapidly decreased.

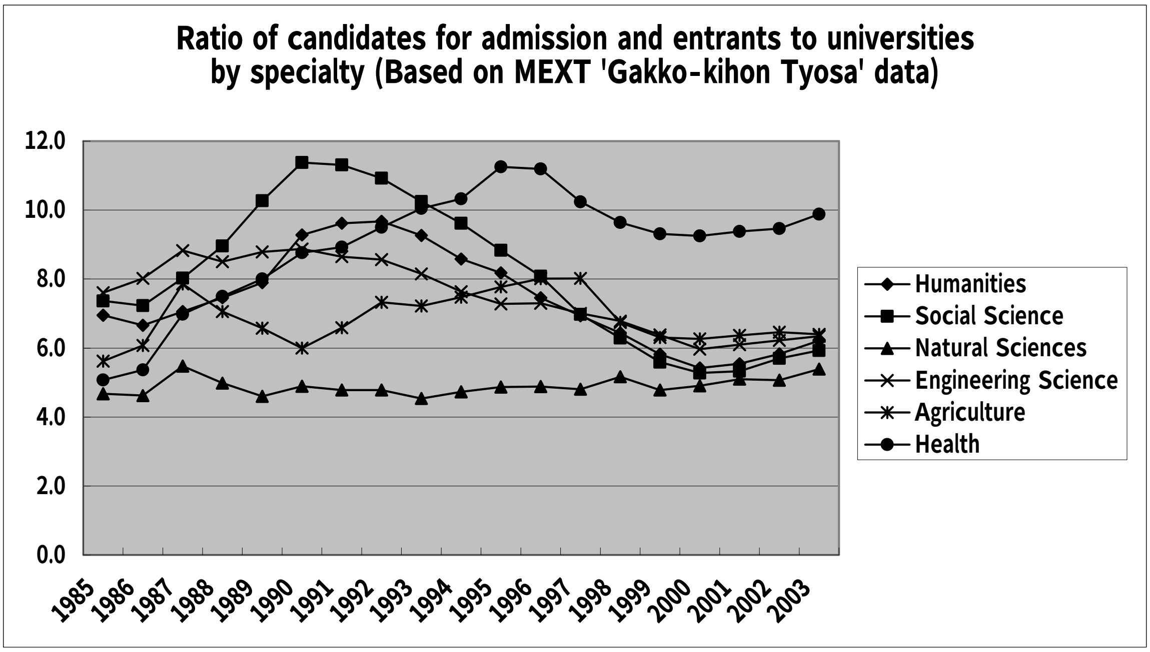
1.1 Change in the number of new entrants to universities

In 1998 and after, the proportion of new entrants in Engineering Science and Natural Science to all new entrants in universities has been gradually decreased to the level of 20.5% in 2003, while it had been about stable during 1985-1998 at the range of 22-23%. Alternatively, the field of medical sciences and new interdisciplinary fields have been growing their proportions of students in universities after 1998. Engineering Science has reduced their number of new entrants by 8.3% from 1998 to 2003.



1.2 Change in the number of candidates to universities

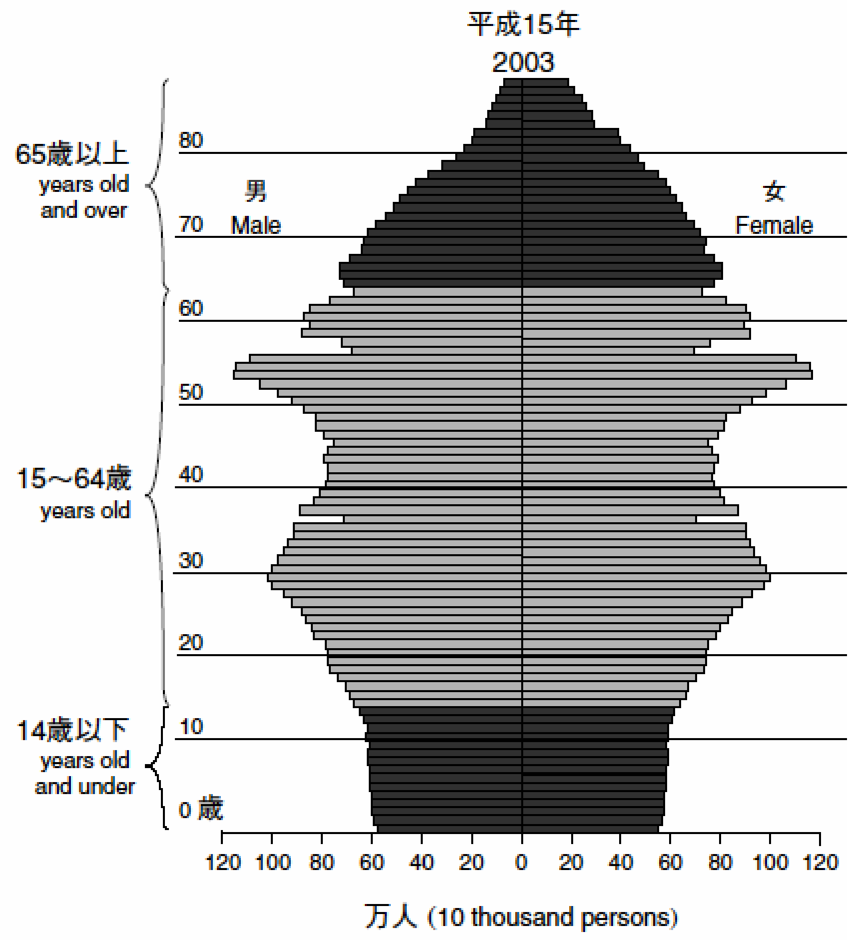
Admission ratio of the number of candidates to the number of new entrants in universities can be compared by academic fields. During the 10 years of 1990's, the admission ratio in Engineering Science had been decreasing and then about stable after 2000. During this period, the ratio in Natural Science has been about stable at the lowest level among fields. Across all fields, the ratio had depressed between 1998 and 1999. For a long time period, the ratio in Engineering Science has been decreasing. The field of Engineering Science was used to be the most popular one in the late 1980's, but it has now become a less popular field as well as Natural Science.



1.3 Decrease of younger population

Average number of new births from one woman is now 1.29 that is the lowest record in Japan, while the average life length of Japanese is the longest of the world. The total population will start to decrease from 2007. It is predicted that the size of producing age population (15 to 64 year olds) will be 14% in 2020 and 20% in 2030 less than that in 2000. Assumed the same proportion (approx. 88%) of high school graduates to the whole population of the same age, number of high school graduates will be decreased 20% in 2010 and 23% in 2020 from the in 2000. Hence, number of university students in S&T fields will also be decreased if the proportion to all university students will not change. Namely, it will be difficult for industry to recruit human resources in S&T fields. At the same time, schools may suffer from lacking science and mathematics teachers.

'Population Pyramid' in 2003



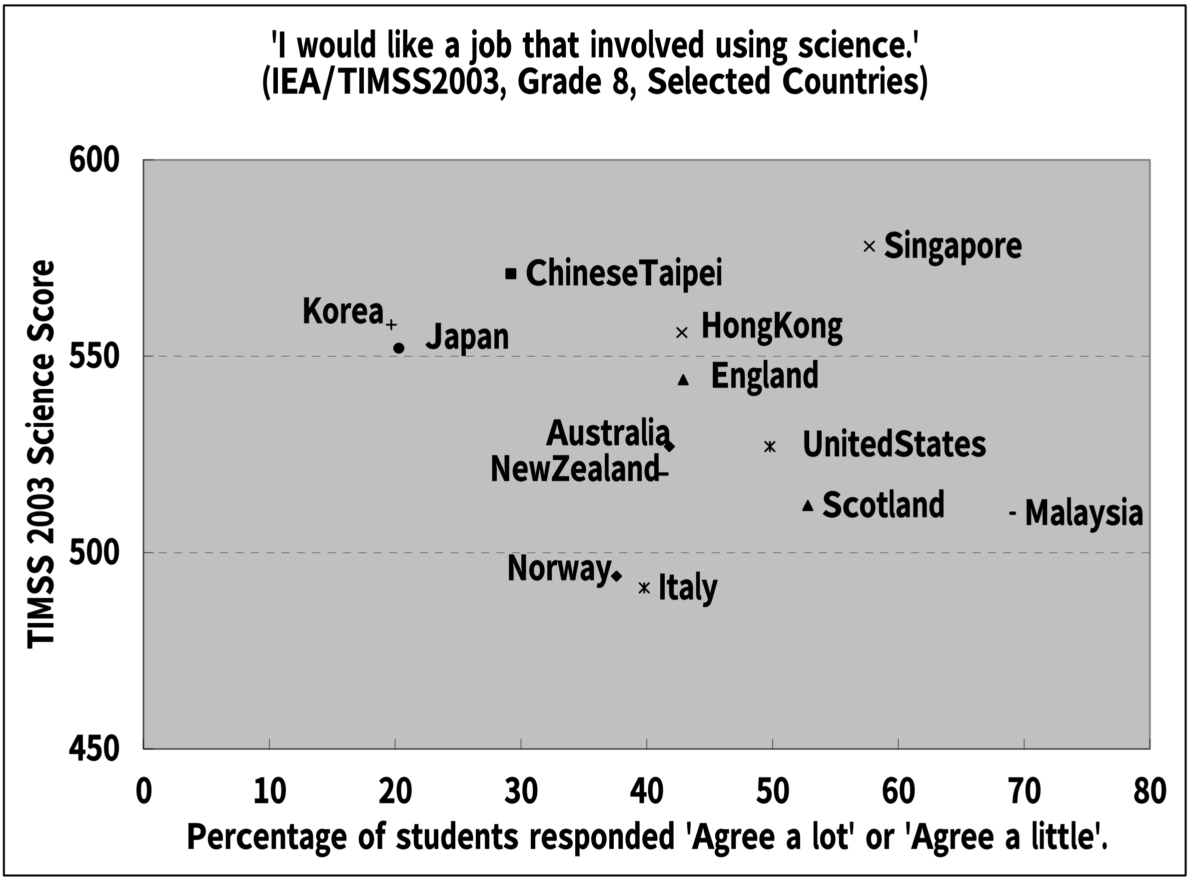
(Japan Statistical Yearbook 2005)

2. Interest in S&T fields

Making it higher the proportion of students who want S&T studies and jobs in the same cohort can solve the problem of lacking human resource in S&T fields. In terms of this aspect, there is a large room to elevate the level of interest in S&T fields in Japan.

2.1 Interest in S&T jobs

In the result of IEA/TIMSS 2003 questionnaire, about 20% of Japanese 8th graders affirmatively answered to 'I would like a job that involved using science', while the proportions were 40-50% in Australia, England, USA, and so on. Much higher proportion of students in many countries is interested in getting a S&T related job than that in Japan.

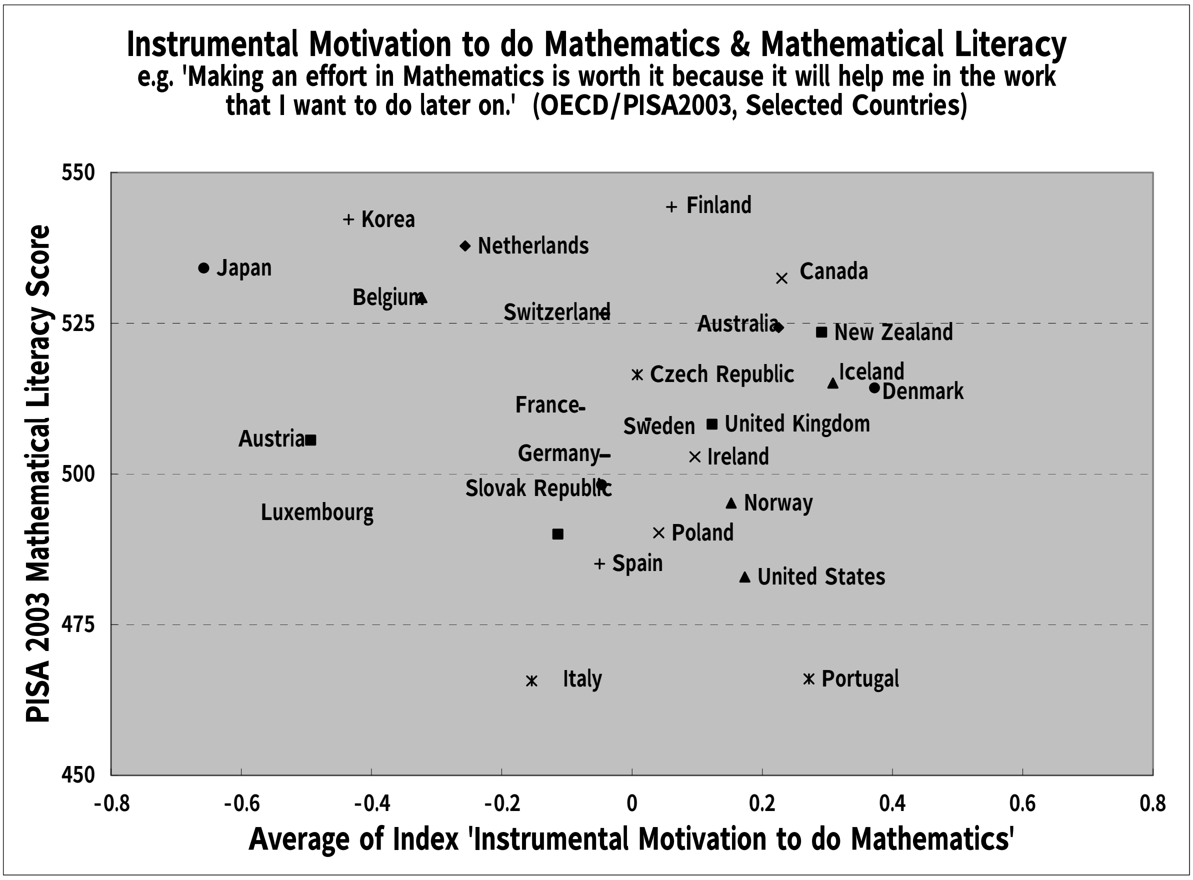


2.2 Motivation – comparison among OECD countries

In the OECD/PISA 2003 questionnaire, various indices were measured as background variables to explain the level of mathematical literacy. (PISA in 2006 will explore the background factors of scientific literacy.)

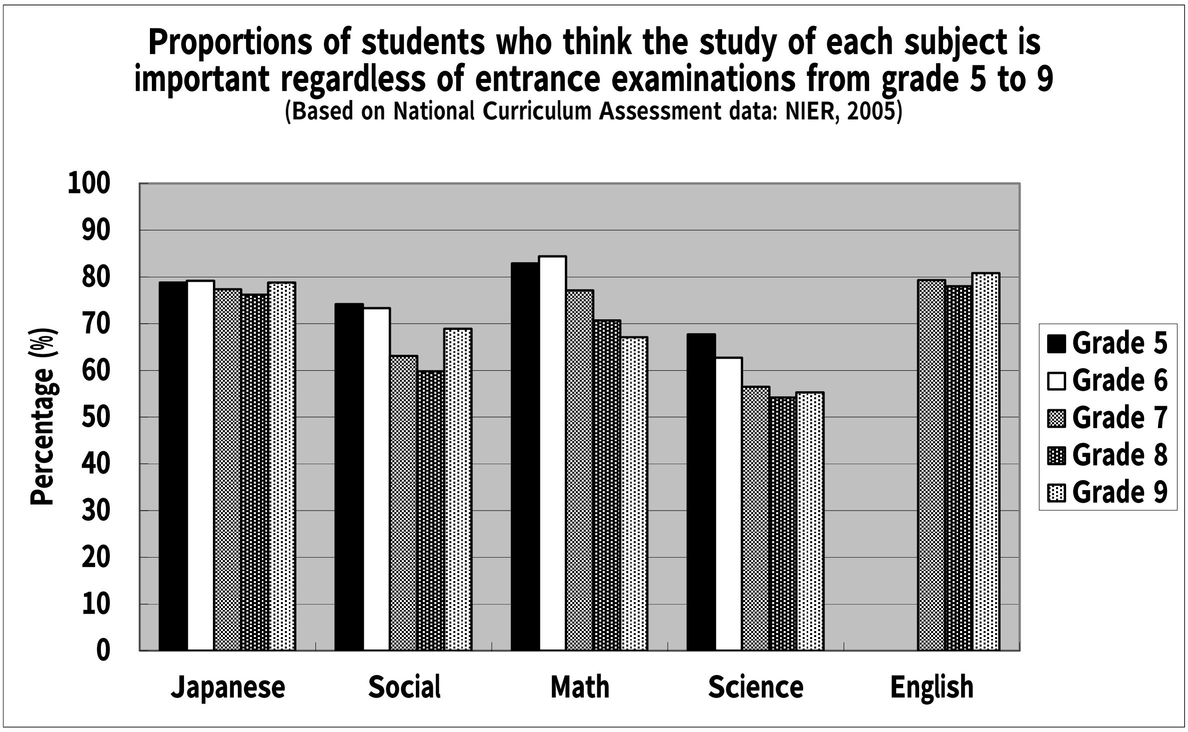
Instrumental Motivation to do Mathematics is an index composed of responses in four questions such as an example of 'Making an effort in mathematics is worth it because it will help me in the work that I want to do later on' and an important predictor for course selection, career choice and performance.

The result of Japanese 15 year olds was at the top level in mathematical literacy, but at the bottom level in the Instrumental Motivation to do Mathematics as shown in the graph below. Japanese students are hardly aware of the value of studying mathematics on their future.



2.3 Motivation – comparison with other subjects

In the questionnaire result of 2004 National curriculum achievement survey (NIER, 2005) for 5th grade through 9th grade students, the proportion of students who answered affirmatively to the question 'the <subject> is important regardless of entrance examinations' (<subject> is replaced by each name of five subjects) was the lowest in Science among five subjects as shown in the graph below. Science is thought as relatively the most unimportant subject by Japanese students.



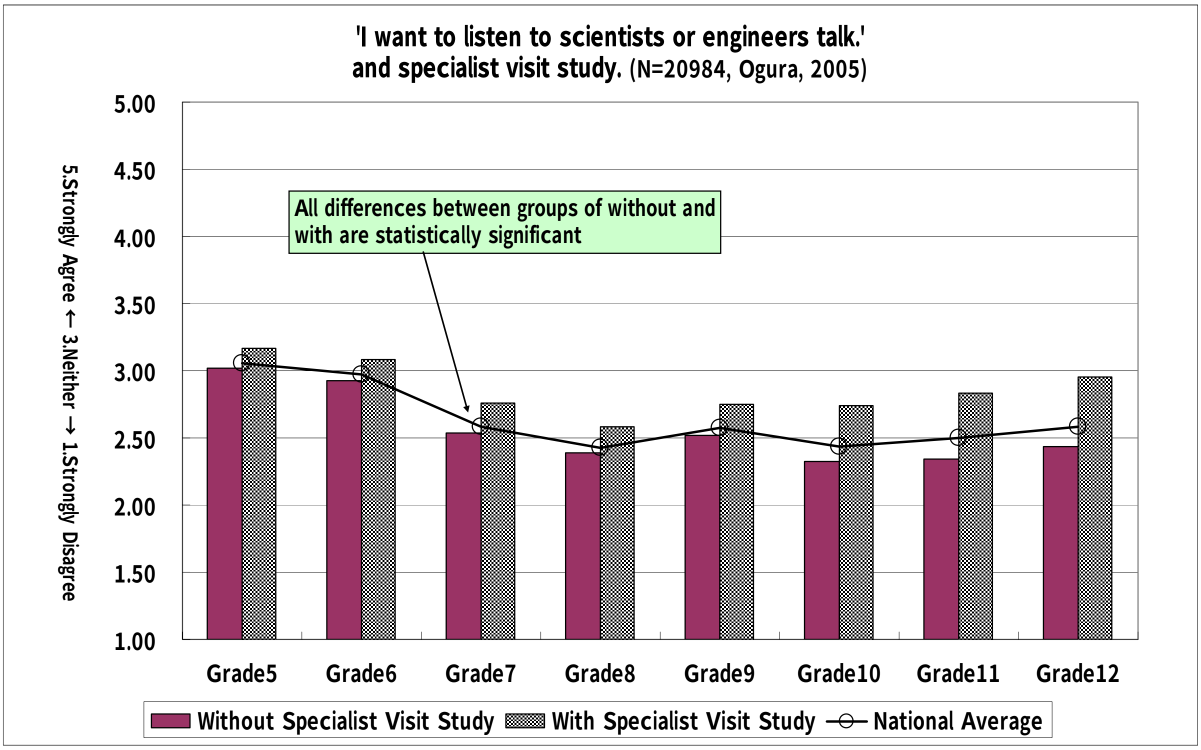
3 Findings of effective activities

Increasing the number of students in S&T fields is urgent need in Japan. There have been various activities at elementary and secondary education. In 2002, MEXT has started national initiative called as 'Kagaku-Gijyutsu Rika Daisuki Plan' (Science Literacy Enhancement Initiatives, in english) in which various activities for promoting S&T education has been organized and supported.

At this moment, some effective activities have been found in results of research.

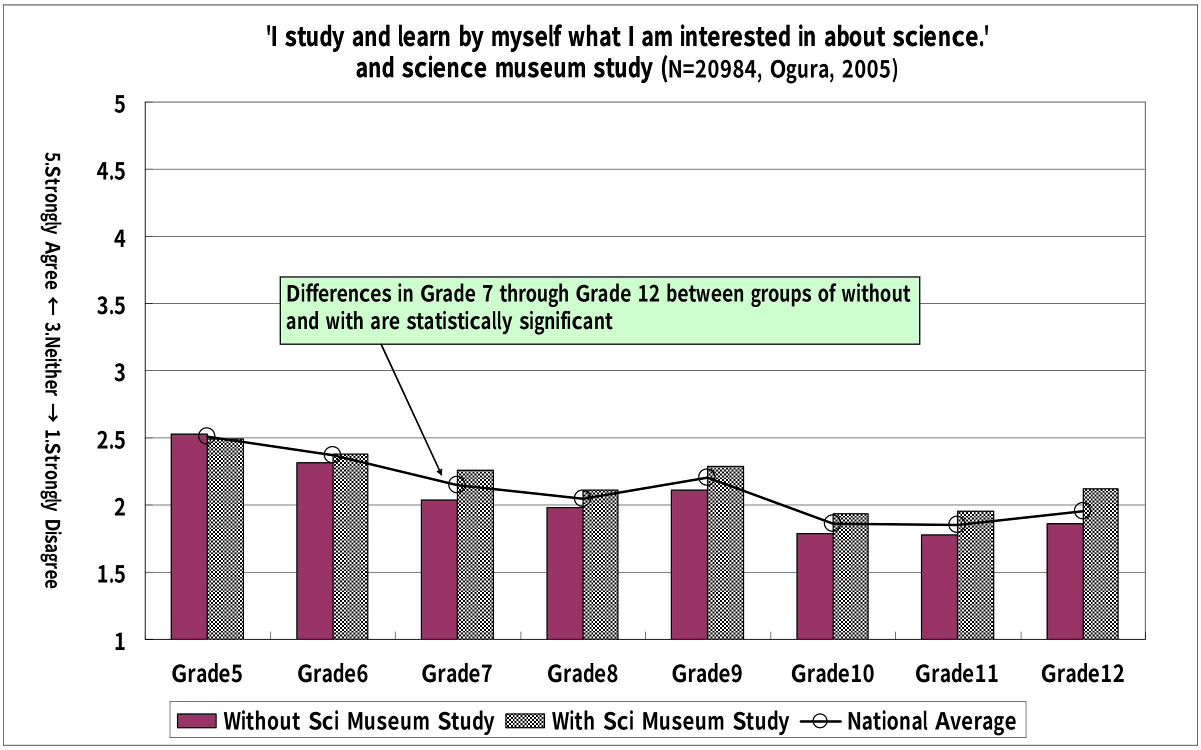
3.1 Science learning from science experts

Inviting science experts (scientists, engineers) to science lessons is not an easy activity for schools because of the limitations of human and financial resources. However, students who have experienced this type of activity are significantly more motivated to learn science than students who have not. The graph below is an example of this effect. This type of learning is one of activities most emphasized in the 'Kagaku-Gijyutsu Rika Daisuki Plan'



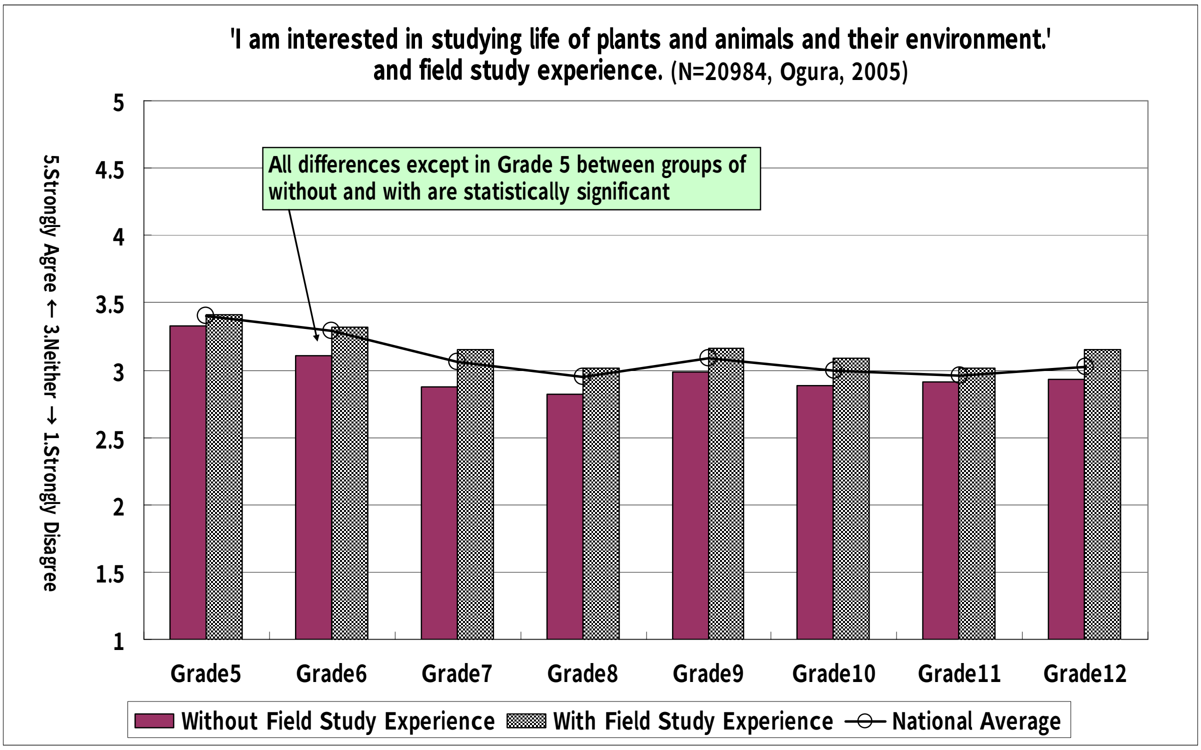
3.2 Science learning by visiting science museums and research institutes

Visiting science and technology museums or research institutes to have science lessons for students is not an easy activity for schools because of the difficulty of making enough time and the limitation of financial resources. However, students who have experienced this type of activity are significantly more motivated to learn science than students who have not. The graph below is an example of this effect. This type of learning is also one of activities emphasized in the 'Kagaku-Gijyutsu Rika Daisuki Plan'



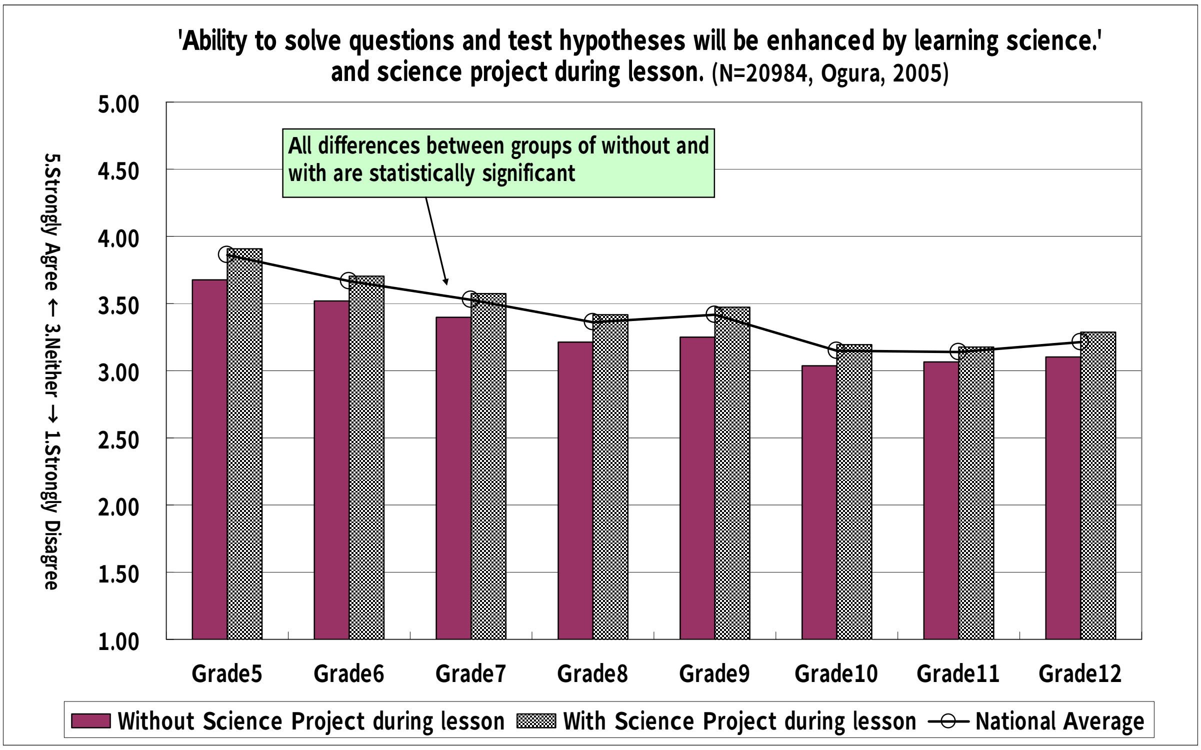
3.3 Science learning by going out (field study)

Going out into the field to study science in nature with living things is not an easy activity for schools because of the difficulty of making enough time, limitation of financial resources, and safety issues. However, students who have experienced this type of activity are significantly more motivated to learn science than students who have not. The graph below is an example of this effect.



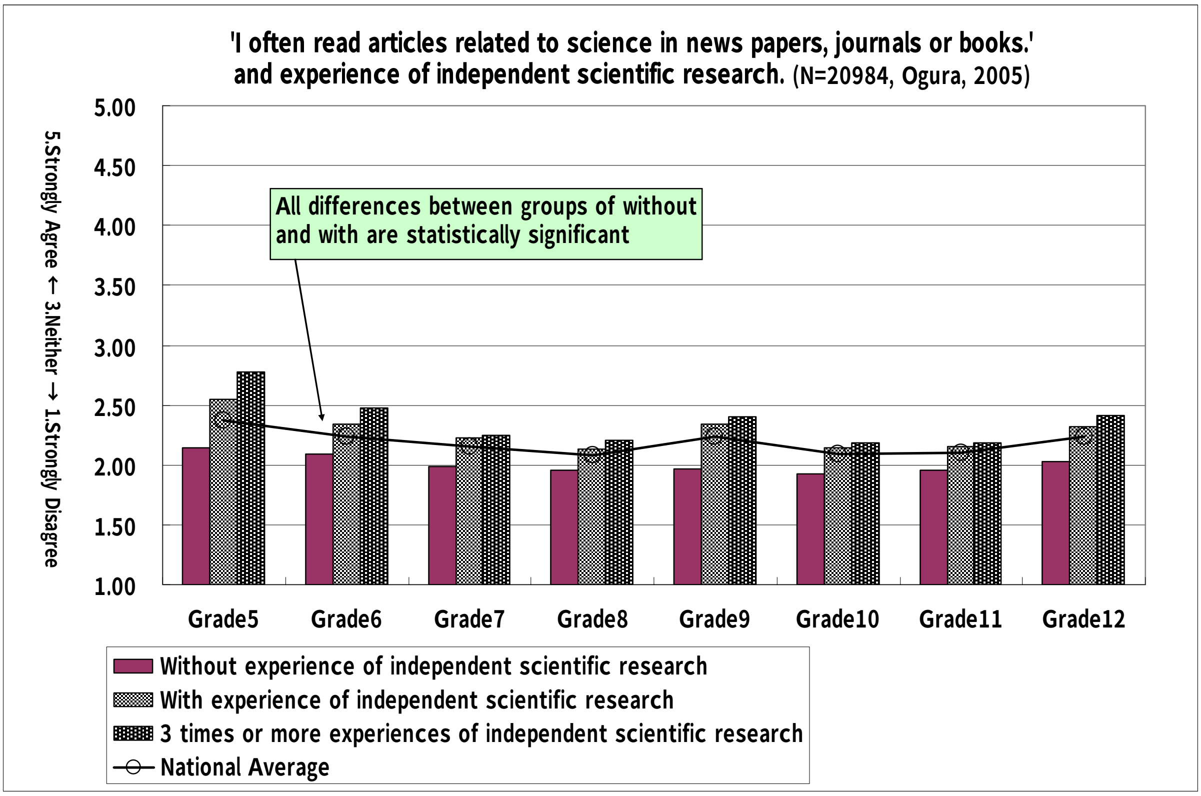
3.4 Science learning by doing a project

Having students do projects in which they design investigations on specific questions and make research reports or presentations during science lessons is not an easy activity for schools because of the difficulty of making enough time and individualized teaching. However, students who have experienced this type of activity are significantly more motivated to learn science than students who have not. The graph below is an example of this effect. This type of learning is one of activities emphasized in the 'Kagaku-Gijyutsu Rika Daisuki Plan', especially in the 'Super-Science High schools'.



3.5 Independent scientific research

Despite out-of-curriculum, Japanese youngsters practice well the independent scientific research during summer holidays. About 70% of all students have experienced it at least once by grade 9, and the average times of experience is about 2.5 in all students. Students who have experienced this type of activity are significantly more motivated to learn science, even more in students who have experienced 3 times or more, than students who have not, as shown in an example of the graph below.



3.6 Effect of activities in 'Rika-daisuki schools'

As a national measure under the 'Kagaku-Gijyutsu Rika Daisuki Plan', 105 elementary and 62 lower-secondary schools in 19 areas had been designated as 'Rika-daisuki schools' for two years since 2003. In designated schools, science and mathematics programs with focusing on observations and experiments, enrichment of elective subjects and advanced learning had been practiced. Designated schools were not special ones, and participated students were not selected and essentially the same group of students in normal schools at the start of the program. Hence the difference of outcome between these groups at the end of the two years' program suggests the effect of activities.

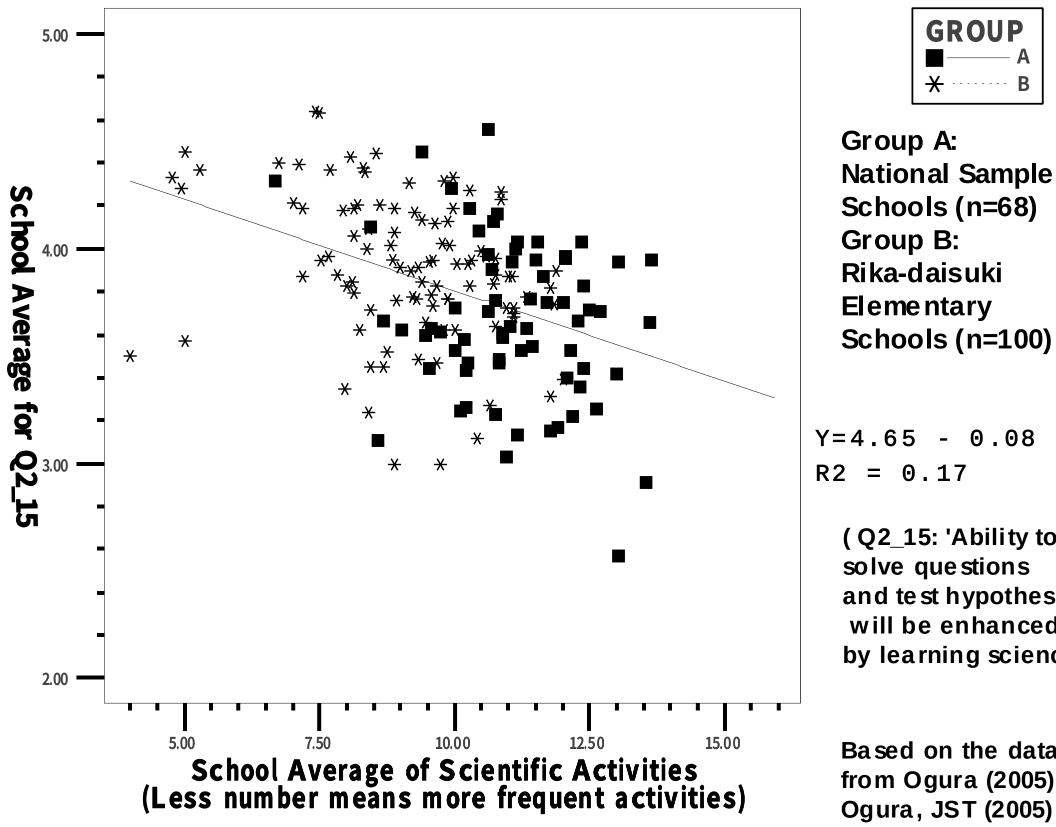
Elementary school level

School averages of students' affirmative awareness in science learning were compared between 'Rika-daisuki schools' whose students had participated in their two years' program and normal schools randomly sampled.

Next graph shows one of results of 6th graders at elementary school level , in which horizontal axis represents the infrequent level of 'advanced science educational activities' that is derived from the four types of activities, i.e., science learning from science experts, science learning by visiting science museums and research institutes, science learning by going out, and science learning by doing a project, and vertical axis shows school average of students' affirmative responses to the question : 'Ability of solve questions and test hypotheses will be enhanced by learning science'.

As the regression line suggests, the more advanced science educational activities are frequent (left side on the horizontal axis), the more responses of students of the school are affirmative. Though there are variances among schools within 'Rika-daisuki schools' and within normal schools in the level of advanced science educational activities and the level of school average of students' responses, 'Rika-daisuki schools' in general practiced more frequently of advanced science educational activities than normal schools, and their students showed more affirmative awareness in science learning.

Relationship between intensity of scientific school activities and awareness of science at 6th grade level



Group A: National Sample Schools (n=68)
Group B: Rika-daisuki Elementary Schools (n=100)

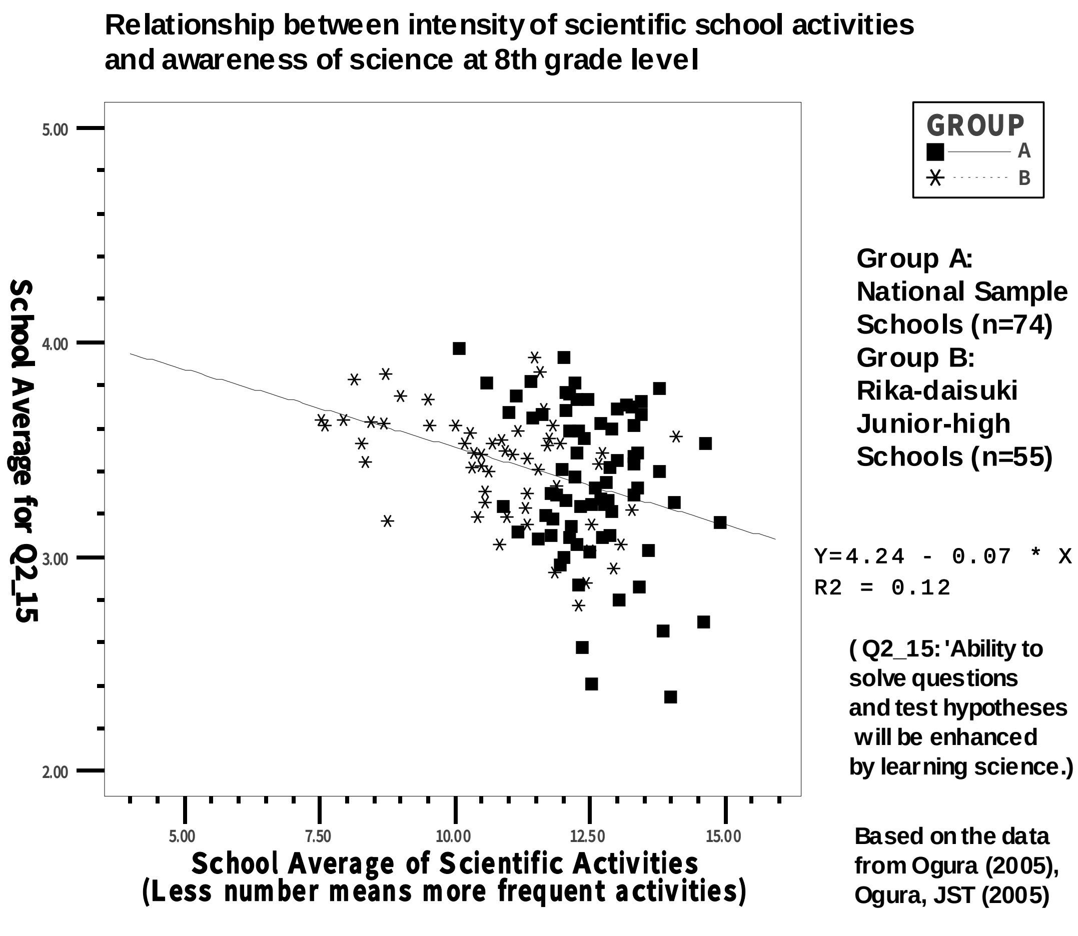
Y=4.65 - 0.08 * X
R2 = 0.17

(Q2_15: 'Ability to solve questions and test hypotheses will be enhanced by learning science.)

Based on the data from Ogura (2005), Ogura, JST (2005)

Lower-secondary school level

Next graph shows the result of the same analysis for 8th graders at lower-secondary school level. As in the elementary school level, the more advanced science educational activities are frequent, the more responses of students of the school are affirmative. 'Rika-daisuki schools' in general practiced more frequently of advanced science educational activities than normal schools, and their students showed more affirmative awareness in science learning. However, compared to the case in elementary schools, advanced science educational activities are less practiced, and the level of students' affirmative awareness in science learning is lower as a whole.



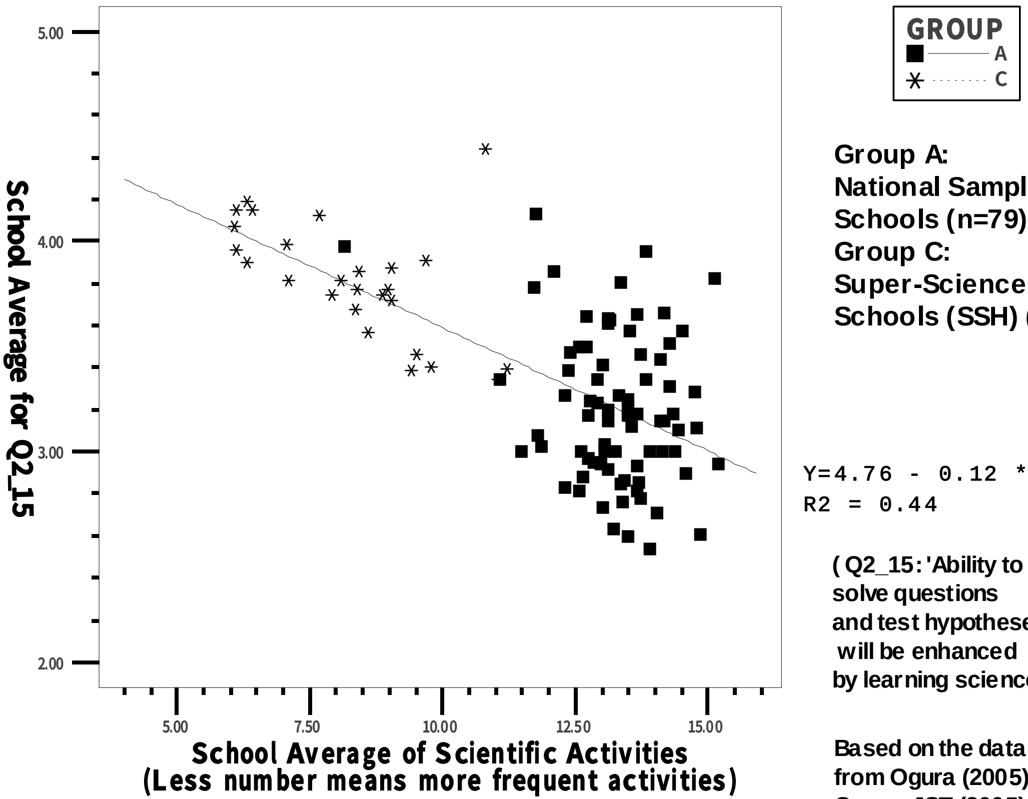
3.7 Effect of activity 'Super Science High schools'

As a major national measure under the 'Kagaku-Gijyutsu Rika Daisuki Plan', 26 upper-secondary schools around the nation had been designated as 'Super Science High-schools (SSH)' for three years since 2002. In designated schools, special programs focusing on science, mathematics and technology, with emphasis on cooperative measures with universities and research institutes had been practiced. Designated schools were relatively high achievement schools, and participated students were selected by entrance examinations and have had higher level of interest in and motivation to science learning than the students in normal schools had from the start of the program.

School averages of students' affirmative awareness in science learning were compared between 'SSH' whose students had participated in their three years' program and normal schools of academic course randomly sampled (main stream of university candidates, about half of all high-school students belong to this course). Next graph shows the result for 12^{th} graders. The axes represent the same meaning as in the previous graphs.

As the regression line suggests, the more advanced science educational activities are frequent, the more responses of students of the school are affirmative. Though there are variances among schools within 'SSH' in the level of advanced science educational activities and the level of school average of students' responses, 'SSH' in general practiced more frequently of advanced science educational activities than normal schools, and their students showed more affirmative awareness in science learning. However, this difference does not directly mean the effect of activities in SSH, because their students had higher motivation to science learning at the start of activities. Rather, this difference suggests the successful result of appropriate advanced science educational activities practiced for highly motivated students.

Relationship between intensity of scientific school activities and awareness of science at 12th grade level



Group A: National Sample Schools (n=79)
Group C: Super-Science High Schools (SSH) (n=26)

Y=4.76 - 0.12 * X
R2 = 0.44

(Q2_15: 'Ability to solve questions and test hypotheses will be enhanced by learning science.)

Based on the data from Ogura (2005), Ogura, JST (2005)

4. Suggestions

In order to improve the level of interest in S&T among Japanese at elementary and secondary school level and to increase students coming to S&T fields to study at universities and engage actively in S&T fields in future, following measures can be suggested:

Providing for more students and in more frequently

a. opportunities to learn science from science experts
b. opportunities to visit science museums and research institutes to learn science
c. opportunities to go for field and study science in nature with living things
d. opportunities to do science projects in science lessons
e. supports to develop their own scientific researches

As the level of interest in S&T fields improves,

f. expanding the proportion of admission of new entrants in Engineering Science and Natural Science

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