Paper presented at the PISA research conference in Kiel, Germany, September 14-16 2009.

Comparison of Attitudes toward Science between Grade 9 and 10 Japanese Students By Using the PISA Questions and Its Implications on Science Teaching in Japan

OGURA Yasushi
National Institute for Educational Policy Research

Abstract: The Japanese sample of PISA is 10^{th} graders at the 1st grade of upper-secondary school level. Most of them had entered their schools only three months before the PISA test. The results showed that the level of attitudes toward science of Japanese 10^{th} graders is quite low. To analyze and interpret the results of PISA, this study explored attitudes toward science of Japanese 9^{th} graders at the end of lower-secondary school level by using the same questions that were used in PISA 2006.

Randomly sampled 89 lower-secondary schools and about 3000 9^{th} graders participated in this follow-up study in January of 2008. If the result of 9^{th} graders also showed the low level of attitudes toward science, the problem is thought as being formed before entering upper-secondary school level.

Major findings are: (1) Japanese students are losing their interest in science at grade 10, (2) the level of motivation to learn science at grade 9 is low and further lowered at grade 10, (3) the level of self-efficacy in learning science is low both at grade 9 and 10, and (4) responsible attitude toward environment and resources is well developed by grade 10. The difference of science teaching styles between lower- and upper-secondary schools can explain why Japanese PISA sample showed quite low level of attitudes toward science.

Background

PISA (Program for International Student Assessment) conducted by OECD (Organization for Economic Cooperation and Development) in 2006 measured various aspects of attitudes toward science in the cognitive test of scientific literacy and in the student questionnaire (OECD, 2006; OECD, 2007a; OECD, 2007b). Collected data are a rich source for educational researchers and policy makers to analyze the situation of their science education system in comparison with other systems and to identify needs for the improvement.

Japanese students performed a relatively high achievement of scientific literacy in the cognitive test of 2006 PISA where the OECD average is 500 points while Japanese average is 531 (standard error is 3.4). However, the level of attitudes toward science in most aspects was quite low among the participated countries. Figure 1 summarizes the mean value and the standard error of scales and indices of attitudes toward science in 2006 PISA.
Level of scale or indices in the aspects of "Students' self-beliefs", "Support for scientific enquiry", and "Interest in science" are very low compared to the OECD average.

The results of 2006 PISA gave strong impact to science education community, policy makers, media, and industrial community that needs the best work force in developing science and technology, because the results simply suggested that Japanese students tend not to believe themselves to be able to understand science, not to support for scientific enquiry, and not to be interested in science not only in 10^{th} grade but also in their future.

This situation is problematic for Japanese science education to be improved. However, it is not apparent when the problems occurred. Identifying the source of the problem is necessary to find the way for the improvement.

There is a fundamental difficulty in PISA design to analyze the data of Japanese students in relation to the school factors. Because grade based sampling can be used as the age cohort sampling in Japan, Japanese sample of PISA as representing the fifteen years old population is all 10th graders at the 1st grade level of upper-secondary school. Most of them had entered their schools only three months before the PISA test. Japanese students' data of PISA are thought to be strongly influenced by their lower-secondary education, although there is no data to analyze the influence. Furthermore, educations in lower- and upper-secondary schools are very different, because students at grade 10 are selected based on achievement by entrance examination test. It enables for upper-secondary schools to adjust their education for the level of achievement of their students, while the education at lower-secondary schools covers all achievement levels of students.

There need additional data to 2006 PISA in order to explain whether the results of Japanese students' attitudes toward science are due to the influence of upper-secondary education or lower-secondary education or both.

Objective

This study aims to analyze the origin of the problems of Japanese students' attitudes toward science observed at grade 10 in 2006 PISA by collecting students' data at grade 9 and comparing the levels of attitudes between these grades. In order to make this comparison possible, the same questions in 2006 PISA should be used for this study.

If the results at grade 10 were worse than those at grade 9, problems should be occurring in the upper-secondary level. On the contrary, if the results at grade 9 were also problematic like as at grade 10, problems should have occurred by the end of lower-secondary level.

Method

89 lower-secondary schools from 194 randomly sampled lower-secondary schools from all schools of Japan and their 2994 students of randomly selected one classroom in 9th grade of each school participated in this study in January of 2008. The timing is almost the end of lower-secondary education in Japan. Most of the 9th graders take entrance examination test in February or March for getting into upper-secondary schools. Upper-secondary education starts for 10th graders in April and the PISA study was conducted in July 2006 in Japan. There are five or six month difference in the timing of study between the PISA in 2006 and this study in 2008. Because there had been no change in national course of study, these two groups are supposed to have had the same curriculum by the time of the study. If there was difference in the results of these two groups, it can be interpreted that there must be the origin of the difference in upper-secondary education.

This study uses the same questions in the 2006 PISA student questionnaire in order to compare the results with those of 2006 PISA (OECD, 2007c). The group of questions that composed an index of attitudes toward science in 2006 PISA is also used in comparing the results as the same group of questions in this study.

Result

General interest in science

Figure 2 shows the result of questions on "general interest in science" answered by students in 30 OECD countries participated in 2006 PISA and Japanese students at 9th grade in this study. Percentages of students reporting high or medium interest in each of eight topics from A to H as well as the average of them are shown. Countries are sorted by the average.

The level of "general interest in science" in Japanese 9th graders is higher than that in Japanese 10th graders in most of the topics. There are 10 percent or larger decrease in "Topics in chemistry", "Topics in physics", and "Ways scientists design experiments". It can be said that Japanese 10th graders are losing their level of "general interest in science" from the level of that at grade 9. The problem of losing "general interest in science" occurs at upper-secondary level in Japan.

Instrumental motivation to learn science

Figure 3 shows the result of questions on "instrumental motivation to learn science". Percentages of students agreeing or strongly agreeing with each of five questions from A to E as well as the average of them are shown.

Percentages of Japanese students at both grades are low compared to other OECD countries. Japanese 10th graders show further low percentages than 9th graders and the bottom level of "Instrumental motivation to learn science" among OECD countries. The problem of low level of "Instrumental motivation to learn science" exists both at lower- and upper-secondary levels.

There are only 51 and 42 percents of students in Japanese 9th and 10th graders, respectively, who agree or strongly agree with "I study school science because I know it is useful for me", while it is 67 percent in OECD average. Japanese education by grade 10 fails to teach students what values science learning gives them.

Self-efficacy in science

Figure 4 shows the result of questions on "self-efficacy in science". Percentages of students believing that they can perform easily or with a bit of effort in each of eight tasks from A to H as well as the average of them are shown.

Percentages of Japanese students at both grades are low or at the lowest level among OECD countries. The problem of low level of "self-efficacy in science" has occurred by the end of lower-secondary level and continues to upper-secondary level.

There are about twenty or more percent gap from the OECD average in the tasks; "Interpret the scientific information provided on the labeling of food items", "Describe the role of antibiotics in the treatment of disease", and "Discuss how new evidence can lead you to change your understanding about the possibility of life on Mars". The subjects to do these eight tasks are not scientists nor engineers but ordinal citizens who possess scientific literacy. For example, scientific explanations of antibiotics, vaccination, bacteria and viruses are not taught for all students in Japan, but every citizen may need to understand these in their life. Japanese education by grade 10 fails to teach students necessary scientific knowledge and skills to become citizens.

Responsibility for sustainable development

Figure 5 shows the result of questions on "students' responsibility for sustainable development". Percentages of students agreeing or strongly agreeing with each of seven questions from A to G as well as the average of them are shown.

Percentages of Japanese students at both grades are relatively high among the OECD countries. Japanese elementary and secondary education has put emphasis on learning of environmental problems not in science subject but in the periods of integrated study since 2000. This result may represent a success of the efforts. Japanese grade 9 and 10 students have developed their responsible attitude toward environment and resources through their school education.

Discussion

Interest in science

Country of high achievement does not mean also the success in fostering the attitude toward science, especially interest in science. Students in Finland where the level of achievement of scientific literacy was the top showed the bottom level of interest in science among OECD countries. Students in Canada where the level of achievement of scientific literacy was the second, however, showed a relatively high level of interest in science. Interest in science is important as a predictor of lifelong science learning and a career in science or technology field. Interest is closely related construct to intrinsic motivation. (Krapp et al. 1992; Osborne et al. 2003; Tobias 1994). Students can learn, because they are interested. Both raising achievement and fostering interest should be important goal of science education. In order to improve interest in science, it should be understood why it declines at upper-secondary level.

Possible explanations of the decline of interest

One possible explanation of the decline of interest found in Japanese 10th graders is that the pressure for high achievement may restrain interest in further learning, because supporting autonomy to learn is important to maintain interest and intrinsic motivation (Deci 1992). Because Japanese students are highly stressed by periodical examinations several times a year and entrance examinations at the end of grade 9 and 12, it is possible that Japanese students are deprived the room to develop their interest in and enjoyment of science. However, this explanation cannot explain the difference of decline of students' interest in different topics. There are larger differences in topics in chemistry and physics and ways scientists design experiments than in other topics.

Influence of science teaching

Another explanation of the decline of students' interest in science is that their science lessons are not interested for students compared to lessons at lower-secondary level. Figure 6 shows the result of questions related to "inquiry based science teaching". Percentages of students reporting "In all lessons" or "In most lessons" for each of six teaching patterns from A to F as well as the average of them are shown.

There are big differences in the percentages of each teaching pattern between students at grade 9 and 10. Japanese 10th graders have less opportunity to conduct scientific investigation and to do science experiment than 9th graders do.

Figure 7 shows the mean of index of general interest in learning science of Japanese 10th grade students by responses to the six questions on inquiry based science teaching. It is apparent that students reporting "In all lessons" or "In most lessons" are more interested than students reporting "Some lessons" or "Hardly ever". Although students are interested in inquiry based learning, science teaching at grade 10 does not orient it. This suggests an approach to improve the problematic situation of students' interest in science at upper-secondary level.

Purpose to learn science

Even though students are not interested in science, if they are extrinsically motivated, they can learn. But the findings of low level of motivation to learn science at grade 9 and further low level at grade 10 suggest that Japanese students are not instrumentally motivated to learn science.

Instrumental motivation is thought as an important predictor for course selection, career choice and performance (Wigfield and Eccles 1992; Wigfield et al. 1998). Students may pursue tasks because of their importance for future goals. Such a task has utility value and gives students extrinsic reason to pursue it. Students can learn, because it is valuable.

Learning science can be more valuable if the learning can be applied to real life. Figure 8 shows the result of questions how science lessons are taught in connected with real life. Percentages of students reporting "In all lessons" or "In most lessons" for each of five teaching patterns from A to E as well as the average of them are shown.

Percentages of Japanese students at both grades are low compared to other OECD countries. Japanese 10th graders show further low percentages than 9th graders and the bottom level of science lessons in connected with real life among OECD countries. There are only 12 percent of Japanese 10th graders who report "In all lessons" or "In most lessons" in which the teacher uses science to help students understand the world outside school, while the percentage is 38 in OECD average.

Most of Japanese students may not be able to understand the purpose of learning science because of lacking connection with real life. They will not be taking science courses in following years. Japanese science education both in lower- and upper-secondary schools should teach science with the value for students to learn.

Conclusion

It was found that: (1) Japanese students are losing their interest in science at grade 10, (2) the level of motivation to learn science at grade 9 is low and further lowered at grade 10, (3) the level of self-efficacy in learning science is low both at grade 9 and 10, and (4) responsible attitude toward environment and resources is well developed by grade 10. This study could successfully analyze the origin of the problems of Japanese students' attitudes toward science.

The difference of science teaching styles between lower- and upper-secondary schools can explain why Japanese PISA sample showed quite low level of attitudes toward science. Students are interested in inquiry based learning, while science teaching at upper-secondary level does not orient it. Science taught both in lower- and upper-secondary schools does not seem valuable for students to learn, and lacks contents necessary scientific knowledge and skills to become citizens. Japanese science education needs actions to change its teaching and contents so that their students can well develop not only the aspect of achievement of but also the aspects of attitudes toward science as scientific literacy that are required to live in society.

Not the all aspects of attitudes toward science of Japanese students are at low level. Japanese students at grades 9 and 10 have developed their responsible attitude toward environment and resources through the periods of integrated study in their elementary and secondary schools. As the United Nations Educational, Scientific and Cultural

Organization decided the ten years from 2005 as the Decade of Education for Sustainable Development (UNESCO 2004), individual choosing actions for sustainable development is getting more and more important in today's society. This successful effort in Japanese school education should be continued.

References

Deci, E. L.: The Relation of Interest to the Motivation of Behavior: A Self-Determination Theory Perspective. In *The role of interest in learning and development*, eds. K. A. Renninger, S. Hidi, and A. Krapp, 43-70, Hillsdale, NJ: Lawrence Erlbaum Associates, 1992.

Krapp, A., Hidi, S., and Renninger, K. A.: Interest, learning and development. In *The role of interest in learning and development*, eds. K. A. Renninger, S. Hidi, and A. Krapp, 3-25, Hillsdale, NJ: Lawrence Erlbaum Associates, 1992.

OECD: Assessing Scientific, Reading and Mathematical Literacy: A Framework for PISA 2006, OECD, Paris, 2006.

OECD: PISA 2006 Science competencies for tomorrow's world - Volume 1: Analysis. OECD, Paris, 2007a.

OECD: PISA 2006 Science competencies for tomorrow's world - Volume 2: Data. OECD, Paris, 2007b.

OECD: The PISA International Database (http://pisa2006.acer.edu.au/) , 2007c.

Osborne, J., Simon, S., and Collins, S.: Attitudes towards science: a review of the literature and its implications. *International Journal of Science Education* 25(9): 1049-1079, 2003.

Tobias, S.: Interest, Prior Knowledge, and Learning. *Review of Educational Research* 64(1): 37-54, 1994.

UNESCO (United Nations Educational, Scientific and Cultural Organisation) 2004. United Nations Decade of Education for Sustainable Development 2005-2014: Draft International Implementation Scheme. Paris: UNESCO.

Wigfield, A., and Eccles, J. S.: The Development of Achievement Task Values: A Theoretical Analysis. *Developmental Review* 12: 265-310, 1992.

Wigfield, A., Eccles, J. S., and Rodriguez, D.: The Development of Children's Motivation in School Context. *Review of Research in Education* 23: 73-118, 1998.

Note

This paper extended the analysis and interpretation in following paper of preliminary phase of this study.

Ogura, Y.: Comparison of Attitudes Toward Science Between Japanese Students of Grade 9 and 10 by Using the PISA Questions. (written in Japanese) *Journal of Japan Society for Science Education*, 32(4): 330-339, 2008.

This study was supported by the Grant-in-Aid for Scientific Research (project number 19300267) from the Japan Society for the Promotion of Science (JSPS). The presentation of this study at the PISA research conference in 2009 held in Kiel is supported by the Center for Promotion of Science Education in Japan Science and Technology Agency (JST). Their supports are appreciated.

Author & Contact Address

Yasushi Ogura
Senior Researcher
Curriculum Research Center
National Institute for Educational Policy Research (NIER)
3-2-2 Kasumigaseki, Chiyoda,
Tokyo 100-8951, Japan
Tel. +81,367336862
Fax. +81,367336975
Email: ogura@nier.go.jp
Web: http://www.nier.go.jp/

Figure 1. Scales and indices of attitudes toward science in 2006 PISA and the value of mean (M) and the standard error (SE)

Students' self-beliefs
Index of self-efficacy in science [M=-0.53, SE=0.02]
Index of self-concept in science [M=-0.87, SE=0.02]
Support for scientific enquiry
Support for scientific enquiry scale [M=468, SE=2.3]
Index of general value of science [M=-0.18, SE=0.02]
Index of personal value of science [M=-0.23, SE=0.02]
Interest in science
Interest in scientific topics scale [M=512, SE=2.1]
Index of general interest in science [M=-0.13, SE=0.02]
Index of enjoyment of science [M=-0.26, SE=0.02]
Index of instrumental motivation to learn science [M=-0.43, SE=0.03]
Index of future-oriented motivation to learn science [M=-0.24, SE=0.02]
Index of science-related activities [M=-0.62, SE=0.02]
Responsibility towards resources and environments
Index of students' awareness of environmental issues [M=-0.13, SE=0.02]
Index of students' optimism regarding environmental issues [M=0.10, SE=0.02]
Index of students' responsibility for sustainable development [M=0.04 SE=0.02]
Index of students' level of concern for environmental issues [M=0.01, SE=0.01]

Figure 2. Result of questions on *general interest in science*

A) Human biology
B) Topics in astronomy
C) Topics in chemistry
D) Topics in physics
E) The biology of plants
F) Ways scientists design experiments
G) Topics in geology
H) What is required for scientific explanations

Country	Percentage of students reporting high or medium interest in								average
	A	B	C	D	E	F	G	H	
Mexico	84	72	74	75	76	74	65	66	73
Germany	77	52	59	56	57	54	49	42	56
France	75	57	60	65	51	50	48	38	56
Turkey	78	56	50	47	63	53	42	46	54
Luxembourg	75	49	58	55	49	61	45	41	54
Greece	78	55	53	53	57	48	40	47	54
Italy	74	65	46	44	48	62	49	42	54
Portugal	61	53	56	58	41	61	47	51	53
Canada	70	58	64	56	51	45	42	33	52
Japan at 9th grade	**65**	**59**	**58**	**50**	**63**	**45**	**39**	**31**	**51**
Austria	76	51	47	49	55	53	43	34	51
Belgium	73	53	52	52	49	50	42	36	51
United States	68	58	56	52	45	45	42	34	50
Poland	77	53	42	36	58	52	43	35	50
Switzerland	51	52	59	55	41	52	47	39	50
Norway	47	52	58	56	36	59	43	43	49
OECD average	**68**	**53**	**50**	**49**	**47**	**46**	**41**	**36**	**49**
United Kingdom	75	49	55	51	47	41	35	35	49
Slovak Republic	69	55	41	46	47	46	44	30	47
Czech Republic	69	57	40	47	40	54	37	35	47
Ireland	77	47	44	41	55	40	34	33	46
Hungary	72	59	36	41	44	43	40	37	46
New Zealand	66	50	55	49	44	38	36	30	46
Iceland	62	60	47	50	36	38	42	31	46
Sweden	61	53	50	48	37	44	35	35	45
Japan at 10th grade	**65**	**55**	**48**	**40**	**58**	**34**	**33**	**25**	**45**
Denmark	59	39	53	52	37	37	30	36	43
Australia	62	46	48	44	40	36	32	29	42
Korea	62	52	42	31	45	24	42	28	41
Spain	59	43	36	35	41	43	34	29	40
Finland	66	48	45	41	33	24	31	26	39
Netherlands	63	36	38	40	39	30	28	27	38

Figure 3. Result of questions on *instrumental motivation to learn science*

A) I study school science because I know it is useful for me.
B) Making an effort in my school science subject(s) is worth it because this will help me in the work I want to do later on.
C) Studying my school science subject(s) is worthwhile for me because what I learn will improve my career prospects.
D) I will learn many things in my school science subject(s) that will help me get a job.
E) What I learn in my school science subject(s) is important for me because I need this for what I want to study later on.

Country	Percentage of students agreeing or strongly agreeing with the following statements					average
	A	B	C	D	E	
Mexico	86	86	85	79	82	84
Portugal	84	75	81	76	78	79
Turkey	73	80	73	69	79	75
United States	77	78	70	70	68	73
Canada	75	73	72	69	63	71
Poland	73	68	73	66	71	70
Italy	76	66	72	63	64	68
United Kingdom	75	71	71	65	54	67
New Zealand	71	69	68	66	56	66
Ireland	73	67	68	67	54	66
Greece	70	65	63	58	61	63
Australia	69	66	64	62	55	63
Spain	66	66	63	62	54	62
Iceland	65	62	60	57	64	62
Denmark	67	64	61	54	60	61
OECD average	**67**	**63**	**61**	**56**	**56**	**60**
Hungary	66	69	53	53	55	59
Sweden	62	62	63	52	55	59
France	67	59	61	48	52	57
Germany	66	58	55	50	48	55
Norway	60	56	59	48	53	55
Luxembourg	61	57	54	49	48	54
Slovak Republic	62	55	56	52	43	54
Belgium	57	56	55	48	48	53
Netherlands	62	54	56	44	46	52
Czech Republic	62	50	49	47	52	52
Finland	63	53	51	48	43	52
Korea	55	57	52	46	45	51
Switzerland	60	54	49	41	44	50
Japan at 9th grade	**51**	**51**	**47**	**43**	**48**	**48**
Austria	55	44	47	38	36	44
Japan at 10th grade	**42**	**47**	**41**	**39**	**42**	**42**

Figure 4. Result of questions on *self-efficacy in science*

A) Explain why earthquakes occur more frequently in some areas than in others.
B) Recognise science question that underlies a newspaper report on a health issue.
C) Interpret the scientific information provided on the labelling of food items.
D) Predict how changes to an environment will affect the survival of certain species.
E) Identify the science question associated with the disposal of garbage.
F) Describe the role of antibiotics in the treatment of disease.
G) Identify the better of two explanations for the formation of acid rain.
H) Discuss how new evidence can lead you to change your understanding about the possibility of life on Mars.

Country	Percentage of students who believe they can perform the following tasks either easily or with a bit of effort								average
	A	B	C	D	E	F	G	H	
Poland	76	76	82	71	62	72	71	59	71
Norway	78	65	66	66	68	77	76	61	70
Portugal	75	75	72	71	76	61	66	57	69
United States	76	79	71	77	64	63	58	59	68
Canada	76	78	72	78	64	59	62	57	68
Slovak Republic	76	83	77	54	61	63	67	60	68
United Kingdom	75	79	69	77	67	60	61	52	67
Czech Republic	81	81	61	67	60	71	57	57	67
Iceland	79	72	74	72	58	63	55	59	67
Mexico	74	78	62	67	77	57	62	55	66
Australia	78	78	68	75	61	59	54	55	66
Netherlands	82	78	60	62	60	66	65	53	66
Germany	83	78	61	69	62	64	64	44	66
Turkey	73	76	72	65	64	61	57	51	65
Finland	83	77	68	56	63	53	48	64	64
OECD average	**76**	**73**	**64**	**64**	**62**	**59**	**58**	**51**	**63**
Ireland	81	68	64	63	69	55	64	41	63
Sweden	80	67	65	67	58	53	58	54	63
New Zealand	78	73	64	68	58	58	48	50	62
Denmark	78	77	70	59	54	42	49	62	62
Hungary	70	72	66	49	74	63	62	35	61
France	79	65	67	59	52	70	43	54	61
Belgium	67	73	67	64	51	58	57	52	61
Spain	73	61	62	59	55	54	61	56	60
Luxembourg	78	71	57	65	57	58	49	44	60
Austria	78	73	53	61	63	55	58	36	60
Italy	77	70	63	64	57	46	56	46	60
Greece	67	67	52	56	61	57	59	42	58
Switzerland	77	69	55	62	54	52	45	41	57
Korea	72	68	47	53	65	55	56	39	57
Japan at 9th grade	**65**	**62**	**43**	**66**	**66**	**34**	**47**	**32**	**52**
Japan at 10th grade	**62**	**64**	**44**	**58**	**61**	**33**	**43**	**26**	**49**

Figure 5. Result of questions on *students' responsibility for sustainable development*

A) Industries should be required to prove that they safely dispose of dangerous waste materials.
B) I am in favour of having laws that protect the habitats of endangered species.
C) It is important to carry out regular checks on the emissions from cars as a condition of their use.
D) To reduce waste, the use of plastic packaging should be kept to a minimum.
E) Electricity should be produced from renewable sources as much as possible, even if this increases the cost.
F) It disturbs me when energy is wasted through the unnecessary use of electrical appliances.
G) I am in favour of having laws that regulate factory emissions even if this would increase the price of products.

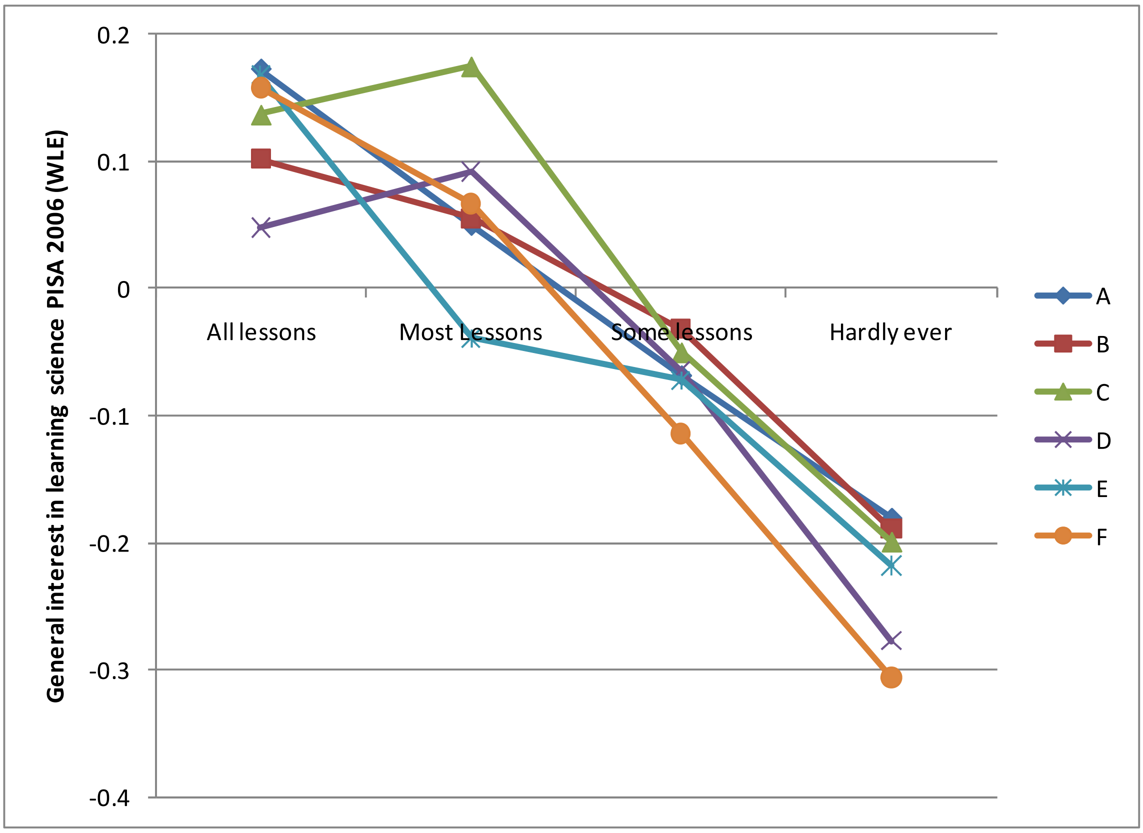
Country	Percentage of students agreeing or strongly agreeing with the following statements							average
	A	B	C	D	E	F	G	
Portugal	98	98	98	92	93	90	90	94
Turkey	93	95	96	90	89	92	94	93
Korea	97	96	97	94	92	85	86	93
Spain	96	97	94	84	88	88	81	90
Mexico	94	96	92	91	80	89	83	89
Poland	93	95	90	88	89	79	85	89
Hungary	94	94	95	86	82	77	85	88
France	94	95	95	85	77	87	77	87
Greece	91	90	97	85	79	82	76	86
Italy	95	96	96	80	81	84	68	86
Japan at 9th grade	**90**	**93**	**86**	**91**	**88**	**77**	**76**	**86**
Japan at 10th grade	**88**	**92**	**89**	**90**	**88**	**73**	**71**	**84**
Belgium	94	91	94	86	74	76	68	83
Canada	93	93	93	86	82	69	66	83
OECD average	**92**	**92**	**91**	**82**	**79**	**69**	**69**	**82**
Ireland	94	93	92	92	84	60	61	82
Luxembourg	89	91	91	85	75	72	63	81
Switzerland	92	92	93	82	74	69	62	81
Finland	91	91	93	81	79	59	71	81
Denmark	92	92	81	82	79	54	75	79
Australia	92	93	90	88	78	62	52	79
Austria	92	91	87	81	69	63	69	79
Slovak Republic	94	83	91	73	81	72	56	78
United Kingdom	90	89	92	82	82	58	56	78
United States	88	90	89	77	75	63	56	77
New Zealand	90	92	90	83	75	58	49	77
Germany	91	91	89	80	66	64	53	76
Norway	88	88	83	74	72	53	73	76
Czech Republic	93	93	93	64	71	52	63	75
Iceland	89	91	86	73	77	45	65	75
Sweden	92	86	86	63	72	52	69	74
Netherlands	92	90	88	75	65	51	53	73

Figure 6. Result of questions on inquiry based science teaching

A) Students are required to design how a <school science> question could be investigated in the laboratory
B) Students are allowed to design their own experiments
C) Students are given the chance to choose their own investigations
D) Students are asked to do an investigation to test out their own ideas
E) Students spend time in the laboratory doing practical experiments
F) Students are asked to draw conclusions from an experiment they have conducted

Country	Percentage of students answered "In all lessons" or "In most lessons" with the following statements						average
	A	B	C	D	E	F	
Turkey	27	42	45	42	28	53	39
Mexico	34	34	34	47	35	60	37
United States	45	30	28	38	45	69	35
Portugal	25	28	28	36	13	53	29
Greece	26	23	33	33	20	53	29
Japan at 9th grade	**22**	**17**	**15**	**47**	**32**	**52**	**25**
Canada	33	18	18	29	28	66	25
Denmark	51	13	11	14	61	63	22
Australia	28	16	16	26	25	65	21
United Kingdom	36	14	12	23	27	67	21
Switzerland	22	18	17	23	23	61	20
OECD average	**22**	**17**	**16**	**23**	**22**	**51**	**19**
France	23	17	16	22	23	68	19
Italy	16	16	20	24	17	36	19
New Zealand	26	14	12	22	23	58	19
Poland	14	16	16	28	8	59	18
Germany	25	14	16	19	22	65	18
Sweden	21	19	13	18	28	61	18
Luxembourg	19	16	16	20	19	49	18
Norway	26	13	13	16	24	49	17
Slovak Republic	13	18	16	21	12	37	17
Netherlands	26	13	12	17	30	51	17
Austria	20	12	14	18	16	38	16
Ireland	23	10	13	17	35	62	16
Spain	14	13	12	20	8	48	15
Korea	13	13	12	13	9	26	13
Czech Republic	10	13	8	18	9	37	12
Japan at 10th grade	**9**	**9**	**8**	**22**	**10**	**26**	**12**
Belgium	11	12	12	14	12	49	12
Hungary	8	12	10	17	9	34	12
Iceland	15	9	6	12	7	26	10
Finland	10	5	7	14	22	55	9

Figure 7. Mean of index of general interest in learning science of Japanese students by responses to six questions on inquiry based science teaching



A) Students are required to design how a <school science> question could be investigated in the laboratory
B) Students are allowed to design their own experiments
C) Students are given the chance to choose their own investigations
D) Students are asked to do an investigation to test out their own ideas
E) Students spend time in the laboratory doing practical experiments
F) Students are asked to draw conclusions from an experiment they have conducted

Figure 8. Result of questions on science lessons taught in connected with real life

A) The students are asked to apply a <school science> concept to everyday problems
B) The teacher explains how a <school science> idea can be applied to a number of different phenomena
C) The teacher uses <school science> to help students understand the world outside school
D) The teacher clearly explains the relevance of <broad science> concepts to our lives
E) The teacher uses examples of technological application to show how <school science> is relevant to society

Country	Percentage of students answered "In all lessons" or "In most lessons" with the following statements					average
	A	B	C	D	E	
United States	50	68	58	57	50	57
Canada	50	72	53	58	49	56
Greece	40	63	54	60	48	53
Mexico	43	67	45	57	51	53
Portugal	38	61	53	60	49	52
Australia	39	66	49	55	41	50
New Zealand	38	66	48	51	37	48
Denmark	36	73	45	44	37	47
Switzerland	30	65	45	49	41	46
Turkey	39	56	42	46	45	46
Poland	32	69	34	48	39	45
United Kingdom	33	59	40	45	33	42
Ireland	26	61	45	47	30	42
France	32	65	37	43	32	42
OECD average	**30**	**59**	**38**	**46**	**34**	**41**
Iceland	23	67	36	49	29	41
Hungary	20	61	43	49	28	40
Sweden	28	62	34	41	32	39
Italy	27	50	36	48	32	39
Spain	24	56	30	47	36	39
Austria	21	56	38	44	33	38
Germany	25	57	38	39	31	38
Belgium	26	61	33	38	32	38
Norway	25	56	37	42	28	38
Luxembourg	21	55	34	41	30	36
Finland	25	61	31	41	20	36
Slovak Republic	21	45	29	54	26	35
Czech Republic	23	51	27	43	33	35
Netherlands	26	51	25	42	25	34
Japan at 9th grade	**22**	**45**	**25**	**36**	**30**	**32**
Korea	21	59	18	35	25	32
Japan at 10th grade	**11**	**26**	**12**	**19**	**16**	**17**