Comparison of Attitudes of the Stakeholders of School Education in Japan and Other Countries towards Areas of Science

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Abstract

This research addresses the attitudes of the stakeholders of the school education (students, parents and teachers) towards learning and teaching science in the multinational context. In particular, it aims to study the perception of areas of science (physics, chemistry, life, Earth and environmental science) in the dimensions of their understanding, personal values (interests, priorities, motivations) and social experience. Also, the survey targets the issues associated with the perception of science fields and scientific literacy in regard to the environmental problems. In particular, awareness and attitudes to the environmental problems in relation to the country of the respondents' citizenship and the global scale are studied. The research is conducted by a questionnaire in several countries (Japan, Malaysia, Ukraine and others) to analyze both public and private sectors of the school education. Although a number of countries, including Japan, are top performers in international contests of science education, the scientific literacy of their citizens of different age groups does not always correspond to their scores, and the attitude towards science is often rather negative. The literacy and the attitude, however, vary depending on science topics and areas of science, as indicated by a number of research reports. Such differences in performance and perception are crucial for the development of education in both formal (primary and secondary) and informal (lifelong learning) perspectives and should not be underestimated. Therefore, this research raises the questions: 'Is there a concept of a relative importance of science fields in the school education globally?' and 'What is the sustainable development for science education?'

Keywords: attitude, environmental problems, multinational, school, science education

Introduction

For recent decades, research in school science education has been substantially focused on perception of educational practices by students and teachers. Some key findings made in this regard and related to the present research might be summarized as follows. 1. Students having a higher academic performance tend to show more positive attitudes towards learning science than low performers (Barrington and Henderriks, 1988). 2. Students in less 'wealthy' economies seem to be more interested in science than students in more 'wealthy' economies (Sjoberg and Schreiner, 2010). 3. While some studies indicate that interest towards science declines with age (Hadden and Johnstone, 1982, 1983; Barrington and Henderriks, 1988; Simpson and Oliver, 1985; Piburn and Baker, 1993), others link it rather to the changes in the curricula (Reid and Skryabina, 2002; Suzuki, 2007). 3. Boys internationally tend to show more positive attitudes towards science, especially physics, than girls (Weinberg, 1995; Skryabina, 2000; Reid and Skryabina, 2002; Sjoberg and Schreiner, 2010). 4. Boys state that science is rather easy for them more often than girls. 5. Boys are more likely to choose physics and chemistry as selective courses in secondary school, while more girls choose biology (Clarke, 1972; McGuffin, 1973; Reid and Skryabina, 2002).

Obviously, international approaches in school science education have a significant variation. One of the most basic differences between systems of education lies in the stage at which school science becomes divided into subjects: physics, chemistry, life science (biology), Earth science (geography), astronomy, ecology, and so on. In some countries this segregation of science is introduced at the primary school level, in others it happens in lower or upper secondary school. While international research provides a wide range of studies, the majority of those concerning the latter system (where science is divided at the later stages), investigates the perception of science as one subject (Martin *et al*, 2008). In such case, the data concerning attitudes towards science in these two groups of countries become incomparable. This research targets to address the issue that was rather not sufficiently highlighted in other studies, i.e. an international comparison of attitudes towards school physics, chemistry, biology, Earth and environmental science in both types of education systems. Another issue that was rather not addressed and is an objective for this study is the analysis of attitudes of three main stakeholders in school education: students, teachers and parents. The primary focus is the differences in perception of science related to the respondents' sex and background (nationality, educational system and so on).

Methodology

The objectives of the research are summarized as follows.

Objective 1: to conduct an international comparison of attitudes of male and female students towards areas of school science in regard to a) understanding; b) interest in learning and as a future career; c) perceived level of complexity; d) perceived usefulness of knowledge. The selected countries should include two education systems: 1) the one in which science is studied as a number of subjects from the early stage (primary school or the beginning of lower secondary school), and 2) from the later stage (upper secondary school).

Objective 2: to study societal beliefs and values in relation to science education through comparison of students' perception of science with the one of teachers' and parents.

Methods for the research are summarized as follows.

1. Analysis of secondary data (systematic review of research reports and other documents).

2. Primary data collection involving questionnaires for students, parents and teachers.

The outline of the questionnaire for students is as follows:

a) target population: students of the second year of upper secondary schools, 16 y.o.;

b) number of samples: at least 200 (preferably 100 of each sex) for each country;

c) schools: public and private, at least three in each country.

Students of the second year of upper secondary schools (age 16) were selected as the target population, because at this level science is divided into a number of disciplines in majority of countries.

For a preliminary stage of analysis, five countries were selected according to the structure of their education system: Japan, Malaysia, Russia, Ukraine, and Sri Lanka. In Japan and Malaysia, science is taught as one discipline up to grade 10. In Ukraine and Russia, it is divided into subjects starting from grade 5. Sri Lanka represents a transitional system that has recently (since 2006) introduced areas of science instead of a unified subject starting from grade 7.

The outline of the questionnaire for teachers is as follows:

a) target population: teachers of the third year of lower secondary school;

b) type of the education system: where science is one subject up to grade 10;

c) number of samples: at least 50;

d) schools: public and private.

Such target population and the type of the education system were selected, because when science is taught as one area, it is possible to receive teachers' assessment of students' perception of all its areas.

The outline of the questionnaire for parents is as follows:

a) target population: parents of at least one child who is studying in either lower or higher secondary school;

b) number of samples: at least 100.

Results

1. Students' attitudes towards areas of science

1.1 Students' own assessment

Students' attitudes towards areas of science (physics – Ph, chemistry – Ch, biology – bi, Earth science – ES, environmental science – EnvS) were evaluated according to the scale from 1 to 4 as follows: 1 (dislike and rather dislike); 2 (indifferent); 3 (little interest); 4 (moderate and deep interest). The number of samples was 200 from each of three countries: Japan, Malaysia, Ukraine (100 for each sex); 100 from Russia (50 for each sex); 50 from Sri Lanka (only female students). The survey covered in total 9 schools: 2 in Japan (JP), 3 in Malaysia (MY), 2 in Ukraine (UA), 1 in Russia (RU) and Sri Lanka (SL) respectively.

The mean was calculated as:

$$\mu = \sum_{i=0}^{n} p_i \, x_i \,,$$

Where x_i – a value, p_i – the probability of x.

The standard error was calculated as:

$$SE_{\bar{x}} = \frac{\sigma}{\sqrt{n}},$$

Where σ – the standard deviation, n – the size of the sample.

The standard deviation was calculated as:

$$\sigma = \sqrt{\sum_{i=0}^{n} p_i \, (x_i - \mu)} \,,$$

Where x_i – the mean of x.

The mean value and the standard error are presented in Table 1.

Table 1. Students' perception of science (own assessment)

Country	Boys					Girls				
	Ph	Ch	Bi	ES	EnvS	Ph	Ch	Bi	ES	EnvS
JP	2.839 ±0.107	2.925 ±0.106	2.903 ±0.111	2.527 ±0.100	2.688 ±0.103	2.151 ±0.094	2.538 ±0.099	2.914 ±0.098	2.516 ±0.093	2.602 ±0.094
MY	2.939 ±0.115	2.939 ±0.113	2.948 ±0.108	2.604 ±0.105	2.570 ±0.104	2.753 ±0.114	3.124 ±0.107	3.216 ±0.104	2.839 ±0.111	2.925 ±0.108
UA	2.950 ±0.108	2.790 ±0.111	3.120 ±0.099	3.260 ±0.101	2.850 ±0.105	2.610 ±0.108	2.780 ±0.107	3.710 ±0.070	3.180 ±0.093	3.310 ±0.096
RU	2.800 ±0.147	2.700 ±0.132	3.320 ±0.098	2.790 ±0.165	2.800 ±0.147	2.430 ±0.155	2.620 ±0.163	3.440 ±0.099	3.090 ±0.092	3.050 ±0.121
SL	n/a n/a	n/a n/a	n/a n/a	n/a n/a	n/a n/a	3.000 ±0.159	3.340 ±0.124	3.490 ±0.138	n/a n/a	n/a n/a

Mean value ± standard error.

The results of Table 1 are summarized as follows.

1. Boys in each country are almost equally interested in physics, chemistry and biology (Russia is an exception, but only 1 school was analyzed).

2. Girls' level of interest towards physics is lower than towards other areas of science, and biology is the most 'interesting' area of science for them. Girls from Ukraine express an exceptionally high level of interest towards biology.

3. For boys from Japan and Malaysia, Earth and environmental sciences might be the 'least interesting' areas. In contrast, for boys from Russia and Ukraine Earth science might be 'the most interesting' one.

4. Girls from Japan are the 'least interested' in all areas of science.

1.2 Teachers' and parents' assessment (Japan's case)

Comparison of students' attitudes towards science with an assessment of those attitudes made by teachers and parents is valuable, because it may identify an 'image' (i.e. perception, including perceived importance and so on) of school science in a particular society. Moreover, some features of this perception might be international and even global. As a preliminary analysis, such comparison was conducted in regard to 4 areas of science (physics, chemistry, biology, Earth science) involving school

teachers and parents of school students in Japan. 78 samples from teachers of grade 3 of 27 lower secondary schools, and 100 samples of parents whose children attend either lower or upper secondary schools were collected. Both groups were asked, what areas of science students tend to 'like' in their opinion. Also, teachers were requested to give an additional assessment by the scale explained earlier (from 'dislike' to 'deep interest').

The results are presented in Tables 2 and 3.

Table 2. Students' perception of science (teachers' and parents' assessment)

Attitude	Boys (teachers, %)				Girls (teachers, %)				Boys (parents, %)				Girls (parents, %)			
	Ph	Ch	Bi	ES	Ph	Ch	Bi	ES	Ph	Ch	Bi	ES	Ph	Ch	Bi	ES
'Like'	44	72	23	6	2	34	83	9	62	70	12	16	6	22	86	12

Table 3. Students' perception of science (teachers' assessment and own assessment)

Attitude	Boys (teachers, %)				Girls (teachers, %)				Boys, %				Girls, %			
	Ph	Ch	Bi	ES	Ph	Ch	Bi	ES	Ph	Ch	Bi	ES	Ph	Ch	Bi	ES
Dislike	13	3	5	2	34	11	2	3	10	8	12	16	11	22	11	6
Indifferent	3	2	7	17	18	7	3	18	28	28	22	28	32	45	41	28
Interest*	45	75	49	37	10	43	72	35	33	37	37	17	25	10	20	32

* - Includes categories 'moderate interest' and 'deep interest'

According to Tables 2 and 3, teachers' and parents' evaluation in regard to areas of school science that students 'like' and are 'interested in' is somewhat similar. In particular, boys are considered to prefer (to like and be interested in) chemistry over other areas of science, while girls are considered to prefer biology. It is supposed that the 'least favorite' and 'interesting' for boys is Earth science. For girls, it is physics and Earth science. The comparison of students' own assessment with that made by teachers (Table 3) shows a considerable difference between them. In particular, boys tend to have a significantly higher level of interest towards chemistry in teachers' opinion, while in the students' answers there was no noticeable difference in attitudes towards physics, chemistry and biology.

The results of Table 2 may identify a perception of biology and Earth science as fields that boys in Japan 'do not like'. Therefore, they might be evaluated as rather 'inappropriate' for male students in the Japanese society, despite teachers consider biology to be somewhat 'interesting' for boys (Table 3). In this regard, questions 1 (Table 2) and 2 (Table 3) should be referred, as the survey's results depend on how the questions were formulated. Question 1 enquired about areas of science that students 'like' in respondents' opinion. Question 2 presupposed a scale ranging from 'dislike' to 'deep interest'. Presumably, respondents either considered the categories 'like' and 'interesting' as rather independent, or might have preferred to express a positive opinion concerning the level of students' interest in science. The latter assumption might find proof in the present survey. When comparing teachers' and students' assessment (Table 3), teachers tend to overestimate the level of students' positive attitudes towards all areas of science.

2. 'Useful' and 'useless' areas of science (students' assessment)

In order to investigate possible reasons of attitudes towards science, students were asked to evaluate the usefulness of areas of science for the daily life by the following scale: 1) 'absolutely not useful'; 2) 'rather not useful'; 3) 'rather useful'; 4) 'useful'. The results are presented in Table 4.

Table 4. 'Not useful' areas of science (students' assessment)

Country	'Not useful'* areas of science									
	Boys, %					Girls, %				
	Ph	Ch	Bi	ES	EnvS	Ph	Ch	Bi	ES	EnvS
JP	32	25	29	31	22	40	37	31	29	18
MY	15	22	13	30	29	24	30	13	24	23
UA	28	37	23	23	21	20	24	3	16	15
RU	57	53	47	41	37	57	48	17	13	13
SL	n/a	n/a	n/a	n/a	n/a	4	9	0	n/a	n/a

* - Includes categories 'absolutely not useful' and 'rather not useful'

According to Table 4, boys from Russia were the most 'sceptical' about the usefulness of science among all groups of students. In contrast, girls from Sri Lanka were the most 'confident' in this regard. However, in each of these countries a rather insufficient number of samples was collected. In general, girls' evaluation tends to fluctuate depending on the area of science to a higher degree than that of boys. The level of students' interest towards science and the perception of its 'usefulness' seem to be rather independent values as the comparison of Tables 1 and 5 indicates. Students may have a negative attitude towards particular areas of science, but

perceive them as 'useful', and the opposite.

3. 'Complex' and 'simple' areas of science (students' assessment)

To investigate a possibility of correlation of students' interest towards science with other aspects of its perception, the target population was asked to give an assessment of 'complex' and 'simple' areas of science. The assessment scale was designated as follows: 1) 'simple', 2) 'rather simple', 3) 'rather complex', 4) 'complex'. Table 5 shows the results in regard to areas of science evaluated by students as 'simple' and 'rather simple'.

Table 5. 'Simple' areas of science (students' assessment)

Country	'Simple' areas of science									
	Boys, %					Girls, %				
	Ph	Ch	Bi	ES	EnvS	Ph	Ch	Bi	ES	EnvS
JP	38	47	47	43	45	21	30	51	40	37
MY	36	27	31	47	55	16	25	28	49	45
UA	40	30	65	77	74	22	19	66	65	78
RU	36	14	57	79	57	23	9	73	73	77
SL	n/a	n/a	n/a	n/a	n/a	26	13	24	n/a	n/a

According to Table 5, boys from all countries tend to evaluate physics and chemistry as 'simple' more often than girls. Boys from Japan consider all areas of science to be 'simple' to a similar degree, while there is a significant difference between areas of science in assessment of other groups of students of both sexes. Boys from Malaysia, Russia and Ukraine and all groups of girls tend to evaluate Earth and environmental sciences as more 'simple' than physics and chemistry. Also, boys and girls from Ukraine and Russia characterize biology as 'simple'. Comparison of data presented in Tables 1 and 5 shows, that the interest towards areas of science may have little correlation with their perceived level of complexity. Students may evaluate some areas of science as 'simple', but have a lower level of interest towards them than to 'more complex' ones.

4. Students' interest towards careers in science

Students' attitudes towards careers in areas of science were evaluated by the scale from 1 to 6 as follows: 1 (dislike); 2 (rather dislike); 3 (indifferent); 4 (little interest); 5 (moderate interest); 6 (deep interest). The results are shown in Table 6.

Table 6. Interest towards careers in science (students' assessment)

Country	Interest* towards careers in science									
	Boys, %					Girls, %				
	Ph	Ch	Bi	ES	EnvS	Ph	Ch	Bi	ES	EnvS
JP	24	22	28	9	18	6	14	23	12	15
MY	43	38	33	15	14	29	36	49	28	30
UA	28	34	35	35	23	24	35	72	30	46
RU	25	20	20	17	7	17	17	43	35	22
SL	n/a	n/a	n/a	n/a	n/a	48	59	67	n/a	n/a

* - Includes categories 'moderate interest' and 'deep interest'

According to Table 6, boys from Japan, Malaysia and Russia express a deeper interest towards physics, chemistry and biology as career options than towards Earth and environmental sciences. Boys from Malaysia are more positive in this regard towards physics, and boys in Ukraine are towards Earth science than boys from other countries. Girls from all countries seem to be motivated to choose a career in biology more than in other areas of science. The 'least interesting' for them appears to be physics. Girls from Japan might be less interested in a career in any area of science than their coevals of both sexes. Girls from Malaysia, Ukraine and Russia are 2-3 times more interested in a career in Environmental science than boys. Girls from Sri Lanka seem to be more interested in physics and chemistry than other groups of girls. This trend might be explained by a higher level of interest in science careers of students from less 'wealthy' economies in general. However, girls from Ukraine taking part in the present survey expressed a higher interest towards biology as a career option than students from Sri Lanka. Also, they showed the highest level of interest towards learning this area of science (Table 1). However, it is unclear, whether this phenomena would be present if an equal number of samples from all participating countries was collected, or in a survey of a larger scale.

Comparison of Tables 1 and 6 shows, that there is a considerable difference in attitudes of boys from Malaysia and Japan towards two blocks of science: 1) physics, chemistry, biology, and 2) Earth and environmental sciences in both categories (learning and career). Students from both countries are significantly more positive towards block 1 comparing to block 2. It is unclear though, if these categories (interest in learning and interest in career) are interrelated in students' perception, and what reasons for them are. While in both systems of education Earth science is considered to be an area of minor importance in comparison to other three, the present study does not determine the correlation degree between this factor and the trend in students' attitudes.

5. Country's support of careers in science (students' assessment)

One of the factors of students' motivation when selecting a certain career might be economic benefits associated with it. Therefore, to study possible reasons of students' attitudes towards careers in science, as a part of the present survey students were asked to give an assessment of the salary level of scientists and researchers in their countries of residence. The assessment was conducted according to the following scale: 1) insufficient, 2) rather insufficient, 3) rather sufficient, 4) sufficient. Table 7 shows the percentages of students who consider the salaries of scientists and researchers to be insufficient in their countries.

Table 7. 'Insufficient' science and research salaries (students' assessment)

Country	'Insufficient'* science and research salaries									
	Boys, %					Girls, %				
	Ph	Ch	Bi	ES	EnvS	Ph	Ch	Bi	ES	EnvS
JP	41	40	40	42	43	31	30	33	26	25
MY	30	32	35	34	36	43	37	37	46	48
UA	51	62	56	56	40	62	43	49	53	46
RU	27	20	33	27	47	39	35	22	26	30
SL	n/a	n/a	n/a	n/a	n/a	65	67	61	n/a	n/a

* - Includes categories 'insufficient' and 'rather insufficient'

According to Table 7, there are no significant differences between areas of science in the assessment of students of a certain sex in each country. There is one exception: evaluation of the environmental science by boys from Russia. However, it may be the result of a smaller number of samples collected from this country in comparison with others. Table 7 shows that boys and girls in each of countries-participants tend to give a rather similar assessment. In general, more students from Ukraine and Sri Lanka evaluate science and research salaries in their countries as 'insufficient' in comparison to Japan, Malaysia and Russia. Comparison of Tables 6 and 7 shows that students' attitudes towards careers in science may have little correlation with the assessment of economic benefits associated with them. In particular, fluctuations among values indicating the interest towards careers in certain areas of science are significant (Table 6), while all areas might be evaluated similarly in terms of science and research salaries (Table 7).

6. Science for top and low performers (Japan's case)

There might be certain beliefs associated with science teaching and learning in a particular society and even globally. The present survey addressed one of the most basic and controversial, i.e. whether there are areas of science that top and low performers in science are not supposed to 'like'. If such tendency is present, it might become one of the factors defining the students' choice of science subjects in secondary and higher education. The assessment was made by Japanese school teachers and parents of children attending either lower or upper secondary school. The respondents were asked, whether there are areas of science which students with high and low marks in science tend to like. The results are presented in Table 8.

Table 8. Areas of science that top and low performers in science like (teachers' and parents' assessment, Japan's case)

Attitude	Top performers (teachers, %)				Low performers (teachers, %)				Top performers (parents, %)				Low performers (parents, %)			
	Ph	Ch	Bi	ES	Ph	Ch	Bi	ES	Ph	Ch	Bi	ES	Ph	Ch	Bi	ES
'Like'	66	75	23	6	3	11	78	20	88	66	14	8	10	7	83	33

According to Table 8, the evaluation given by teachers and parents draws up a similar trend. In particular, low performers in science are not considered to 'like' physics and chemistry. However, they are supposed to 'like' biology. In opposite, top performers are supposed to 'like' physics and 'chemistry' to a much higher degree than biology and Earth science. In particular, only 23% of teachers and 14% of parents expressed an opinion that top performers 'like' biology. In regard to Earth science it is 6% and 8% respectively. The reasons of this perception are unclear, but there might be an image of biology and Earth science as areas that 'do not fit' the top performers in school science. Such image might be the result of an assessment of school biology and Earth science as 'simple' subjects in comparison to 'exact sciences' involving accurate quantitative expressions and precise predictions (physics and chemistry). While this part of the survey concerned Japan, such tendency might be a universal one.

Conclusions

The conclusions are summarized as follows.

1. Male students in all countries expressed a similar degree of interest towards learning physics, chemistry and biology and these areas of science as career options. A significant difference in attitudes is present in case of Earth science between blocks

of countries (Japan, Malaysia and Russia, Ukraine), which represent two different systems of education. Male students from the latter block express significantly more positive attitudes than their coevals from the former one. However, the degree of correlation between the attitudes and the characteristics of the education systems are unclear.

2. Female students in all countries are the 'least positive' towards learning physics, and it as a career option, and the 'most positive' towards biology. Female students from Japan might be the 'least interested' in regard to both categories.

3. According to teachers' and parents' assessment in case of Japan, male students are considered to prefer chemistry rather than other areas of science, while girls are considered to prefer biology. It is supposed that the 'least favorite' and 'interesting' for boys is Earth science. For girls, it is physics and Earth science.

4. Male and female students from Japan are more indifferent toward learning science than considered by their teachers.

5. Students' attitudes towards areas of science and the degree of their 'usefulness' might be rather independent values. This statement might be also correct in relation to perception of science areas as 'simple' or 'complex'.

6. Students' attitudes towards a career in a certain area of science may have little correlation with the economic benefits associated with it.

7. In Japanese society, there might be a belief that students who are top performers in school science do not prefer biology and Earth science. It may be a universal tendency.

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