Research Paper

Teachers' Assessment of Biology Education in Comparison to Other Areas of Science in Lower Secondary Schools of Japan - A Case Study -

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This research aims to analyze characteristics of a relative prioritization of physics and chemistry in comparison to biology in lower secondary schools of Japan. Analysis is conducted in regard to instructional time, curriculum content and the impact of the last education reform. It is based on the results of a questionnaire for teachers of Science ('Rika') of grades 7-9 that collected 68 samples from 27 public schools. This study identifies biology as an area of science with less instructional time and content than physics and chemistry in teaching practice. In grades 7 and 8, respectively, 82% and 91% of teachers estimate that instructional time for biology might be less than recommended in teachers' manuals. Sixty-six percent of teachers state that biology is the area of science that has less content than physics and chemistry. These and other tendencies outlined by the present research may be common for the majority of schools in Japan and have international analogues.

Key words: *biology curriculum, biology in science teaching, Japanese lower secondary school, teachers' assessment*

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INTRODUCTION

The 21st century is referred to as 'the era of biology' (Johnson 2008; National Research Council 2009). However, it is unclear whether systems of school education worldwide are prepared for a challenge of promoting biology education. In particular, if they place an equal emphasis on this area of science in comparison to others. When an education system is balanced between the various science disciplines, they have similar characteristics in regard to instructional time, amount of content, its particularity and updates, *etc*. This kind of balance ensures a successful development of biology and of the whole system of science teaching and learning.

Publications on Japanese biology and environmental education cover a wide range of topics including curriculum analysis (Kato 2011), development of teaching materials (Watanabe 2011; Naekawa 2012), teachers' education (Hotta and Chiba 2012; Matsumori *et al.* 2012), international comparison (Katayama 2010; Chong and Ikezaki 2011), policy evaluation and perspectives (Nakamichi 2008; Hatogai 2010), attitudes and ethics (Suzuki, 2007; Yamamoto 2012; Yamaya and Suzuki 2012), and others. International research provides a significant number of manuscripts investigating the state of biology education in National Standards and teaching practices in different countries (Beyer *et al.* 2009; Donnelly and Sadler 2009; Roseman *et al.* 2010; Cepni and Kara 2011; Nargund-Joshi *et al.* 2011; Geilsa and Graca 2012; Hasson and Yarden 2012; Long 2012; Park and Chen 2012; Semali and Mehta 2012; Vedder-

Weiss and Fortus 2013; Bostan 2013).

In 2009-2012, school science education in Japan experienced a reform that resulted in a number of structural changes, a revision of curricula and an increase of instructional time for Science (MEXT 2008).

Neither Japanese nor foreign authors have been focused on the following research objectives before or after the reform: (1) if in Japan all areas of school science (physics, chemistry, biology, Earth science) have equal characteristics in relation to instructional time and content in National Standards and teaching practices; (2) if there are more and less 'prioritized' (emphasized) areas of science, and the reasons and consequences of this phenomena.

An analysis of areas of science in terms of their 'importance' (factual prioritization) is essential, especially in an education system where science is taught as one subject till upper secondary school level. This kind of study would contribute to the understanding of a wide range of characteristics and issues in education, including reasons for students' attitudes, performance, scientific literacy, and so on. Moreover, such phenomena as 'primary' (more prioritized) and 'secondary' (less prioritized) areas of science in school education might exist at the global (international) scale and therefore have major consequences in terms of general knowledge of biological phenomena.

This study examines the position of biology in Japanese lower secondary schools (grades 7-9) in terms of its priority among areas composing the subject Science. The goal of the research is to contribute to the development of life science education by advancing the present body of knowledge in it, and by establishing the basis for a further international comparison of its practices through studying them in the schools of Japan.

In Japan, there are two types of schools: public and private. This survey targets only public ones because of their significantly greater number and more 'general' approaches in science education in contrast to private schools that may offer rather specialized curricula.

The study uses mixed methods to address three objectives:

Objective 1: to compare instructional time allotted to biology and other areas of science (physics, chemistry and Earth science) officially (in teachers' manuals, guidebooks, *etc*.) and in practice in lower secondary schools of Japan.

Objective 2: to compare the curriculum content of biology and other areas of science in the National Curriculum Standards and in practice.

Objective 3: to evaluate the impact of 2009-2012 reform of the National Curriculum Standards ('The Course of Study') on biology in comparison to physics, chemistry, Earth science, *i.e.* to identify recent tendencies in the development of science education in Japan.

Objectives 1 and 2 inquire whether biology is 'equal' to other areas of science in the two most fundamental characteristics: instructional time and content. Objective 3 inquires about the degree of impact of the last reform on areas of science, *i.e.* if all of them are emphasized equally by the reform.

RESEARCH METHODOLOGY

Methods for objectives 1-3 include an analysis of primary data obtained by a survey conducted using a questionnaire for lower secondary school teachers of Science (subject 'Rika'), and secondary data obtained by the review of the National Curriculum Standards (called 'The Course of Study' in Japan), the Curriculum Guidelines, manuals for school teachers, Japanese and international publications.

The questionnaire consisted of 22 questions and was structured as follows:

1. Personal background and experience (8 questions);
2. Teaching practices in areas of science curricula (8 questions);

3. General assessment of school science education in Japan (6 questions).

In this paper, respondents' answers on 13 questions out of 22 are presented. Questions regarding respondents' personal background included the following: the grade(s) which respondents were teaching at the time when the survey was conducted, years of teaching experience, and the major (the main area of study when they were in higher educational institutions).

Two approaches were used to determine instructional time allotted to biology and other areas of science (Objective 1). Firstly, a review and analysis of teachers' manuals that are published in Japan by textbook publishing companies were conducted. There was no significant difference in main characteristics of teachers' manuals published by different publishers while all of them are based on Courses of Study established by the Ministry of Education, Culture, Sports, Science and Technology of Japan (MEXT). In this research, a series of teachers' manuals published by Dainippon Tosho (Dainippon Tosho 2012 a, b, c) were reviewed and analysed, because those were the most commonly used ones in the schools where the survey was conducted. According to them, total instructional time is almost equally divided between the four areas of science.

After this stage of analysis, respondents were asked about their factual practices in science teaching by the questionnaire.

Questions inquiring about the instructional time were as follows:

Question a: If 'Science' was to be divided into 4 areas (physics, chemistry, biology, Earth science), is there a difference in factual instructional time between the areas in general? If there is, place the areas of science according to their instructional time in practice from 1 (the least) to 4 (the most).

Question b: Indicate the percentage of instructional time for each area of science in teachers' manuals and in practice (by grade).

Question c: Indicate areas of science for which you experience a deficiency of instructional time (by grade).

Question d: Indicate areas of science consuming more instructional time than designated in teachers' manuals (by grade).

Question e: Indicate areas of science for which instructional time increase or reduction might be recommended (by grade).

Questions inquiring about the content (Objective 2) were as follows.

Question f: If 'Science' was to be divided into 4 areas (physics, chemistry, biology, Earth science), is there a difference in the amount of content between the areas in general? If there is, place the areas of science according to the amount of content from 1 (the least) to 4 (the most).

Question g: Indicate areas of science for which new content might be recommended (by grade).

Question h: Indicate areas of science for which more detailed content might be recommended (by grade).

Question i: Indicate areas of science for which an increase in the number of experiments might be recommended (by grade).

Concerning the impact of the reform (Objective 3) there was one question as follows: 'Indicate areas of science that experienced the most substantial changes caused by the last reform in education (2009-2012) by grade.'

Schools selected for the survey were located in areas with varying population density, from some rather rural locations in Yamanashi Prefecture (Yamanashi and Kofu cities), to others located in the most highly populated areas of the country, such as the Ota Ward of Tokyo Metropolis. Schools were selected randomly. Principals and teachers were contacted by various means of communication (*e.g.* e-mail, postal, telephone, in person) and asked to participate in the survey. Commonly, a questionnaire required from 15 to 20 minutes to complete. From October to December 2012, the questionnaires were administered to 87 teachers of 34 schools. Sixty-eight answer sheets from 27 schools were received till the determined deadline (December 1, 2012). Therefore, the response rate was 78%. The student population taught by the participants was estimated by them as 13 145. Among schools that participated in the survey, five were located in Yamanashi prefecture (three in Kofu City and two in Yamanashi City). Other twenty-two schools were located in various areas of Tokyo Metropolis (9 wards and 7 cities).

Teachers were asked to answer questions for all grades and areas of science regardless of their teaching statuses in the time when the survey was conducted. Also they were asked to leave any question that they did not wish to answer, blank. All participants were informed that the results of the survey would be used for publications in the area of educational research and further studies.

RESULTS

1. Characteristics of the respondents

Distribution of the respondents by the grade(s) taught in the time of the survey (September through November 2012) were as follows: teachers of grade 7 (n=11; 16%); teachers of grades 7 and 8 (n=8; 12%); teachers of grades 7 and 9 (n=4; 6%); teachers of grade 8 (n=18; 26%); teachers of grade 9 (n=17; 25%); teachers of grades 8 and 9 (n=8; 12%); teachers of grades 7, 8 and 9 (n=2; 3%).

Teaching experience of the respondents is presented in Table 1.

According to the subjective self-assessment, distribution of the respondents by their major was as follows:
agriculture: n=6 (9%); biology: n=19 (28%); chemistry: n=18 (27%); Earth science: n=7 (10%); engineering: n=2 (3%); environmental sciences: n=5 (7%); physics: n=15 (22%). Four teachers (6%) claimed to have two majors. However, the majority of the teachers who participated in the survey (94%) had one major, which is common in Japan. Although having one major, lower secondary school teachers in Japan teach the four areas of science (physics, chemistry, biology and Earth science) composing the course of Science, often in two or all three grades.

2. Comparison of instructional time for biology and other areas of science in grades 7-9 in teachers' manuals and in practice

Teachers' manuals and practice

Comparison of allocation of instructional time between areas of science in teachers' manuals (TM) and in practice of the respondents is presented in Table 2. The data presented in Table 2 correspond to question b) of 'Research methodology'. In grade 9, an accurate partition of the instructional time is impossible, as approximately 25% of topics are interdisciplinary topics and research projects.

Table 1. Teaching experience of the respondents

Teaching experience (years)	<1	1-5	6-10	11-15	16-20	21-25	26-30	over 30
Number of Teachers	9	14	12	4	10	4	11	4
Percentage	13	20	18	6	15	6	16	6

Table 2. Instructional time for areas of science in teachers' manuals (TM) and in practice by grade*

Area of science	Grade	Instructional time (%)		Number of Teachers (%)		
		TM	Teaching practices**	More than in TM	As in TM	Less than in TM
Physics	7	27	25-35	32	18	50
	8	23	20-30	97	0	3
	9	28	25-35	---	---	---
Chemistry	7	25	20-35	41	50	9
	8	26	25-35	41	3	56
	9	27	23-33	---	---	---
Biology	7	27	19-30	9	9	82
	8	30	20-30	0	9	91
	9	23	17-27	---	---	---
Earth Science	7	21	15-30	45	0	55
	8	21	15-30	59	3	38
	9	22	20-30	---	---	---

* Answers (n=62)
** Instructional time for areas of science in practice. For example, teachers of grade 7 estimate instructional time for biology in practice to vary between 19% and 30%.

As shown in Table 2, in grades 7 and 8, 82% and 91% of respondents, respectively, allotted less time to biology than that prescribed in the teachers' manuals, while they allotted more time to physics and chemistry than prescribed in the manuals. While teachers evaluate variation of instructional time for physics and chemistry in practice from 35 to 20%, in the case of biology it is from 30 to 17%.

In Table 2, assessment of instructional time for areas of science by grade is presented. Next, respondents were asked if there was a difference in instructional time between areas of science in general. If the answer was positive, respondents were asked to rate areas of science from 1 (the least) to 4 (the most) according to their instructional time (Question a) of 'Research methodology'). So, for example, if physics is rated as '1', it is the area of science with the least instructional time. Answering this question, forty-nine respondents out of 68 reported a difference in instructional time depending on the science field. Others (19) reported no such difference, *i.e.* they allotted instructional time equally between all areas of science. The results are presented in Table 3.

Table 3. Areas of science according to their instructional time from 1 (the least) to 4 (the most) in practice*

Place	Number of Teachers (%)			
	Physics	Chemistry	Biology	Earth Science
1	4	14	28	70
2	21	19	37	12
3	56	32	26	4
4	19	35	9	14

* Answers (n=49)
Shaded areas indicate the highest percentage in each column.

As shown in Table 3, 9% of teachers state that biology is the field with the most instructional time, for physics it is 19%, and for chemistry it is 35%. In contrast, 28% of teachers claim that biology is the field with the least instructional time, while for physics and chemistry it is 4% and 14% respectively. Approximately 70% of respondents evaluate Earth science as the area with the least instructional time; 37% - biology as number 2; 56% - physics as number 3; and 35% - chemistry as the area with the most instructional time (highlighted by shaded areas).

Tables 2 and 3 show that factual instructional time in grades 7-9 of Japanese schools differs from that recommended by the teachers' manuals. This deviation might be caused by the imbalanced content, teachers' perception of science fields, for example, assessment of their complexity or importance for students' future, *etc.* There was no tendency for teachers to allot more time to teaching the area of science related to their majors.

When teachers experience a lack of time for instruction in science topics, they may reallocate teaching hours between topics and disciplines. However, if there are 'priority' disciplines or topics in science education, *i.e.* certain areas are considered to be 'more important', teaching hours may be reallocated in their favour independently of time deficiency for other areas.

Areas of science with the deficiency of instructional time

Teachers' evaluation of the deficiency of instructional time for areas composing Science in grades 7-9 of Japanese schools (Question c) of 'Research methodology') is shown in Table 4.

As shown in Table 4, more teachers report that they experience a deficiency of instructional time for physics, chemistry and Earth science than for biology in grades 7-9. In particular, while 14% of teachers of grades 7-9 report to have not enough time for instruction in biology, in other areas of science it is 41, 59 and 39%, respectively.

Table 4 highlights the deficiency of instructional time that may be caused by various reasons, such as teachers' assessment of their own skills in science instruction, perceived level of complexity of science areas for students, *etc.* However, it is crucial to understand how teachers evaluate the allocation of instructional time 'officially', *i.e.* in National Standards, teachers' manuals, *etc.* Therefore, respondents were asked if factual instructional time in classrooms exceeded that prescribed by teachers' manuals.

Areas of science requiring more instructional time than prescribed

Table 5 shows the number of respondents stating that the instructional time for certain areas of science in practice exceeded that recommended by teachers' manuals (Question d) of 'Research methodology'.

Table 4. Deficiency of instructional time in science by grade (multiple selection)*

Grade	Teachers who feel the deficiency of instructional time (%)			
	Physics	Chemistry	Biology	Earth Science
7	22	29	4	20
8	20	25	10	18
9	14	29	6	16
Overall	41	59	14	39

* Answers (n=49)

Table 5. Areas of science consuming more instructional time than designated in teachers' manuals (multiple selection)*

Grade	Teachers who consume more instructional time than recommended (%)			
	Physics	Chemistry	Biology	Earth Science
7	36	29	10	0
8	19	39	7	0
9	16	36	3	0
Overall	52	77	16	0

* Answers (n=31).

As shown in Table 5, 52% and 77% of teachers state that physics and chemistry consume more instructional time than in teachers' manuals. In the case of biology only 16% of respondents give this statement. It means that instruction in physics and chemistry requires additional hours more often than instruction in biology. Therefore, teachers appear to reallocate instructional time between areas of science, *i.e.* use that prescribed for biology for teaching physics and chemistry.

Areas of science where instructional time increase or reduction might be appropriate

Teachers' evaluation of areas of science which might require additional instructional time or its reduction (Question e) of 'Research methodology' is presented in Table 6.

An increase of instructional time for at least one areas of science in at least one grade was recommended by 39 teachers. Accordingly, a reduction of instructional time was recommended by 22 teachers. So if, for example, a teacher recommended to reduce the instructional time for grade 7 physics and for grade 8 chemistry, it was counted as a single 'decrease' answer (it is approximately 5% of the 22 respondents) for both grade 7 Physics and grade 8 Chemistry. 'Increase' answers were counted in the same manner, but there were 39 respondents. Accordingly, the percentage of 39 respondents was calculated. So, if the same person answered 'increase the time' for one area and 'reduce the time' for another, these were counted as two separate answers.

Table 6. Areas of science in grades 7-9 for which the increase or reduction of instructional time might be appropriate (teachers' assessment, multiple selection)

Grade	Increase (teachers %)*				Reduction (teachers %)**			
	Ph	Ch	Bi	ES	Ph	Ch	Bi	ES
7	33	41	21	33	18	9	27	18
8	36	33	21	10	14	14	23	32
9	21	49	13	21	32	9	14	23

* Answers (n=39)
**Answers (n=22)
Ph – physics, Ch – chemistry, Bi – biology, ES – Earth science

As shown in Table 6, teachers identify physics, chemistry and Earth science as areas of science which require additional instructional time to a higher degree than biology in all grades of lower secondary school, with the exception of biology and Earth science comparison, grade 8. For biology a reduction in instructional time is suggested to a higher degree than in physics and chemistry, with the exception of biology and physics comparison in grade 9. However, according to teachers' manuals for grade 9 science, biology has 23% of instructional time which is less than for physics and chemistry. Also, the results highlight respondents' general preference to increase time for chemistry in all grades than to decrease it ('increase': 41%, 33%, 49%; 'decrease': 9%, 14%, 9%, respectively). The same pattern is observed in relation to physics in grades 7 and 8 ('increase': 33% and 36%; 'decrease': 18% and 14%, respectively). Although, in grade 9 it is the opposite: teachers may prefer to decrease physics' instructional time. For Earth science, there is a stronger preference to increase instructional time in grade 7 (33%), to decrease it in grade 8 (32%), and an equal preference to increase and decrease in grade 9 (21% and 23% respectively). For biology, almost equal number of respondents would prefer to increase and decrease instructional time in all grades ('increase': 21%, 21%, 13%; 'decrease': 27%, 23%, 14%, respectively).

3. Curriculum content for biology in comparison to other areas of science in the National Curriculum Standards and in practice in Japanese lower secondary schools

In regards to the content of biology in Science, analysis was conducted using four parameters: 1) amount of content; 2) areas of science requiring new content; 3) areas of science requiring more detailed content; 4) areas of science requiring an increase in the number of experiments.

Amount of content

When answering Question f) of 'Research methodology', twenty-four respondents out of 68 reported that areas of lower secondary school science differ in terms of the content. Distribution of areas of science according to their content from 1 (an area with the least amount of content) to 4 (an area with the most amount of content) is presented in Table 7.

Teachers identify biology as the area of science that has less content than physics and chemistry. While 4% of teachers state that biology is the field with the most content, for physics it is 33%, for chemistry it is 42%. Approximately 79% of respondents identify Earth science as the field with the least amount of content; 58% - biology as number 2; 42% - physics as number 3; 42% - chemistry as the field with the most amount of content (highlighted by shaded areas).

Areas of science requiring new or more detailed content

Teachers' assessment of the necessity for new or more detailed content for lower secondary school science is presented in Table 8. The data shown in Table 8 is teachers' responses to the Questions g and h of 'Research methodology'.

Table 7. Content for areas of science from 1 (the least) to 4 (the most) (teachers' assessment)

Place	Amount of content (teachers %)			
	Physics	Chemistry	Biology	Earth Science
1	8	4	8	79
2	17	17	58	8
3	42	37	30	0
4	33	42	4	13

* Answers (n=24).
Shaded areas indicate the highest percentage in each column.

Teachers state that chemistry requires new content to a higher degree than biology in grades 7 and 8 (44% and 40% comparing to 13% and 33%, respectively). Though, in grades 8 and 9 biology requires new content more than physics and Earth science. At the same time, the respondents evaluate physics, chemistry and Earth science as areas of science which require more detailed content to a higher degree than biology in all grades of lower secondary school with the exception of biology and Earth science comparison, grade 8.

Areas of science requiring an increase in the number of experiments

Summary of teachers' opinions concerning the areas of science which require an increase in the number of experiments (Question i) of 'Research methodology' is presented in Table 9.

The respondents evaluate biology as the field that requires an increase in the number of experiments to a higher degree than others in grades 7-9. Apparently, teachers are not as satisfied with present biology experiments as with those in physics and chemistry.

Table 8. Areas of science requiring new or more detailed content by grade (teachers' assessment, multiple selection)*

Grade	New content (teachers %)*				More detailed content (teachers %)**			
	Ph	Ch	Bi	ES	Ph	Ch	Bi	ES
7	13	44	13	31	50	25	9	16
8	20	40	33	7	44	31	16	9
9	13	35	35	17	29	42	10	19

* Answers (n=16, grade 7; n=15, grade 8; n=23, grade 9)
** Answers (n=44, grade 7; n=45, grade 8; n= 52, grade 9)
Ph – physics, Ch – chemistry, Bi – biology, ES – Earth science

Table 9. Areas of science requiring an increase in the number of experiments (teachers' assessment, multiple selection)

Grade	Fields requiring an increase in the number of experiments (teachers %)			
	Physics	Chemistry	Biology	Earth Science
7	18	21	32	29
8	14	25	36	25
9	13	21	34	32

* Answers (n=38, grade 7; n=44, grade 8; n=38, grade 9)

4. Assessment of the impact of 2009-2012 reform on science teaching in Japan

Various aspects of school science reform (the revision of the Course of Study) that happened in Japan in 2009-2012 have been addressed and analysed (Arani and Fukaya 2010; Gordon *et al*. 2010; Hatogai 2010; Nakamichi 2010). The reform's methodological platform, structural aspects, quantitative and qualitative characteristics were described by these researchers. However, teachers' assessment of the reform's impact on areas composing Science has not been conducted yet. Therefore, as a part of this survey the respondents were asked what fields experienced 'the most substantial change' in terms of curriculum with the reform.

More teachers of all grades identify physics and chemistry as the areas that experienced 'the most substantial' changes with the last reform in contrast to biology and Earth science (Table 10).

Table 10. Impact of the education reform of 2009-2012 on areas of science (teachers' assessment, multiple selection)

Grade	Areas of science (teachers %)			
	Physics	Chemistry	Biology	Earth Science
7	37	41	14	8
8	36	30	23	11
9	20	56	14	10

* Answers (n=51, grade 7; n=53, grade 8, n=57, grade 9)

DISCUSSION

Survey analysis

The results of the survey indicate that biology instructional time in lower secondary schools is less than recommended by teachers' manuals, *i.e.* it is reduced by teachers in favour of physics and chemistry. Accordingly, its content is reduced (partly taught superficially or not taught). Therefore, biology is relatively less prioritized than physics and chemistry in the teaching practice of some Japanese lower secondary schools, while no differences were determined in National Curriculum Standards or teachers' manuals. In order to identify, if this tendency is present in the majority of public and private secondary schools in the country, the same research should be conducted on a larger scale (a larger number of respondents from different areas).

The explanation of a reallocation of teaching hours in favour of physics and chemistry might be that these areas require and consume more instructional time than designated, as indicated by the survey's participants.

Teachers identify the following reasons of this situation:

(1) Physics and chemistry underwent more substantial changes than biology during the education reform of 2009-2012, as shown in Table 10;

(2) They became more difficult for students as a result of the reform, and are more difficult for students than biology in general, as suggested by respondents through personal communication.

Teachers suggest more detailed content for physics and chemistry, while for biology they do not. In contrast, for biology they suggest new content and an increase in the number of experiments. It means that teachers evaluate the present curricula in physics and chemistry as not detailed enough. This may be one of the reasons why they are complex for students' comprehension. Two other reasons are mentioned above. As a result, instruction in physics and chemistry consumes more time than recommended. Instead, the content of biology is detailed enough, so it does not require additional time and even allows its reduction, till new content and more experiments are introduced into this area.

It is unclear whether the present situation in science education is a consequence of the reform, because teachers also state that physics and chemistry are in general more complex disciplines for students. Therefore, to identify if the tendency of prioritization of these two areas of science over biology is an emerging and temporary phenomenon (the result of the reform), or a long-existing and continuous trend, further research is needed. For example, a similar survey after a certain period of time may provide an answer. However, other social and economic issues, such as teachers' and students' attitudes and perception of science education, characteristics of the secondary and higher education system, entrance examination procedures, pedagogical education, requirements of the labour market, and others, have to be taken into account.

Findings of the survey may find proof in international research data. In particular, TIMSS project (The Trends in International Mathematics and Science Study) highlights an issue relevant to its results.

TIMSS analysis

The Trends in International Mathematics and Science Study (TIMSS) is one of two major international projects for educational comparison and assessment. The project presents a set of data, and, in particular, 'an average percentage of students taught TIMSS science topics' up to and including grade 8 by areas of science (physics, chemistry, biology, Earth science, and environmental science). According to TIMSS 2003 and 2007, the percentage of Japanese students who were taught TIMSS biology topics is 39% and 32% in comparison to an international average of 70% and 66%, respectively. The figures in physics (68% in 2003; 67% in 2007) and chemistry (80% in 2003; 81% in 2007) are higher or close to the international average. Over 40% of TIMSS biology topics in both 2003 and 2007 were not included in the Japanese curriculum through grades 1-8 (Martin et al. 2004, 2008). When analysing this data, some characteristics of Japanese education are to be considered. In Japan, a number of topics concerning the human body and its processes are a part of a separate subject (Physical Education). Therefore, they may not be taught as biology topics. However, TIMSS reports might have outlined a relative prevalence of physics and chemistry over biology in Japanese schools in terms of the implemented curriculum. This assumption finds linkage to the results of the present study.

Consequences of the present position of biology in Japanese school science

Assessment of educational policies and practices is known to be a particularly complex matter because of their long-lasting outcomes, various stakeholders and issues involved, and arising controversies. Japan is one of the top countries in students' performance in science according to PISA (Program for International Student Assessment) and TIMSS (Trends in Mathematics and Science Study) (PISA 2006; Martin *et al*. 2008, 2012). Because of this, its education system is often evaluated as 'highly effective'. However, the questions used for students' assessment in both projects in general replicate basic experiments which are a part of most curricula worldwide, though Japanese schools have better resources for conducting them than the majority of participating countries. Also, Japanese science curricula are more focused on the experimental part of curricula rather than on the theoretical one, while other countries might have a different approach.

While PISA and TIMSS evaluate science knowledge of the general student population and include basic problems, International Science Olympiads include a more advanced scientific content and examine a small group of top-performing students. In 2006-2012, Japanese teams each consisting of 4 students won 5 gold medals in biology (3 of which were awarded in 2011) and 8 in chemistry. In physics, a team of 5 students won 10 gold medals during this period of time (IBO 2012; IChO 2012; IPhO 2012). Therefore, Japan in Science Olympiads may have a relatively lower performance in biology than in chemistry and physics. However, an assessment of these results is complex as it involves various issues. For example, students' performance may depend on the translation of test problems which are often more extensive in biology than in other areas of science (Matsuda, personal communication, 2012).

There is a substantial difference between Japanese and top performers' figures in all areas of science. In biology, China, USA and Chinese Taipei have won 26, 27 and 20 gold medals in 2006-2012, respectively (IBO 2012).

While exact causes of a relatively lower performance of Japanese students in biology Olympiads are to be studied, the present issues of biology education might be linked to it.

Other possible consequence of the situation with biology in Japan might be the scientific literacy of Japanese adults. Organization for Economic Co-operation and Development (OECD) states that it is the lowest among participants. According to some researchers, in biological concepts it is lower than in other areas of science (National Science Foundation 2006).

CONCLUSIONS

This study found a substantial difference between science curricula designated for lower secondary schools in Japan and implemented in them. Biology is given a lower priority in comparison to physics and chemistry in teaching practices of grades from 7 to 9, while there is no such tendency in either National Standards or teachers' manuals. As a result, the system of factual science education may be rather unbalanced, and it may have negative consequences in various areas, such as education, science, economy, and others. It is unclear if prioritization of physics and chemistry is a result of the last reform of science education, and if this tendency is present in the majority of schools in Japan. To clarify these issues a further research is necessary. However, this study contributes to the present body of knowledge about biology education in Japan by analysing a previously overlooked tendency.

Respondents of this survey identified the areas for development not only in biology, but in the whole system of school science education in Japan, such as a deficiency of instructional time, quantity and particularity of content, improvements in regard to science experiments, and others. In this regard the present survey also makes a contribution into the development of Japanese science education, especially if these issues will be studied and addressed by educators and officials.

A presence of 'primary' (more prioritized) and 'secondary' (less prioritized) areas of science in school education will undoubtedly influence a wide range of educational issues in a country where such tendency is observed. The survey establishes a basis for an international comparison of the disposition of priorities in science education conducted in Japan, while it does not identify if the Japanese tendency is a unique, or an international one.

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