Science teacher education in Japan: Implications for developing countries

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1. Introduction

It is said that the 21st century is an era of a "knowledge-based society" in which new knowledge and technology should play an important role in the foundation of activities in policy, economy and culture. To live in this rapidly changing era, problem solving skills are important because firstly, we have to find the issues; secondly, we have to think deeply after we learn something related to the issues; thirdly, we have to decide based on evidence; and finally, we have to take action. Science education plays an important role in cultivating problem solving skills because learners find their own issues to research, they think of the method of experiment and collect data, then they think well and draw conclusions. For countries like Japan, which have limited natural resources, science education is also important to train human resources like scientists and engineers. Also the citizens in democratic countries, who have to select policies through voting, should decide based on evidence. Science education helps them to have such skills.

This paper briefly reviews the current condition of Japanese learners and teachers in science education. Then it also describes some measures conducted to cope with the challenges of Japanese science education. Finally some implications for science teacher education in developing countries will be given.

2. Current conditions of Japanese learners in science education

International and domestic surveys of Japanese learners for science education indicate their relatively strong performance and challenges as to their attitude towards science.

(1) TIMSS survey

The Trends in International Mathematics and Science Study (TIMSS) measures trends in mathematics and science achievement at fourth and eighth grade levels and it provides comparative information about educational achievement across countries (IEA, 2008). In the TIMSS survey of science assessment, the average scale score of Japanese Grade 4 learners and Grade 8 learners is in the top stream (See Table 1). TIMSS2007 also surveys the learners' attitude to learn science. 53% of Japanese G8 learners think "learning science will help me in

my daily life", while the international average is 84%. 27% of Japanese G8 learners think "I need to learn other subjects", while the international average is 70%.

(2) PISA survey

The Programme for International Student Assessment (PISA) assesses the extent to which learners near the end of compulsory education have acquired the knowledge and skills that are essential for full participation in society, focusing on learner competencies in the key subject areas of reading, mathematics and science. PISA seeks to assess not only whether learners can reproduce what they have learned, but also to examine how well they can extrapolate from what they have learned and apply their knowledge in novel settings, ones related to school and non-school contexts (OECD, 2007).

Mean performance on the science scale of Japanese learners in the PISA survey is shown in Table 2. Performance of Japanese learners of scientific literacy in the 2006 survey declines a little from that of 2003 and 2000 (OECD, 2007). Japanese learners are good at "Using scientific evidence", but not good at "Identifying scientific issues" and "Explain phenomena scientifically". The PISA survey also shows learners' attitude towards the sciences (Table 3). Despite strong academic performance, the attitude of Japanese learners toward science is relatively negative.

Mean performance on the reading scale of Japanese learners in the PISA survey is shown in Table 4. In comparison with that of science literacy, performance on reading is not so strong and it declined in 2003 and retains a similar level in 2006.

(3) "Survey on specific issues (Science) JFY2005"

The National Institute for Educational Policy Research (2007) reported the result of a survey on specific issues (Science). The result indicates the challenges for Japanese learners in science education. For both elementary and lower secondary school learners, the following points are challenging; to think of the method of experimentation for solving issues and to consider based on the experiment data and skills in conducting experiments.

(4) Experiences of Japanese learners with Nature

According to the survey of the National Institute of Youth Education (2006), Japanese learners have fewer experiences with nature in JFY2005 in comparison with the same survey in FY1998 (Table 5). Experiences with nature like catching insects, seeing a sunrise or sunset and swimming in the sea or a river are thought to be the foundation of learning the sciences.

3. Current conditions for science teachers

(1) Pre-service training

Hashimoto (2009) indicates that university students do not have to study much subject content because the necessary credits to be acquired at university changed in 1999 (Table 6). Students can have an elementary school grade 1 license without learning science.

According to the survey of the Japan Science and Technology Agency (2009), less than half of elementary school teachers who teach science major in science at university (Table 7). Especially only 28 % of classroom teachers major in science. For lower secondary teachers most of them major in science at university. Half of the teachers in elementary school feel some challenges to teach science, especially 58% of teachers who have a non-science major at university feel challenges (Table 8). Their teaching experiences correlate to the ratio of the teachers who feel challenges. 60% of teachers who have less than a ten year teaching career feel challenges to teach science (Table 9).

The Japan Science and Technology Agency (2009) also illustrates the conditions of school or cluster based in-service training. 75% of lower secondary teachers open their science class to other teachers for lesson study at least once per year. Only 18% of classroom teachers open their science class because they also teach other subjects (Table 10). More than 80% of teachers in elementary and lower secondary teachers have a chance to discuss about their science lessons with their colleagues in the same school (Table11). For classroom teachers in elementary school, there are few chances to have meetings related to science education with teachers of other schools (Table 12).

4. New Japanese school curriculum “Course of Study”

Almost every ten years, the course of study is revised considering educational issues at that time. To deal with the current challenges of Japanese learners, the Minister of Education asked the Central Council for Education to discuss guidelines to revise the school curriculum. The Central Council for Education reviewed the current Course of Study based on the data of international and domestic surveys andutilized comments from teachers, parents, etc. The Central Council for Education submitted the report on the revision of the course of study to the Ministry of Education in January 2008. The Ministry of Education determined the new course of study for elementary school and lower secondary school in March 2008. The new course of study will be fully implemented from April of 2011. Some contents of mathematics and science were implemented from April of 2009 in advance.

The new course of study emphasized the following points;

(a) Language activities in each subject to enhance thinking ability, judgment and expressive ability
(b) Mathematic and science education to give foundations of science and technology
(c) Education on traditions and culture to enhance own identities

(d) Moral education to acquire basic standard of behavior
(e) Activities to have various experiences
(f) Foreign activities in elementary school

Basic principles for science are the following points:

(a) Reconstruction of domains in the science curriculum to cultivate basic knowledge and skills: “Energy”, “Particles”, “Life” and “Earth”
(b) To cultivate scientific thinking and expressive ability: Emphasizing on interpretation of observation and experiment results, on expression about what learners think
(c) To cultivate interest for science: to connect science content with the learners’ daily life, future career and sustainable development
(d) To experience learner activities in nature and practical exercises of making instruments

Periods for science in elementary school and lower secondary school will be increased from current course of study (Table 13) and some new topics will be added.

5. Some initiatives related to promote science education

(1) Promotion of Learning Ability Improvement Study

The purpose of this project is to investigate the appropriate teaching strategy to acquire the following skills and attitudes through action research in school:

(a) Well-established basics and fundamentals
(b) Thinking ability, judgment, expressive ability and problem solving ability
(c) Desire to continue to study

The Ministry of Education designated 121 elementary schools and 77 lower secondary schools in cooperation with prefectural boards of education in 2008 for a three year study. Each school conducts action research using lesson study method. Three elementary schools and six lower secondary schools conduct their research focusing on science. An example of a research theme is “Teaching Instructions for acquisition of comprehensive learning ability”. The schools hold a lesson study conference open to other schools after their study. The purpose of the conference is to present the outcomes of the action research; teachers of other schools in the region come and see model lessons. The Supervisors of the Boards of Education are invited as commentators in the post lesson conference. Demonstration lessons are presented and participants observe the lesson. Participants have a chance to discuss in the post lesson conference.

(2) Lesson study related to the implementation of new curriculum: case of lower secondary school attached to Naruto University of Education

One of the roles of university attached schools in Japan is to conduct action research and share the outcome to other schools. The 2009 research theme of the lower secondary school attached to Naruto University of Education is “Lessons which enhance thinking ability, judgment and expressive ability – through fruitful language activities”. This theme is directly

related to the implementation of the new course of study, which emphasizes language activities. Under this theme, each subject teacher including science teachers developed their lesson plan, conducted lessons and discussed. The result of the research was shared at the annual lesson study conference in June 2010. Also a research bulletin was published for sharing outcomes.

(3) "Training for mathematics and science teachers to improve their instructional skill"

The Japan Science and Technology Agency funded the training program to improve instructional skills. Boards of education coordinate the program in cooperation with universities and/or science museums. Practical and problem solving exercises, like observation and/or experiment, should be included. Also the program should have activities through which participants acquire the skill and knowledge to apply their lessons. The number of training workshops is 282 workshops in JFY2009, 224 workshops in JFY2008, 161 workshops in JFY2007 and 155 workshops in JFY2006.

(4) Science subject of University for future elementary school teachers: case of Naruto University of Education

"Science Education in Elementary Schools I" is a subject for the second grade of Naruto University of Education. It is compulsory for students of the elementary school course. Therefore students whose major is non-science have to take this subject. In the first half of this subject, students learn the outline of science curriculum of elementary schools in Japan, how to make lesson plans and how to implement experiments/observations. Then students are divided into groups. Each group is asked to implement a lesson with experiment or observation activity. Students select a topic for the lesson from textbooks, and develop teaching and learning materials. They try materials before implementation of the lesson. They prepare the lesson plan through these processes. One of the students in the group presents the lesson. Other groups play the role of elementary school students. After the presentation, students discuss how the lesson was implemented. Both good points and the challenges of the lesson are indicated, and constructive suggestions are provided. This subject gives students a good chance to experience both experiment and lesson study.

6. Implications for developing countries

Each country has its own challenges for science education and Japan is not an exception. In Japan, challenges for learners are identified based on the evidence collected by international or domestic surveys. To overcome these challenges new school curriculum is planned and implemented. School-based lesson study contributes to the realization of the intended curriculum as the implemented one. These evidenced-based approaches combined with school-based lesson study are also applicable for developing countries.

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Table 1 TIMSS survey result of Japanese learners

		2007	2004	1999	1995
Grade 4	Average scale score	548	543	-	553
	Ranking in participating countries	4/36	3/25	-	2/26
Grade 8	Average scale score	554	552	550	554
	Ranking in participating countries	3/49	6/46	4/38	3/41

Source: IEA (1997a, 1997b, 2000, 2004, 2008)

Table 2 PISA survey result of Japanese learners for scientific literacy

	2006	2003	2000
Score	531	548	550
Average of OECD countries	500	500	500
Ranking in participating countries	6/57	2/41	2/32

Source: OECD (2001, 2004, 2007)

Table 3 Attitude towards science of Japanese learners in the PISA 2006 survey. Typical negative attitudes of Japanese learners were selected. The number indicates the percentage of learners who agree or strongly agree with the statement.

Category of attitude	Statement	Japanese learners	OECD average
Personal value of science	I will use science many ways when I am an adult.	44	64
	When I leave school there will be many opportunities for me to use science.	48	59
Self concept in science	I can usually give good answers to test questions on school science topics.	29	65
Enjoyment of science	I am interested in learning science.	50	63
	I am happy to do science problems.	29	43
Instrumental motivation	I study school science because I know it is useful for me.	42	67
	Studying my school science subjects is worthwhile for me because what I learn will improve my career prospects.	41	61

Source: OECD (2007)

Table 4 PISA survey result of Japanese learners for reading literacy

	2006	2003	2000
Score	498	498	522
Average of OECD countries	492	494	500
Ranking in participating countries	15/57	14/41	8/32

Source: OECD (2007, 2004, 2001)

Table 5 Japanese learners' experiences with nature

Learners who have very few experiences	JFY2005	JFY1998
To catch insects like butterflies, dragonflies, grasshoppers etc.	34.9%	18.7%
To see sunrise and/or sunset	43.1%	33.6%
To swim in the sea and/or a river	26.0%	9.8%

Target: Grade 4, 6 and 8 learners
Source: National Institute of Youth Education (2006)

Table 6 Necessary credits to be acquired at university.

	Kind of licence	Specialist subject credits	Professional subject credits	Specialist Subject or Professional subject	Experience in care for the elderly
1999-Present	Elementary School Grade1	8	41	10	7
	Lower Secondary School Grade1	20	31	8	7
1998	Elementary School Grade1	18	41	0	7
	Lower Secondary School Grade1	40	19	0	7
1997	Elementary School Grade1	18	41	20	0
	Lower Secondary School Grade1	40	19	0	0

Source: Hashimoto (2009)

Table 7 Field in which science teachers major at university

	Who major in science at university	Who major in non-science subject at university
Elementary school classroom teacher	27.7%	72.3%
Elementary school Head of science team	46.7%	53.3%
Elementary school teacher who teaches science only	43.0%	57.0%
Lower secondary science teacher	94.9%	5.1%

Source: Japan Science and Technology Agency (2009)

Table 8 Percentage of elementary school teachers who feel challenges to teach science and their major at university

All teachers	Who major in science at university	Who major in non-science subject at university
50.5%	31.1%	57.8%

Source: Japan Science and Technology Agency (2009)

Table 9 Percentage of elementary school teachers who feel challenges to teach science and their teaching career

Under 5 years	From 5 to below 10 years	From 10 to below 20 years	From 20 to below 30 years	From 30 to above
63.5%	62.5%	38.7%	44.1%	46.3%

Source: Japan Science and Technology Agency (2009)

Table 10 Percentage of science teachers who open their science class to other teachers for in-service training

	Who open their science class at least 1 time per year	Who never open their science class
Elementary school classroom teacher	18.4%	52.7%
Elementary school Head of science team	42.9%	34.8%
Elementary school teacher who teaches science only	60.5%	24.6%
Lower secondary science teacher	74.5%	6.6%

Source: Japan Science and Technology Agency (2009)

Table 11 Percentage of science teachers who discuss about science lessons with other teachers in their school

	Who discuss at least a few times per year	Who never discuss
Elementary school Classroom teacher	83.5%	16.3%
Elementary school Head of science team	81.3%	18.5%
Elementary school teacher who teaches science only	83.3%	16.7%
Lower secondary science teacher	86.4%	9.6%

Source: Japan Science and Technology Agency (2009)

Table 12 Percentage of science teachers who have meetings with other school science teachers for in-service training

	Who meet at least 1 time per year	Who never meet
Elementary school Classroom teacher	21.5%	59.3%
Elementary school Head of science team	73.5%	17.0%
Elementary school teacher who teaches science only	64.0%	25.4%
Lower secondary science teacher	89.0%	5.6%

Source: Japan Science and Technology Agency (2009)

Table 13 Periods for science lessons in each year

	Elementary school				Lower secondary school		
	Grade 3	Grade 4	Grade 5	Grade 6	Grade 7	Grade 8	Grade 9
Current course of study	70	90	95	95	105	105	80
New course of study	90	105	105	105	105	140	140

Source: MEXT (1998a, 1998b, 2008a, 2008b)