Improving Science Education by Introducing “Core Science Teachers” to Local Cities in Japan

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Abstract

A large proportion of Japanese teachers feels difficulty in teaching science in various reasons. Elementary teachers may lack fundamental knowledge and skills to teach science in explorative approach. Lower-secondary teachers may lack scientific knowledge of some contents, skills to use new tools to teach, pedagogical knowledge of teaching and learning, etc.
Situation of teachers is very busy. Few in-service training for effective science teaching is available for individual teachers every year.
Saitama University established the “Core Science Teacher Training Program” in 2012 in collaboration with Saitama City and Saitama Prefecture education boards. The purpose of the program is to train skillful science teachers and certify them as “Core Science Teacher (CST)”, in order to increase formal and informal quality in-service training opportunities for general teachers in the local area. They are regular teachers, but are supposed to function as an adviser or a model teacher of science teaching. The training program for the CSTs consists of five domains: I. Emerging science, II. Effective science experiments, III. Effective science teaching, IV. Developing science talents, V. Communicating science. Intensive training programs have been organized by the university and the educational boards.
By the end of 2015 fiscal year, 34 teachers have been certified as the CSTs. About the half belongs to Saitama City. Total of 6800 teachers participated in formal in-service training where the CSTs act as the model teacher. They give also informal training sessions mainly in their schools.
The result of 2015 National Assessment of Academic Ability (NAAA) of 9th grade science showed apparent improvement in Saitama City students compared to the result of 2012. CSTs can be thought as an important factor influencing the improvement. But the result of Saitama Prefecture did not show such progress. The difference between these approaches was considered and the conditions need for improving science education at a local area were suggested.

1. Situation of Science Education in Japan

According to the TIMSS (Trend of International Mathematics and Science Study) [1] and the PISA (Programme for International Student Assessment) [2], science scores of Japanese students in these studies have been at a high level internationally. Japanese government (MEXT) periodically has checked the situation of student achievement and learning by using these international studies and annual National Assessments of Academic Ability (NAAA) [3] to identify if any problem exists in the results in the light of National Courses of Study [4]: Japanese curriculum standards. Found problems have been informed with practical suggestions to schools for the purpose of making improvements in their educational process, and supervisors under local educational boards have provided concrete advice to schools and teachers on site. Every school also checks their own results of the national assessment and makes their plan for the improvement onward. Major changes in national curriculum necessary for the improvement have been embedded in the revision of the National Courses of Study for every about 10 years. Through these processes, the CAPD cycle, Check-Act-Plan-Do then Check again, functions nationwide, and the robust situation of student achievement has been sustained.
Japanese teachers are typically graduates from 4-year university with enough credits of required courses to obtain a teacher certificate and took teacher employment exam. After passed the competitive exam, candidates will be hired permanently in principle and each placed at a school as a new teacher where one year induction program for intensive professional development (PD) will be undertaken in and out of the school. 5-year, 10-year, 20-year experienced teachers also receive a range of programs for PD apt for each stage. Teacher certificate should be renewed for every 10 years and the renewal courses are also important opportunities for teachers to update their professional knowledge and skills. In addition to these formal PD processes, individual school carries out their own PDs through lesson study, action research, and other types of OJTs. Supervisors under

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local educational boards visit all schools in the area periodically to observe the lessons and give practical advice for the improvement to teachers and administrators of the school. There are also variety of PD sessions run by public or private organizations in free of charge or charge for voluntary participants. These are common features nationwide. It seems that the PD system for Japanese teachers is well organized. It does not work well as far as science teaching, however.

JST [5] in 2008 reported that about 50% of class teachers in elementary schools feels difficulty in teaching science. Among young teachers, less than 10-year experience, it increases to over 60%. About 70% of class teachers in elementary schools have no chance to observe science lessons taught by other teachers for their PD, and more than a half of class teachers expect to have a near "place" where they are supported in teaching science.

This situation is similar in lower-secondary teachers. JST [6] in 2008 reported that about 30% and 45% of science teachers in lower-secondary schools feels difficulty in teaching physics and earth science contents, respectively. Among young teachers, the proportions increase. About 50% of science teachers in lower-secondary schools have no "place" to be supported when they feel difficulty in science teaching, and more than 80% of science teachers expect to have a near "place" where they are supported in teaching science.

It is apparent that a large proportion of Japanese teachers lacks the necessary PD and support in teaching science. Situated in a very busy circumstance, few in-service training opportunities on science teaching are available. The PD system needs to be strengthened to improve science teaching. Otherwise, young teachers cannot overcome their difficulty, then retain it for a long time, causing ineffective science teaching for their students.

2. CST Projects and "Saitama CST"

Problems in Japanese teachers teaching science can be summarized as follows:

- A large proportion of teachers in elementary schools feels difficulty in teaching science. They may lack necessary PD opportunities to learn basic knowledge and skills of science and science experiments and methodology for inquiry-based science teaching.
- Teachers in lower-secondary schools also feels difficulty in teaching science. They may lack necessary PD opportunities to learn wide-range of scientific knowledge and skills, pedagogy of motivating learners, methodology for inquiry-based science teaching, and formative evaluation.

Japanese students' levels of liking and valuing science are internationally at the bottom level in the past TIMSS studies [1]. It influences students avoid or deteriorate science learning at high school, then proceed to non-science professions, causing lack of man-power in science and technology fields and a society of citizens with low level of scientific literacy.

Japan Science and Technology Agency (JST), endowed by MEXT, established Core Science Teacher (CST) Training Program in FY2009 [7], in which a local education board in collaboration with a university can propose 4-year project to JST asking its financial support for training and utilizing CSTs. CST is a teacher who practices excellent teaching and plays core roles in PDs and activities on science education in his or her area. By FY2012, 16 prefectures' projects among 47 prefectures in the nation were selected and financially supported for four years.

Saitama university in collaboration with Saitama prefecture education board and Saitama city education board proposed a project "Saitama CST" and was selected in FY2012 and supported until FY2015. Saitama CST trains teachers of local schools as CSTs and designates their schools as the schools for CST activities. Geographical features of Saitama prefecture are follows:

- Population: approx. 7.3 million
- Elementary schools: approx. 820 schools, 380 thousand students, 20 thousand teachers.
- Lower-secondary schools: approx. 450 schools, 190 thousand students, 12 thousand teachers.

3. Measures

The training program of "Saitama CST" consists of five domains: I. Emerging science, II. Effective science experiments, III. Effective science teaching, IV. Developing science talents, V. Communicating science. Intensive training programs have been organized by the university and the educational boards [8]. CST candidates attend the programs of all domains at least for 120 hours totally at Saitama university, teacher education centre, schools for CST activities, and scientific sites to visit. Certified CSTs act as model teachers in lesson study sessions or advising teachers in experimental skill trainings.
By the end of FY2015, 34 CSTs have been certified, and about 150 PD sessions in which CSTs engage as the core teacher have been held by local educational boards, and about 6800 teachers participated in the sessions from all elementary and lower-secondary public schools in the prefecture. Total of 36 schools have been participated as schools for CST activities

4. Results

It is apparent that CSTs and schools for CST activities have increased the PD opportunities of science teaching for a large number of teachers in elementary and lower-secondary schools in Saitama prefecture. We expected to see a good influence on student learning appeared in the results of National Assessment for Academic Abilities (NAAA) in FY2015.

Average science score	Grade 6, 2012	Grade 6, 2015	Grade 9, 2012	Grade 9, 2015
Nation	60.9%	60.8%	51.0%	53.0%
Saitama prefecture	60.4%	59.2%	48.8%	51.6%
Saitama city	64.1%	62.9%	51.6%	55.8%

Table 1. Summary of average science scores in 2012 and 2015 NAAA in nation, Saitama prefecture, and Saitama city

Rate of positive answer	Grade 6, 2012	Grade 6, 2015	Grade 9, 2012	Grade 9, 2015
Nation	86.0%	87.9%	64.1%	66.8%
Saitama prefecture	86.4%	88.8%	63.2%	68.6%
Saitama city	87.0%	89.5%	70.1%	73.7%

Table 2. Summary of percentages of students who answered "I can understand contents of science lesson well" in 2012 and 2015 NAAA in nation, Saitama prefecture, and Saitama city

Table 1 shows that there was apparent improvement in science scores in Saitama City grade 9 students between 2012 and 2015. National average changed +2.0%, while Saitama city average changed +4.2%. As for grade 6, Saitama city average changed -1.2%, but it is still beyond the national average by +2.1%. Such improvement was not clear in Saitama prefecture, where grade 6 and 9 average changed -1.2% and +1.8%, respectively, both averages are below the national average. CSTs can be thought as an important factor influencing the improvement. But the result of Saitama prefecture did not show such progress in science score.
As for the positive answer rate of students who think "I can understand contents of science lesson", Saitama prefecture as well as Saitama city exceeds the improvement of national averages between 2012 and 2015 both in grade 6 and 9.

5. Consideration

Saitama city, population of 1.3 million, has about 160 elementary and lower-secondary schools. Among the 34 CSTs, 10 belong to Saitama city. And among the 36 schools for CST activities, 20 belong to Saitama city. Figure 1 shows a high density of CST in Saitama city area. The results of Saitama city shown in Table 1 and 2 suggest that CSTs should have been an important factor to realize the improvement of science score and student understanding. Saitama city education board has integrated the CST project within its "science and math education promotion programs" since 2012. The improvement can be explained as the total effect of the integrated measures.
Significant difference between Saitama city and Saitama prefecture that consists of 62 cities is the density of CST and CST activities. There was not apparent progress in science score of Saitama prefecture, but there was a favourable change in students understanding. This suggests that the increase of PD opportunities during the CST project may have been changing science lessons more

understandable ones for students. It is easy to assume that if it was possible to increase the number of CSTs and schools for CST activities, science score will also be improved in other cities.
It is also noteworthy that the CST project should be continued to make the changes more obvious and effective throughout the science educations in the area.

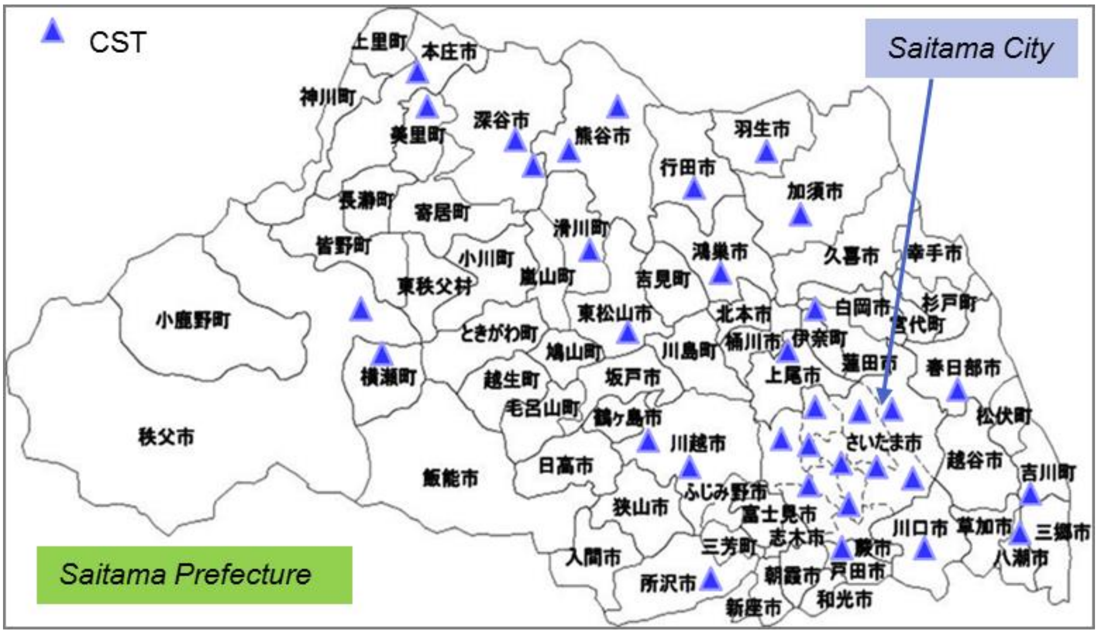

Figure 1. Geographical location of CSTs in Saitama prefecture which consists of 63 cities including Saitama city in FY2016

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