THE SYSTEMIC REFORM OF SCIENCE EDUCATION IN JAPAN—PRESENT AND FUTURE

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Contents

Summary

This paper briefly describes the historical context of Japanese science education and clarifies the issues and problems in Japanese science education. One of the major problems is linking scientific literacy with lifelong learning. In Japan, people do not have a deep understanding of scientific literacy, so this article examines the theory and practice of scientific literacy. The science-technology-society approach in science education was chosen as an innovative model for Japanese society and two quasi-experimental trials took place at a junior high school and a senior high school between two models: the science-technology-society classes and traditional science classes. Comparisons between science teachers in Japan and the U.S. were analyzed. The science-technology-society approach of the two Japanese teachers was found to be still far beyond that of their Iowa counterparts. However, it was found that Japanese science teachers had made many changes in terms of constructivist teaching, using more wait time (i.e. time allowed for the students' responses) appropriately, providing more encouragement for student engagement, and so on. It was found that the science-technology-science approach as a good model for constructivist teaching could be appropriate as an innovative model in science education in Japan. Since this approach to science education requires in-service training and situational practice, individual teachers can never develop by themselves, and systemic change in science education is the only way to develop real innovation in science education in Japan. This means a multidimensional support system in the real sense for the science education required for improving students' scientific literacy.

1. Introduction

1.1. The General Education System in Japan

In 1872, the Ministry of Education established the Japanese school system, which was developed by those who studied abroad immediately following the Meiji Restoration. Science methodologies and practices were imported from Germany, England, France, and the U.S. Many foreign scholars were invited to carry out research and work in Japan. These experiences led many to the belief that everything brought in from foreign countries was valuable. Nobody recognized that Japan was becoming a world leader in science. The Japanese people continued to study and work to gain prominence—often sacrificing their leisure time to do so.

The *Fundamental Law of Education* and the *School Law of 1947* were promulgated under the influence of the U.S. and the 6–3-3–4 organizational systems, which show elementary school years, junior high school years, high school years, and college years, were started. Again, Japanese society had to start from the beginning. As during the Meiji era, there were many obstacles to overcome. With the devastation of war ever present, the people did their best to work toward what was believed to be the good of the greater society. These unusual efforts set the tone nationally and made possible Japanese economic development. One reason for the country's economic and national success is that Japanese citizens believed that they were involved with the ongoing process of developing a well-organized centralized education system. However, times have changed and Japanese society is now being thrust into an arena where people feel they have little experience to guide them. They are questioning whether or not education is indeed an ongoing process.

Currently, many serious environmental problems have attracted attention in Japan. Many citizens believe the problems are the results of the rapid development of science and technology. In Japan the National Course of Study for each aspect of the national curriculum is reformed every eight to 10 years. The last reform was in 1981 for elementary schools and in 1982 for upper secondary schools. Educators and citizens not associated with science believe that too much emphasis has been placed on science education. In response to external pressure and the growing environmental problems, the Ministry of Education felt pressured to amend the National Course of Study. In April 1989 a National Course of Study was agreed upon that de-emphasized science and placed more emphasis on social issues focusing on individualization, internationalization, and information literacy. Nakayama stated that this reform was in actuality a type of science-technology-society (STS) theme in a Japanese context.

By 1988, major efforts for changes in science education in the U.S. were occurring. American educational researchers have published many papers about Japan's educational system. Among these none has been more influential for Japan than those arising from the U.S.-Japan Conference on Cultural and Education Exchange (CULSON), which focused on science and mathematics education. President Ronald Reagan and Prime Minister Yasuhiro Nakasone in Tokyo initiated this project in 1983. The director of this project was Lawrence P. Grayson and the team members were Daniel Antonoplos, Nobuo K. Shimahara, Nevzer G. Stacey, and Tetsuo Okada. Since 1983, three CULSON conferences have been held in the U.S. and Japan. The U.S. Secretary of Education William J. Bennett created a summary paper titled *Japanese Education Today: A Report from the U.S. Study of Education in Japan*, prepared by the Special Task Force of the OERI Japan Study Team. With the influence of CULSON upon Japanese education, it is important to note that the last reforms of the Japanese National Course of Study were developed with STS as the major theme.

The reform for National Curriculum Standards developed in December 1998 has several major characteristics. First of all, in this reform the major challenge was to try to develop education that helped children securely acquire the "absolute value at all ages." Absolute value at all ages means that we believe there are universal values that everybody agrees should be learnt by students, at least within the Japanese context, at certain ages. In order to achieve these incentives and activities for learning, the new subject "Period for Integrated Study" was developed. About 30% of the hours devoted to other subjects were reduced to make way for this new subject. The whole educational system was reorganized for improving Period for Integrated Study, especially for elementary and junior secondary school. Pilot practices were undertaken throughout Japan. The new National Curriculum Standards started from 2002 for compulsory schools.

1.2. Issues in Science Education

At the start of the twenty-first century, all countries in the world had many complicated problems with science education. One of the major problems with science education in Japan is how the system of education is organized. The National Course of Study identifies what every school should cover in all grades; it is amended every eight or 10 years. The content of science for each discipline has been decreased by “careful selection.” Even with these problems, there is a consensus that more and better science and technology are needed in Japan to promote a finer life. In 1989, the reform of the National Course of Education included a reexamination of the interrelationships among science, technology, and society. However, critical deficiencies in the Japanese approach to assimilation attempts were noted when compared to the STS movement in the U.S. The Curriculum Council at the Ministry of Education, Science and Culture, National Course of Study (MESCNCS) developed National Curriculum Standards Reform that commenced in 2002. The major goal of this reform was to help children securely acquire the absolute value at all ages. One of the new frameworks in high school science was the development of elective required subjects. One is Basic Science, which will help students learn science history and the relation between human life and science in order to develop their scientific perception and thinking. Another is Comprehensive Science A, for researching natural phenomena closely related to daily life, including materials and energy, and a third is Comprehensive Science B, for studying biological phenomena and natural phenomena in the global environment.

Another reason that some call the current situation “one of crisis” is the change in individual lifestyles that is occurring as well as general changes in the whole of Japanese society, caused by the accelerated development of science and technology. It is not an exaggeration to identify the major problems today as having come from the interrelationships among science, technology, and society. Many citizens believe that too much development of science and technology may be detrimental to Japanese society. People are being overwhelmed with too much information in too short a time. People are becoming more focused on individual priorities and possessing goods. Time and space among people is becoming smaller and smaller. Physical changes in the environment produced by modern human beings are hard to predict. The development of science and technology in the context of a changing society requires an attitudinal change on the part of teachers and students. Most teachers say that students are becoming rather self-interested and desirous of an easy life. Communication between teachers and students is changing; respect for teachers is decreasing; many students look at teachers as teaching machines. Younger teachers have changed and, like their students, they long for the easy life.

With all the current problems in science education in Japan, it is easy to argue that the situation is likely to worsen in the foreseeable future. To prevent the crisis deepening, new corrective efforts must be undertaken now. Grayson has observed: “For the first time, Japan is in the position of having to advance the state of knowledge, do advanced research, and create its own technologies. Japan must develop a creative, more knowledge-intensive industrial structure.”

2. What is Scientific Literacy

If science itself is a field of research universal to human beings, then is scientific literacy also universal? And if scientific literacy is universal, then is science education also universal? It is interesting to argue these questions when considering the reform of science education for a certain country.

Scientific researchers hope that science will be a never-ending human endeavor, thereby providing them the great happiness of doing science. It is important that scientific literacy be universal throughout all countries. However, there has been no argument on this matter, because of changes in society, cultural differences, the contexts of different countries, and so on. As we enter the twenty-first century, it is time to develop global science literacy.

It is possible to find an important comment on science literacy as far back as 1958, when Paul DeHart Hurd commented that economic or political issues were never discussed with analyses of the educational goals of science and technology. In 1957 when the first Russian satellite, “Sputnik,” was successfully shot into orbit the U.S. government started to identify the importance of science education, focusing on new science. At that time, it was their purpose to develop many high quality scientists and technicians who could compete with those of other countries. So Paul DeHart Hurd’s idea did not enter the mainstream. It was Milton Pella who in 1967 developed the definition of scientific literacy with six elements: interrelationships between science and society, ethics of science, nature of science, conceptual knowledge, science and technology, and science in the humanities. More and more people agreed with the wider view of science literacy after Pella, and interesting debate was carried out in the early 1980s between Hofstein and Yager, and Kromhout and Good. Hofstein and Yager insisted that STS was the core of science literacy. On the other hand, for Kromhout and Good scientific literacy for students should not be as wide ranging as STS but should be involved with the methods and materials for passing scientific knowledge on to students. The major points of Kromhout and Good could be summarized as that student-centered and issue-based science education (STS) would provide students with continuous interests, but the students would not connect the different areas. This means students might have difficulty developing the frameworks of science. So the infrastructure of science would become unstable. In this context, science education in Yager’s context can be identified as issue-based science education, whereas science education in Good’s context can be identified as discipline-based science education. It has been difficult to develop scientific literacy for the new age but the National Science Teachers’ Association (NSTA) developed images of scientifically literate individuals, delineating their features in a 1990 position statement.

Because of these debates, with long discussions about the processes of developing benchmarks and National Science Education Standards (NSES), the meaning of scientific literacy has pretty much been settled. As one of the headquarter members for NSES, Bybee had done detailed research on scientific literacy. He divided science literacy into four categories: nominal scientific literacy, functional scientific literacy, conceptual and procedural scientific literacy, and multidimensional scientific literacy. Nominal scientific literacy is that possessed by children, what cognitive scientists call “alternative frameworks” or “naive theory.” Functional scientific literacy is the level at which people can explain a scientific or technological concept but cannot connect it to bigger or wider images such as a theory. Conceptual and procedural scientific literacy is the level at which people can understand the nature of at least one field of science, possessing an understanding of scientific concepts in that particular field. Multidimensional scientific literacy is the level at which people understand the philosophical, historical, and social dimensions of science and technology that extend beyond the concepts of the scientific disciplines and the procedures of scientific investigation. These ideas on scientific literacy are so important for Japanese society that a consensus must be developed for scientific literacy that is quite similar to Bybee's idea.

3. How Scientific Literacy Can Be Developed (Part A: Theory)

3.1. Developing Scientific Literacy: Science-Technology-Society

The NSTA position on STS provides a broad framework for STS as reform. The NSTA views STS as the teaching and learning of science and technology in the context of human experience. It represents an appropriate science education context for all learners. The emerging research is clear in illustrating that learning science in an STS context produces students with more sophisticated concept mastery and a better ability to use process skills. All students improve in terms of creativity skills, attitude toward science, use of science concepts and processes in their daily living, and in responsible personal decision making.

There are no concepts and/or processes unique to STS; instead STS provides a setting and a reason for considering basic science and technology concepts and processes. STS means focusing on real-world problems that have science and technology components from the students' perspectives, instead of starting with concepts and processes. This allows students to investigate, analyze, and apply concepts and processes to real situations. A good program will have built-in opportunities for the students to extend beyond the classroom to their local communities. These activities should be appropriate for the age of the students and be learner centered. STS should provide the basis for empowering students to make changes and to take responsibility for doing so.

Essentially, STS programs are seen as those that include:

(a) Student identification of problems with local interest and impact
(b) The use of local resources (human and material) to locate information that can be used in problem resolution
(c) The active involvement of students in seeking information that can be applied to solve real-life problems
(d) The extension of learning beyond the class period, the classroom, the school
(e) A focus upon the impact of science and technology on individual students
(f) A view that science content is more than concepts that exist for students to master for tests
(g) An emphasis upon process skills that students can use in their own problem resolution
(h) An emphasis upon career awareness—especially careers related to science and technology
(i) Opportunities for students to experience citizenship roles as they attempt to resolve issues they have identified
(j) Identification of ways that science and technology are likely to affect the future
(k) Some autonomy in the learning process (as individual issues are identified).

Robert Yager has offered contrasts for STS programs. These include a series of critical incidents arising from Project Synthesis, supported by the U.S. National Science

Foundation (NSF). Five critical incidents in the classroom have been identified: goals, curriculum, instruction, assessment, and teachers. Each of these critical incidents provides an opportunity to contrast STS to the situation found in a typical science classroom.

Much work on STS in upper elementary and secondary school programs has been done in the American state of Iowa. The Iowa Chautauqua Program has operated since 1983 as an in-service program to assist teachers and schools implement STS modules; see Figure 3 for the basic features of the program.

3.2. Science-Technology-Society Instruction in Japan

It is apparent why more and more researchers in science education, government researchers in science education, administrative researchers, and science teachers are getting involved with STS in Japan. However, the swiftly changing situation is complicated by much bias on the part of academic scientists and science teachers. The definition of STS is not stable in Japan. University scholars frequently search for a solid theory to explain their actions and advocacy positions. However, there is a difference between understanding STS in an academic sense and using STS in a science class. Examples of teachers illustrating the STS approach and demonstrating the competencies of their students following such instruction can do much to promote STS in Japan. STS has not only become a target for research in science education and other fields; it also provides practical learning activities for future citizens preparing for lifelong learning.

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