6. Development of Instructional Videos of Outstanding Science Classes for Enhancing Scientific Literacy (Grants-in-Aid for Scientific Research (B) for FY2007 to FY2009, No. 19300267)

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1. Purpose and method of the study

This study aims to develop teacher training programs using videos of science classes, for the purpose of enhancing the quality of science teachers as specialists fostering children's scientific literacy. Under auspices of an organization consisting of researchers at universities, elementary and secondary school teachers, persons from the boards of education and education centers, and persons from education-related companies, the study was conducted focusing on the following six aspects.

(1) The designing of science curricula for fostering scientific literacy
(2) Practical methods to foster scientific literacy
(3) Teacher training concerning guidance for scientific literacy, using videos of classes
(4) How scientific literacy has been fostered in foreign countries
(5) The fostering of the technological aspect of scientific literacy
(6) Training DVDs on basic experimental skills required under the new educational guidelines

2. Results of the study

The following are the major results concerning the six aspects mentioned above. The full details, compiled in a 426-page report, are available in the form of a PDF file on my website (http://www.nier.go.jp/ogura/).

(1) The designing of science curricula for fostering scientific literacy

Regarding how to position scientific literacy in science education, we analyzed curricula developed in the United States, Canada, and England, the framework of the OECD's PISA survey and the survey results, science textbooks used in the United States, England, and Canada, and curricula developed after the war in Japan. We then clarified the viewpoints on class structures as a framework to design desirable science classes that foster scientific literacy. Those viewpoints, which are roughly categorized into "I. Circumstances under which a class is conducted," "II. Scientific knowledge to be acquired," "III. Scientific thinking and expressive ability to be acquired," and "IV. Interest, motivation, and attitude to be improved," are further broken down, and by checking items thus broken down, it becomes clear what type of scientific literacy each class aims to foster. Concrete items are as follows.

Viewpoints on class structures for fostering scientific literacy

I. Circumstances under which a class is conducted

A. Coverage

☐One's immediate environment ☐Region ☐Country ☐The Earth ☐Space

B Context

☐Resources/energy – Sustainable development

☐Environment/ecosystem – Beautiful environment and diversified living creatures

☐Disasters/good health – Peaceful and sound life

☐Technology/engineers – Safe and comfortable society

☐Discovery/scientists – Development of science

C Approach

☐Scientific search ☐Problem resolution and *monozukuri* (manufacturing)

☐Decision making ☐Dialogue/explanation/discussion

II. Scientific knowledge to be acquired

☐Knowledge and understanding of respective scientific fields

☐Physics ☐Chemistry ☐Life science ☐Earth and space science ☐Mathematics

☐Technology ☐Information science ☐Social and human science

☐Knowledge and understanding of cross-disciplinary science

☐Purpose ☐Forecast ☐Hypothesis ☐Model ☐Theory ☐Rules

☐Prototype ☐Design ☐Observation ☐Experiment ☐Simulation

☐Test ☐Cases ☐Sampling ☐Production

☐Condition control (Conditions to maintain or change state, conditions to measure)

☐Operational definition

☐Results [☐Qualitative data (observation)

☐Quantitative data (☐Measured value ☐Accuracy ☐Error)]

☐Analysis [☐Classification ☐Tabulation ☐Graphing ☐Mathematical process

☐Statistical analysis ☐Instrumental analysis]

☐Interpretation [☐Logicality ☐Objectivity ☐Falsifiability ☐Evaluation

☐Improvement ☐Conclusion ☐Relevance ☐Cost

☐Risk ☐Trade-off ☐Performance ☐Ethics

☐Protection of intellectual property right]

III. Scientific thinking and expressive ability to be acquired

☐Be aware of a scientific question and plan investigation

☐Scientifically describe, explain and forecast a phenomenon and apply knowledge

☐Reach conclusion by analyzing and critically interpreting scientific evidence and transmit

the conclusion

IV. Interest, motivation, and attitude to be improved

☐Interest in and concern for nature and science

☐Attitude favoring scientific quest and argument

☐Attitude of collaborating and cooperating with others

☐Attitude of judging independently and acting responsibly

☐Attitude of trying to use and apply what one has learned

☐Attitude of trying to apply the knowledge to one's future work life and social life

(2) Practical methods to foster scientific literacy

(i) We compiled practical methods to foster scientific literacy developed by four lower and upper secondary schools.

(ii) We made a report on the preparation of the Japanese version of the Lawson Test, a test designed to measure cognitive levels

(iii) We clarified the problems in fostering scientific literacy based on the results of the PISA2006 and also presented what is needed to support science teachers

(3) Teacher training concerning guidance for scientific literacy, using videos of classes

(i) We compiled information on the efforts underway at Kanazawa University, with regard to the utilization of videos introducing outstanding science classes in teacher training sessions.

(ii) We compiled information on the efforts underway at the University of Miyazaki, with regard to the utilization of such videos in teacher training at a faculty level.

(iii) We compiled information on the efforts underway at the University of Miyazaki, with regard to class studies utilizing outstanding science class videos in the Graduate School of Education.

(iv) We compiled information on the efforts underway at Gifu University, with regard to the analysis of science classes for undergraduate students, as a trial to prepare teaching videos of science classes through a constitutive method.

Furthermore, other than the utilization of class videos, we also conducted research on the following teaching methods.

(v) We reported on the analysis results from the University of Fukui, with regard to the creation of teachers' communities for practicing methods to foster student's capacity for scientific inquiry.

(vi) We reported on the efforts underway at Utsunomiya University, with regard to science classes that teach the usefulness of science technology.

(vii) We reported on the efforts underway in Gifu prefecture, with regard to the development of practical class methods to increase hours for continued observation.

(viii) We reported on the efforts underway in Gifu prefecture, with regard to science technology education utilizing the ARISS School Contact program.

(ix) We reported on the analysis results from Saitama University, with regard to the effects of research learning on the cultivation of scientific literacy.

(x) We reported on the analysis results from Saitama University, with regard to the effects of encouraging discussions among small groups as a means to improve training methods to foster students' ability to interpret things scientifically.

(xi) We publicized the teaching plans and materials for the 17 classes we recorded during this study.

(4) How scientific literacy has been fostered in foreign countries

(i) We analyzed methods to foster students' capacity for scientific inquiry at an early stage of school education, referring to teaching materials developed in England, and reported the results thereof.

(ii) We analyzed the differences between the goals, textbooks, and activities in the so-called 21st Century Science courses (compulsory courses under the GCSE in England) and those in ordinary science courses, and reported the results thereof.

(iii) We analyzed the investigation of IGCSE coursework for private upper secondary schools, and reported the results thereof.

(iv) We conducted an on-site survey of advanced education programs in Australia, and reported the results thereof.

(v) We made a report on teacher training in the United States concerning science classes for enhancing scientific literacy.

(vi) We analyzed methods of fostering scientific literacy in science education in Canada, and reported the results thereof.

(vii) We proposed a new indicator for training human resources with scientific expertise based on the secondary analysis of the PISA survey data.

(viii) We compared the attitudes toward science of Japanese students in the third year of lower secondary school with those of students in the first year of upper secondary school by using the same questionnaire as those used in the PISA survey. We then reported the results thereof.

(5) The fostering of the technological aspect of scientific literacy

(i) We examined the utilization of robots as a solution to the technological problems and

monozukuri-related problems encountered in science classes to foster scientific literacy, and reported the results thereof.

(ii) We examined the utilization of robots in a course unit for the sixth-grade class on the use of electricity, so as to develop a solution to technological problems associated with enhancing scientific literacy.

(iii) Regarding science classes at lower secondary schools, which aim to enhance scientific literacy by utilizing LEGO robots, we reported examination results by several science teachers teaching at lower secondary schools.

(iv) We made a report on the preparation of syllabuses for robot science classes to enhance scientific literacy and scientific ability, as well as practical cases of robot classes conducted at elementary schools.

(v) Regarding teaching methods for enhancing scientific literacy by utilizing robots, we reported the results of workshops targeting elementary and secondary school teachers.

(6) Training DVDs on basic experimental skills required under the new educational guidelines

We developed teaching videos in which cooperators teach effective training methods for basic science experiments to young science teachers teaching at elementary schools or lower secondary schools, and made them into DVDs to be used for training. Basic experiment items include “guidance on how to use a microscope” (elementary and lower secondary schools), “the properties of plastic” (lower secondary schools), “strength of force and extension of spring” (lower secondary schools), “heating by an electric current” (elementary schools), “utilization of electricity” (elementary and lower secondary schools), “experiments on vacuum discharge” (lower secondary schools), “Mendel's law” (lower secondary schools), and “how to use a planisphere” (elementary and lower secondary schools).

The results of the above (1) to (6) all show the future direction that will be taken to promote the development of outstanding science class methods to foster scientific literacy and the training for teachers for that purpose. They provide information on practical examples of teaching materials and teaching methods and are expected to have a significant impact on the future developments in this field. We need to seek means to further disseminate these study results widely.

3. Reports on this study

Research report, “Development of Instructional Videos of Outstanding Science Classes for Enhancing Scientific Literacy” (March 2010) http://www.nier.go.jp/ogura/

Database of the Grants-in-Aid for Scientific Research: http://kaken.nii.ac.jp/ja/p/19300267