Study on the Curriculum to Nurture Competencies
Report 3 of the Study on the Curriculum to Nurture Competencies
Curriculum and Learning Activities of Other Countries (Science Edition)

1. Purpose and summary of the research studies

(1) Purpose of the research studies

The purpose of this study is to further academically refine and restructure the "Basic Research on Curriculum Organization", which was carried out until FY2013, and to conduct a comprehensive, empirical study of the educational goals and content, learning and teaching methods and assessments, with a particular focus this year on the curriculum and learning activities. This report summarizes the curriculum and learning activities in science of several countries out of the research results of the "Study on the Curriculum to Nurture Competencies – a comprehensive study of the goals, content, teaching methods and assessments" (FY2014 - FY2016).

The purpose of the research studies is as follows.

(i) To identify how the three categories of competencies, subject-specific knowledge and learning activities of science are described at the level of the National Curricula in other countries, and to find out if they are interconnected.

(ii) To provide examples of specific teaching practices that show these interconnections from the perspective of nurturing the competencies.

(2) Research framework

In the research studies, for the abovementioned purpose, the research was carried out through a research team being assembled for the project and the team was composed of external members (researchers) being organized, with the cooperation of the International Exchange Committee of the Society of Japan Science Teaching.

The research team composed of external members from various universities. The country given in parentheses () is the country that the member was responsible.

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Susumu Nozoe, Associate Professor, University of Miyazaki (England)
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Jiwon Lee, Research Professor, Korea National University of Education (South Korea)
Minami Kakumu, Graduate Student, Hiroshima University (France (reference material))
Kenichi Goto, Senior Researcher, National Institute for Educational Policy Research (Germany and South Korea)
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(3) Summary of the research

The Department of Curriculum Research of the Curriculum Research Center was chiefly responsible for conducting continuous research on the trends relating to the curriculum criteria of other countries. In the "Basic Research on Curriculum Organization" (FY 2011-2013), which was the predecessor to the current research, research was conducted on the curriculum of other countries focusing on the development of competencies ("Report 6 The Curriculum and Competencies of Other Countries," (2013)).

Based on previous findings, the research for this project focused on the fact that a recommendation had been made by the Special Study Group on Curriculum Planning of the Central Council for Education on improving learning activities towards developing competencies, and a study was conducted focusing on ways of setting out the learning and teaching methods, and learning activities in the curriculum.

The results of this research were published in September 2015 in the form of "The Curriculum and Learning Activities of Other Countries" as project research materials. For the sake of expediency and convenience, these materials were compiled in the form of lists and country comparison tables giving the current situation of each country. This report describes and analyzes in further detail the information given in the research materials, including the situation which serves as the background to the future direction of education reform and the features of the learning activities. In the "Curriculum and Learning Activities of Other Countries", as well as a general description of the curriculum and learning activities, some countries (the United Kingdom (England), Germany, United States) were surveyed, and a summary was given of the curriculum and learning activities for science. This report titled "The Curriculum and Learning Activities of Other Countries" (Science") summarizes the curricula and learning activities for science in those countries.

The major points of the survey in the research are as follows.

1. The competencies, subject-specific knowledge and learning activities of science
   1) How they are described
   2) How they are interconnected
2. The connections between the competencies indicated in the discipline of science and the competencies indicated in the National Curriculum
   1) The connections between the "goals" of science and the competencies in the National Curriculum
   2) Interconnections with other subjects and fields (including the relationship with STEM (Science, Technology, Engineering, and Mathematics) education)
3. Examples of promising science lessons with a view to nurturing the competencies
   1) Particularly focused competencies in the lesson(s)
   2) Lesson information
   3) Learning tasks
   4) Outline of the lesson (content)
   5) Characteristics of lessons connected to the competencies
   6) Characteristic questions (questioning)

Based on the abovementioned survey, "4. The Characteristics of Learning Activities Nurturing the Competencies" was compiled based on the current situation and challenges of the countries.

Eight countries were selected for the survey from the perspective of fully utilizing the accumulated research and for the purpose of continuity. Specifically, there were three European countries: The United Kingdom (England), France (reference material) and Germany; two North American countries: the United States and Canada; one country in the Oceania region: Australia; and two Asian countries: Singapore and South Korea. A survey was only partially conducted for France and therefore it was treated as reference material.

The study conducted an analysis of the descriptions of the scientific competencies, subject-specific knowledge and learning activities based on the National Curricula of the selected countries, and connections between them. In addition, with regard to the connections between the competencies shown in science, which is one specific subject and the competencies indicated in general throughout the entire curriculum, an analysis was conducted on interconnections, in particular, between the "goals" of science and the competencies in the National Curriculum, and connections with other subjects and fields (including the relationship with STEM education).

The characteristic feature of this research is that it takes up one or two examples of science lessons from each country, and specifically tries to show their connections between the competencies described in the curriculum and demonstrated in the lessons. In each example a summary was given of the lesson and a description of the learning tasks, etc., and an analysis was conducted on the characteristics of the lesson connected to the competencies by the person in charge of research on that country. Furthermore, the learning activities shown in each lesson help to see the connections. The results of the study are expected to be used in the future as reference material when considering how we can promote learning activities to nurture competencies in the Japanese science curriculum.

The case examples in the research studies were based on information on the lessons which the researcher in charge of the country was able to obtain amid time and budget constraints. The science lessons in the examples basically targeted science lessons at the lower secondary education stage, but when it was difficult to obtain such information, the science lessons at the upper secondary education stage were also used.

The curriculum and learning activities of select countries in general were compiled as "Report 2 The Curriculum and Learning Activities of Other Countries" (March 2016).

2. Summary of the research results

The research results of "The Curriculum and Learning Activities of Other Countries" (Science Edition) up until the end of FY2015 are shown below.

(1) Research summary 1 (The Curriculum and Learning Activities of Other Countries (Science))

First, for the purpose set out in (i), a summary was given identifying how the three categories of competencies, subject-specific knowledge and learning activities are described in science at the level of the National Curriculum in other countries, and if they are interconnected.

The competencies, subject-specific knowledge and learning activities of science described in the National Curriculum of other countries vary, and each country has country-specific initiatives. On the other hand, the points they had in common include the following.

- Competencies related to subject-specific knowledge such as knowledge of science, concepts and fundamental ideas were indicated. While articulating the subject-specific knowledge, it is considered that they are used for better understanding of the core academic content.
  Examples: scientific knowledge and conceptual understanding (United Kingdom), specialized knowledge (Germany), disciplinary core ideas (United States(NGSS)), science understanding (Australia), knowledge, understanding and application (Singapore)

- Competencies connected to scientific competencies such as science skills, processes and methods were described separately from the subject-specific knowledge.

Examples: the nature, process, and methods of science (Working scientifically） (United Kingdom), thinking, activities and ways of acting (Germany), science and engineering practices (United States(NGSS)), science inquiry skills (Australia), skills and processes (Singapore), the core scientific competencies (South Korea)

- Competencies related to cross-curricular learning and connections between science and society were indicated. As a result, it is thought that even in the science lessons the competencies go beyond the boundaries of the subject, and aim to develop more general competencies.
  Examples: spoken language mathematical requirements (United Kingdom), cross-curricular competencies (Germany), explanations of the interrelations between the practices of the three subjects (United States(NGSS)), science as a human endeavour (Australia)

- For subject-specific knowledge, the basic concepts of energy, materials, functions and structure, and systems were described. For example, in the "fundamental concepts" (Canada), the dimensions leading to a wide range of critical understanding which will be long retained even after the finer details of the learning are forgotten were described as "big ideas". It is thought that the aim is to deepen understanding of the central concepts through such efforts.
  Examples: fundamental concepts (Germany), crosscutting concepts (United States), fundamental concepts (Canada), key ideas (Australia)

- In addition to the competencies relating to the learning activities and subject-specific knowledge, there were cases where the emphasis was on connections between cross-curricular learning and science, and society.
  Examples: Expansion of teaching coordinating the three competencies (United States(NGSS)), specific descriptions of the expected learning outcomes for "knowledge, understanding and application", "skills and processes", "ethics and attitudes" in all of the learning units (Singapore)

- More specific learning activities and methods, etc. were kept to the presentation of examples, giving consideration not to be seen as mandated activities.
  Examples: Although not intending to standardize the teaching and learning process, presentation of paradigm-specific examples for more detailed explanations (Germany), "content elaborations" presents how a teacher can teach the content, as a example (Australia)

(2) Research summary 2 (ingenuity in the lesson to nurture competencies)

For the purpose of (ii), a summary of devices used for lessons to nurture competencies as seen from the examples of teaching practices in other countries is given.

In relation to the competencies of science

- Expand the lesson to take in a broad view not simply restricted to "learning science" but to ultimately "doing science". (UK)
- Assess the status of acquisition of the competencies by constructing a learning situation based on the premise of the students engaging in independent activities, have the students think about experimental methods to more effectively extract the data which is the evidence for the principles which have already been learnt, have the students actually perform verification experiments and write up a report on the verification process and results. (US)
- With regard to the inquiry-based skills of "starting and planning", have the students assume that some form of law must exist by showing them a concrete refraction phenomenon at the start of the lesson; with regard to "acting and recording", give students the opportunity to experiment, and create a ray diagram; and with regard to "analyzing and interpreting", create an opportunity to have the students gather the results of the experiments and to interpret the results. (Canada)
- Have students practice "collaboratively determining the best way when working on an investigation" as indicated in the "content elaboration" of science in the National Curriculum by having individual groups separately decide on a plan for an experiment (selection of experimental methods and equipment), and provide an environment to develop these competencies (Australia).

In relation to the learning activities (including communication in science education)

- Design active lessons where students proactively work on learning (development of the lesson so that all of the students write their ideas on a mini whiteboard of their own, exchange opinions with others in the classroom, and explain the reasons for their thinking, and devise new solutions and ideas using the knowledge that they acquired). (UK)
- With regard to "communication", ensure opportunities for communication among the students and handling of experiments by flexibly changing the structure of the study groups in the class such as by having the students work together in pairs, small groups or the class as a whole. In addition, as a technique to promote discussion, use "place mats", or have the students "orally express their thoughts". (Canada)
- With regard to "being communicative" in the "inquiry-based skills of science", provide opportunities for the exchange of views and discussions on the content, points of view and ways of thinking for multiple subjects in an interdisciplinary curriculum. (Australia)
- Foster scientific communicative competence by having lessons that center on group activities. (Korea)

- Foster scientific thinking, such as critical thinking, and science communication competence through having students decide on their position in an issue and freely express their opinions through valid presentations and debates. (Korea)

In relation to an interdisciplinary curriculum, cross-curricular content and contexts, etc.

- Teach science beyond science learning which has "individual educational value" and extend the value of science learning to serve as an accessible intellectual asset by focusing on knowledge, skills, and understanding of how science acts, and through such learning activities, develop the lesson so that all children and students participate in society in the future with scientific grounding. (UK)
- Spark the desire to learn through learning using context, and make it easier for students to understand the meaning and significance of learning chemistry. (Germany)
- Introduce opportunities where students are able to use ICT to investigate examples of application of the second law of Newton, which students will have studied in physical science, to biology and earth science. (US(NGSS))
- While focusing on group inquiry-based activities, work on confirmation and developmental tasks of basic knowledge to be dealt with in the lesson review and lesson preview within the context of everyday life, society and the environment. (Singapore)
- Establish connections with the real world through an interdisciplinary curriculum, and provide learning which is rich in meaning for the students. Connect the lessons to the content of an interdisciplinary curriculum where the period of learning is spread out over a number of weeks through careful selection of topics related to "questions rich in content" and through "establishing questions even richer in content". (Australia)
- Develop problem-solving skills and cultural understanding by having the students understand that various opinions exist in various groups with regard to human embryo research, and have the students set out a direction for the development of human embryo research through a decision-making process. (Korea)

In relation to STEM (Science, Technology, Engineering, and Mathematics)

- Setting problems which are based on engineering practices involving the design and manufacturing of equipment promotes understanding of scientific concepts through confirming the degree of understanding which utilizes existing knowledge, and also fosters the various competencies necessary for effective interaction with others. (US)
- Have students first acquire the basic concepts of science, and then by having them acquire communications skills through collaborative learning, explore familiar progressive issues including the elements of STEM. (Singapore)