Science Education
at the Stage of Compulsory Education in Japan

Introduction

What is required of us is to more reliably cultivate the competencies in children which will allow them to live independently in this unpredictable future society and to participate in the formation of this society. Since 1945, after the end of World War II, Japanese education has faced changes in the times, has incorporated these changes while paying close attention to the situation, and has constantly striven for improvement. While “Japanese-style school education”, which nurtures children’s knowledge, morals, and physical well-being in an integrated manner, has been steadily producing results according to international surveys, there have also been some issues.

Focusing on science education at the stage of compulsory education in Japan, we will describe the changes in the courses of study, the current state of children’s academic ability and awareness, and the future direction as seen from the new courses of study.

1. Changes in the courses of study

The Ministry of Education, Culture, Sports, Science and Technology (MEXT)[1] sets the “courses of study” – the standards based on which the schools organize their curriculum pursuant to the School Education Act and other laws so that no matter where a child receives education in Japan, he or she will be able receive a certain level of education. The courses of study are revised about once every 10 years, and they set the objectives and overall educational contents for each educational stage at elementary school and lower secondary school[2]. In addition, the Ordinance for Enforcement of the School Education Act stipulates the standard number of class hours per year for subjects taught in elementary and lower secondary schools[3]. Based on these, the curriculum is organized toward the circumstances of the school and its local community. This paper describes science education at the stage of compulsory education.

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[1] MEXT was established in 2001 by merging of the Ministry of Education, Science Sports and Culture, and the Science and Technology Agency.

[2] For kindergartens, elementary schools, lower secondary schools, compulsory education schools, upper secondary schools, secondary education schools, and schools for special needs education as stipulated by the School Education Act.

[3] Kindergartens, elementary schools, lower secondary schools, compulsory education schools, upper secondary schools, secondary education schools, and schools for special needs education as stipulated by the Ordinance for Enforcement of the School Education Act.

(1) 1947

MEXT indicates a new direction for science education through the science edition (draft) of the courses of study for elementary and lower secondary schools. The teaching objectives of the science edition (draft) gives the following three points to be acquired by the students with regard to the problems in their environment so as to ensure that everyone will be able to lead a practical life and live a better life:

(i) Ability to see, think and handle things scientifically.
(ii) Knowledge of scientific principles and applications.
(iii) Attitude to discover the truth and create new things.

In 1953, the “Act for Promotion of Science Education” was enacted, and in 1954, based on the enactment of the “Order for Enforcement of the Act for Promotion of Science Education”, the promotion of science education was ensured in elementary, lower secondary and upper secondary schools, where the government guarantees the expenses for enhancing the equipment used in experiments.

(2) Revision from 1958 to 1960

In this revision, a curriculum that emphasizes systematicity is created with the aim of clarifying the nature of the courses of study as standards and improving science and technology education.

The objectives of elementary school science are as follows:

(i) To develop an attitude of becoming familiar with nature, being interested in things and phenomena, respecting the facts, and trying to learn directly from nature.
(ii) To uncover problems in the natural environment, think in a logical manner based on the facts, use ingenuity, and cultivate the attitude and skills to deal with the problems.
(iii) To understand the natural sciences and basic principles that are closely related to daily life and cultivate an attitude of trying to rationalize life based on these.
(iv) To deepen understanding of the relationship between nature and human life and nurture hearts and minds that are filled with an affection for the natural world

What is required is learning with an empirical and research outlook, and in terms of the curriculum, to cultivate in the students an attitude of pursuing things analytically and logically, and to facilitate their independent and positive learning attitudes.

The content of learning in lower secondary school science became a two-fields

system, with the field one dealing with physics and chemistry content and the field two a dealing with biological and geological content. It was necessary to build a system with an

emphasis on the relevance of the matters to be dealt with where the students could truly understand rather than relying too much on an academic system. What was required was to go in from concrete events, emphasize inductive thinking, teach students to connect learned principles and laws to actual application, to handle content quantitatively, grasp the relationship between events quantitatively, predict changes in events and fully relate events to the learning of mathematics, and to teach lessons so that students were able to fully understand the physical meanings of quantities and mathematical formulas that they were learning.

(3) Revision from 1968 to 1970

In this revision, the modernization of educational content was promoted with the aim of further improving the educational content. On October 4, 1957, the world's first artificial satellite "Sputnik 1" was put into orbit from Kazakhstan in the Union of Soviet Socialist Republics. The news of the successful launch of an artificial satellite ahead of the rest of the world caused a "Sputnik shock", especially in the United States and other Western countries. This sense of crisis caused a major reorganization of the American military, science and education, and a trend towards modernization of educational content. Under the influence of this, the promotion of science and technology in Japan and the modernization of educational content also accelerated.

For elementary schools, the content of science education was organized into three domains: A (living organisms and their environment), B (materials and energy), and C (the Earth and space). Similarly, for lower secondary schools, the content was reviewed, the content of learning increased, and sophistication was promoted. It was necessary to devise ways to attract interest in people's efforts towards nature and the topics of science and technology that were constantly advancing, and to give consideration to children's greater interest in and curiosity about the natural sciences.

For lower secondary school, what was required was to fully achieve the objectives of the field one and two, and to emphasize the systematicity systematic nature of the three years from the first grade to the third grade. In addition, other requirements were to emphasize the process of continuous instruction and inquiry, to ensure students understood basic scientific concepts and to have them learn concrete methods of science. What was also required was teaching a combination of learning such as problem finding, prediction, observation, experiments, measurements, recording, classification, graphing, reasoning, model formation, hypothesis setting, and verification, and quantitative handling where necessary, to have students grasp the relationship between natural things and phenomena quantitatively, to make a close correlation with mathematics, and to have students fully understand the meaning of the quantities and mathematical formulas that they were learning.

(4) Revision from 1977 to 1978

In this revision, based on reflection about the cramming-type teaching brought about through modernization of the learning content, the aim was to reduce the learning content of the subjects and to "*Yutori* Education[4]". In the "Improvement of the Standards of the Curricula for Elementary Schools, Lower Secondary Schools and Upper Secondary Schools (Report)" released in December 1976, it was stated that, while emphasizing the development of children who would be able to think and judge personally, the improvement of the standards of the curricula needed to be conducted with the aim of achieving the following objectives:

(i) To place greater emphasis on moral education and physical education, and to nurture children with an abundant sense of humanity and a balance of knowledge, morals, and physical well-being.
(ii) To carefully select educational content and to foster creative abilities so that students would be able to reliably acquire the basic and fundamental matters of each subject.
(iii) In order to realize Yutori Education , the standard number of class hours for each subject was reduced, and it became possible to add adjustments to the management of the number of class hours in line with the actual conditions of the region and school.
(iv) The goals and content of each subject, etc. stipulated in the courses of study were limited to the core matters and learning guidance through the teacher's own creativity could be fully developed.

The objectives of elementary school science are to "cultivate the ability and attitude to study nature through observations and experiments, as well as to develop a realistic understanding of natural phenomena, and to nurture hearts and minds that are filled with an affection for the natural world".

In addition to capturing the characteristics of nature, what was required was consideration be given to enhance the effectiveness of teaching by making a connection with various activities related to language, quantity, modeling, etc. In addition, another requirement was to give pupils opportunities to go to the field and have experiential activities to familiarize them with nature and to help pupils develop an attitude of cherishing nature.

The objectives of lower secondary school science were to "cultivate the ability and attitude to study nature through observations and experiments, to have students deepen their understanding of nature's things and phenomena, and to become aware of the relationship between nature and humans". Emphasis was placed on direct experience of natural things and phenomena, and consideration was to be given to the development of the ability to examine nature and the formation of basic concepts.

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[4] More relaxed, and stress-free policy education

The teaching content of each subject was reviewed, and the number of class hours was significantly reduced. One credit for class hours in elementary school became 45 minutes, and one credit in lower secondary school became 50 minutes. The number of credit was reduced from 140 credits to 105 credit in the 5th and 6th grades of elementary school, and from 140 credits to 105 credits in the 1st and 2nd grades of lower secondary school.

(5) Revision of 1989

In this revision, the courses of study were revised with the basic aim of “education that makes the most of individuality”. After the revision in 1977, the progress of science and technology and the development of the economy produced material affluence, and at the same time, they had a great influence on various aspects of society such as informatization, internationalization, diversification of values, the nuclear family, and aging. After that, the report of the Curriculum Council in 1987 announced the “development of motivation to learn by oneself and ability to respond to changes in society, and enhancement of education that makes use of individuality”, social studies and science in the first and second grades of elementary school were abolished, and living environment studies was set as a new subject. What was required was that education be promoted to enable each and every individual child to proactively engage in problem-solving activities and to be able to relate learning outcomes to daily life. Life environmental studies in elementary school entailed 102 credit hours in the first grade and 105 credit hours in the second grade, and the number of science classes in and above the third grade was 105 credit hours.

In lower secondary school, the selection of subjects was expanded, and science was established as one of the elective subjects in the third grade. Consideration was given so that advanced and applied learning activities such as task research learning, field observation / experiments, etc. could be developed in various ways according to the characteristics of the students. For the instruction in each field, consideration should be given to ensure the proactive and appropriate use of tools like computers and information and communication networks in areas such as searching for information in the course of observations and experiments, conducting experiments, data processing and experimental

measurements. The standard number of credit hours in the classes of lower secondary school science was 105 credit hours, and 35 credit hours were added when science was selected as an elective subject in the third grade, and so the number of class hours totaled 140 credit hours.

(6) Revision from 1998 to 1999

Towards this revision, proposals were made in the first report of the Central Council for Education entitled, “Education in Japan with a view to the 21st century” that had an emphasis on nurturing “zest for life” in the “relaxed form” of Japanese education.

Regarding the “zest for life”, “no matter how society changes, the competencies to find problems by ourselves, learn by ourselves, think by ourselves, decide and act independently, and to better solve problems” and at the same time, “a human being rich in spirit who shows self-regulation, cooperates with others and has a caring heart and is moved by emotion” and “health and physical strength to live a strong life” were mentioned as important factors. In addition, a complete five-day school week system was introduced (implemented from April 2002) from the perspective of fostering “zest for life” in “*Yutori* Education, and educational content was carefully selected while “the Period for Integrated Studies” was newly established in each grade from the third grade onwards. This period for Integrated Studies allowed students to engage in experiential learning such as nature experiences, social experiences, observation / experiments, tours / surveys, as well as problem-solving learning about an interdisciplinary perspective and comprehensive issues.

The total number of hours of science classes was reduced from 420 credit hours to 350 credit hours in elementary school and from 315 credits to 290 credits in lower secondary school (350 credits hours when science was selected as an elective subject). Improvements were made, such as carefully selecting the subject content of each subject, narrowing the content down to basic and fundamental content, studying diligently in *Yutori* Education , and ensuring that content is firmly established. In addition, devising and improving teaching methods and teaching systems such as individual or group-specific learning, repetitive learning and ensuring team-taught lessons where teachers work cooperatively so that children would be able to reliably acquire the learning content, and to improve individually targeted teaching were included in the general provisions.

Consideration was required to enable students to proactively utilize computers and information communication networks in the development of the ability to scientifically study nature, the formation of basic concepts, information retrieval in the process of observations and experiments, experiments, data processing, and measurements of experiments, etc. In addition, in “science” as an elective subject, consideration was given so that learning activities such as task research, field observation, supplementary learning, and advanced learning could be appropriately handled with creative adjustments by the school so as to develop various learning activities in accordance with the characteristics of the students.

(7) Partial revision in 2003

In response to the report of the Central Council for Education in 2003, “Regarding the immediate curriculum and measures for enhancing and improving teaching in primary and secondary education”, the courses of study were partially revised. Geared towards further clarification of “standardization” of the courses of study and further enhancement of the “Period for Integrated Studies”, the revision was intended to promote further establishment of the courses of study with its basic aim of thorough acquisition of the basic and fundamental matters and development of a “zest for life”, and further achievement of that aim. Specifically, the descriptions in the courses of study were reviewed, and by adding examples of “teaching

according to the degree of mastery of the learning content" in elementary school and "supplementary learning" and "advanced learning" in elementary and lower secondary schools tailored to the individual, it was decided that effective teaching methods should be introduce in flexibly and diversely according to the actual situation of the child and the setting of the teaching.

(8) Revision from 2008 to 2009

In December 2006, the Basic Act on Education was revised for the first time in about 60 years, and in June 2007, the School Education Act was partially revised. While emphasizing the harmony of "solid academic ability", a "rich humanity", and "healthy body", the important elements of academic ability were indicated to be: (i) acquisition of basic and fundamental knowledge and skills, (ii) the necessary ability to think, judge and express in order to solve problems utilizing knowledge and skills, and (iii) the motivation to learn. This basic concept highlighted development of the "zest for life", which had been emphasized in the courses of study since 1996. Based on this basic concept pursuant to revision of the Act and following the release of the report entitled, "Improvement of the courses of study for kindergartens, elementary schools, lower secondary schools, upper secondary schools and schools for special needs education" in January 2008, the courses of study came to be revised.

Emphasis was placed on a balance between the acquisition of knowledge and skills and the development of thinking, judging, and expressiveness, while the number of class hours in the five major subjects was increased by about 10%. In addition, based on the basic concepts of the revision, the enhancement of science and mathematics education was given as the main item of improvement. In the age of a "knowledge-based society", since the curriculum of science and mathematics education was required, in particular, to be internationally applicable, the enhancement of teaching content, teaching through repetition (spiral), and enhancement of observations / experiments, and task learning in science were required in terms of the perspective of systematic content. The following were the goals in science.

Elementary school science (overall objectives)

"To enable pupils to become familiar with nature and to carry out observations and experiments with their own prospectus, as well as to develop their problem-solving abilities and nurture hearts and minds that are filled with an affection for the natural world, and at the same time, to develop a realistic understanding of natural phenomena, and to foster scientific perspectives and ideas."

What was required was to enhance learning activities such as organizing and considering the results of observations and experiments and thinking and giving explanations using scientific words and concepts. Another requirement was via collaboration and cooperation with museums and science learning centers, to proactively utilize them, and to consider the correlation with the class hours for the subject of morals. What was required was fostering

an attitude of valuing the natural environment and contributing to its conservation, proactively promoting problem-solving activities, and moreover, endeavoring to relate learning outcomes to daily life, and encouraging understanding accompanied by a real sense of natural things and phenomena.

Lower secondary school science (overall objectives)

“To enable students to take an active interest in natural things and phenomena, and to carry out observations and experiments with a sense of purpose, while also fostering foundations for the ability to perform investigations scientifically and their positive attitude for doing so. To enable students to deepen understanding of natural things and phenomena, and to cultivate scientific ways of looking and thinking.”

What was required was enhancement of learning activities such as uncovering and observing problems and planning experiments, learning activities to analyze and interpret the results of observations and experiments, and learning activities such as thinking and explaining using scientific concepts. Another requirement was making things in order to deepen understanding of the principles and laws, making things appropriately according to the characteristics of the content, and appropriate teaching in accordance with the characteristics of science while considering the relationship with the class hours for the subject of morals based on the objectives of moral education. Other requirements were consideration in teaching so as to cultivate the basic ability and attitudes to scientifically explore natural things and phenomena, to make it possible to naturally formulate basic concepts step by step, and to touch upon how learning in science is related to various occupations.

Table 1: Changes in the number of class hours of elementary and lower secondary school science classes

	Elementary school							Lower secondary school			
Grade / Year of revision	1	2	3	4	5	6	Total	1	2	3	Total
Revised 1958	68	70	105	105	140	140	628	140	140	140	420
Revised 1968	68	70	105	105	140	140	628	140	140	140	420
Revised 1977	68	70	105	105	105	105	558	105	105	105	315
Revised 1989			105	105	105	105	420	105	105	105～140	315～350
Revised 1998			70	90	95	95	350	105	105	80	290
Revised 2008			90	105	105	105	405	105	140	140	385

One credit hour for an elementary school class is 45 minutes, and one credit hour for a lower secondary school class is 50 minutes. (Prepared by the author from the list of the Courses of Study)

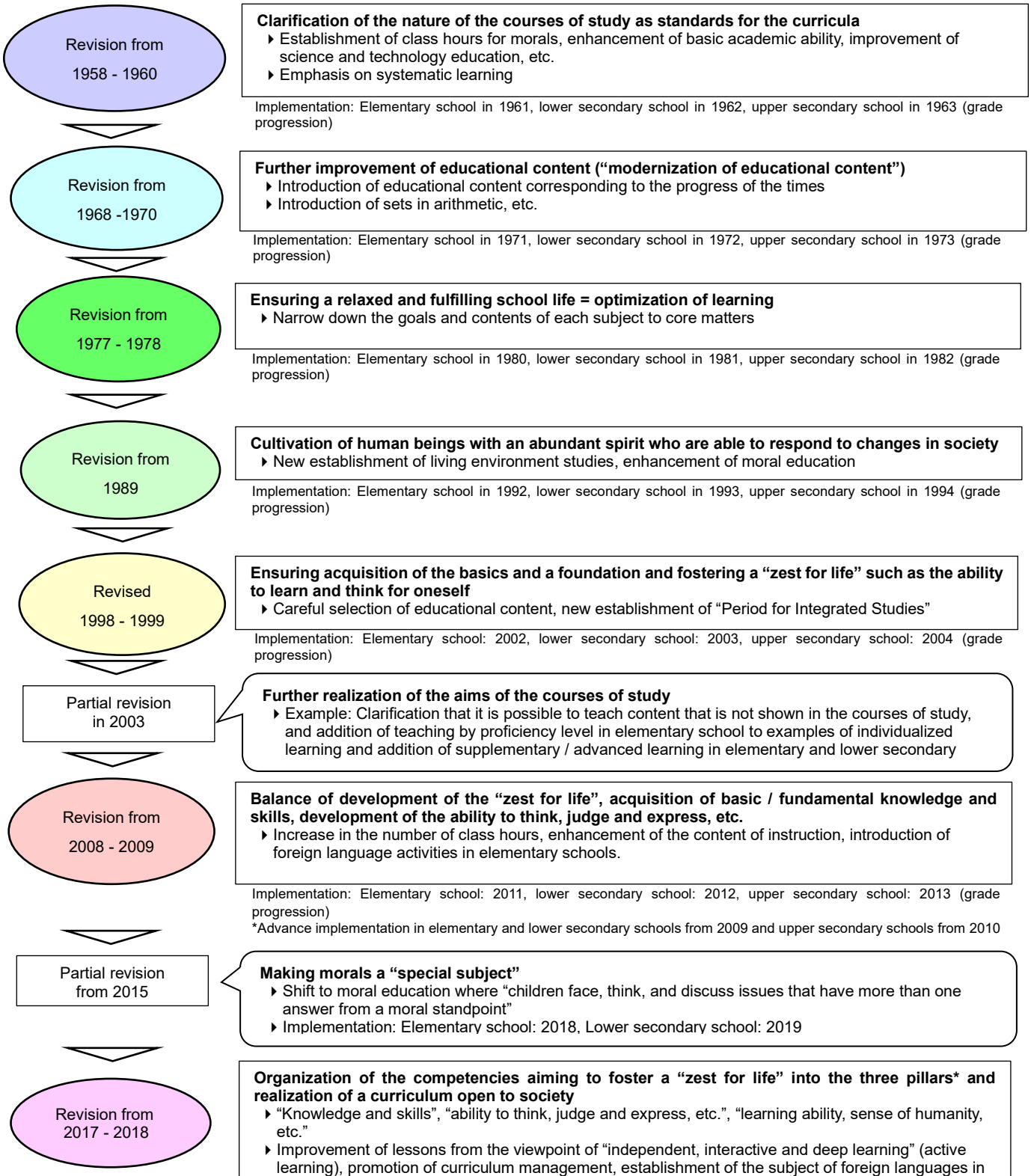


Figure 1: Changes in the courses of study

2. Current status of scientific academic ability and awareness of students as seen from the results of academic ability surveys and learning surveys in Japan and abroad

Japan has been taking part in the “Trends in International Mathematics and Science Study (TIMSS)” administered by the International Association for the Evaluation of Educational Achievement (IEA) since 1995, and the international survey of the “Programme for International Student Assessment (PISA)”, which is a scholastic performance survey for students administered by the Organization for Economic Co-operation and Development (OECD) since 2000. This time, we will introduce the results of the 2015 survey that had the greatest impact on the revision of the courses of study in 2017.

In addition, the Ministry of Education, Culture, Sports, Science and Technology has been administering the “National Assessment of Academic Ability” since 2007. Similarly, these are important materials for revision of the courses of study.

(1) Trends in International Mathematics and Science Study (TIMSS)

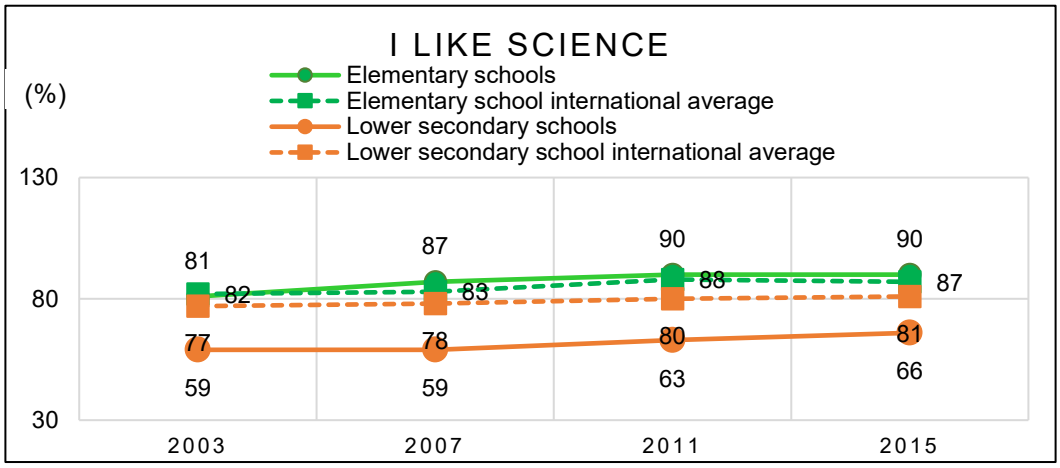
The International Association for the Evaluation of Educational Achievement (IEA) measures the degree of educational achievement of students in arithmetic / mathematics and science at the primary and secondary stage of education. In order to evaluate the degree of acquisition of the basic knowledge and skills learned in the school curriculum, in Japan, the “Trends in International Mathematics and Science Study (TIMSS)”, which is conducted every four years, is targeted at children in the 4th grade of elementary school and students in the 2nd grade of lower secondary school.

Some of the points revealed from the 2015 survey results are as follows.

- Both elementary and lower secondary schools continue to maintain high rankings in all subjects, and the average score has increased significantly compared to the previous survey.
- Similar to the previous survey, except for “I like science” in elementary school, there are many items that are below the international average, but the percentage of students who consider arithmetic / mathematics, and science to be fun is increasing, and in lower secondary schools, the gap with the international average appears to be narrowing.
- In lower secondary schools, the percentage of students who say mathematics and science are “useful for daily life” and “I need to do well to get the job I want”, is increasing, and the trend seems to be the gap with the international average appears to be narrowing.

		1995	1999	2003	2007	2011	2015
4th grade elementary school	Science	553 points (2nd/26 countries)	(No survey implemented)	Significant decline 543 points (3rd/25 countries)	No significant change 548 points (4th/36 countries)	Significant increase 559 points (4th/50 countries)	Significant increase 569 points (4th/50 countries)
2nd grade lower secondary school	Science	554 countries (3rd/41 countries)	No significant change 550 points (4th/38 countries)	No significant change 552 points (6th/45 countries)	No significant change 554 points (3rd/48 countries)	No significant change 558 points (4th/42 countries)	Significant increase 571 points (2nd/39 countries)

Figure 2: Changes in the average score in 2015
Trends in International Mathematics and Science Study（TIMSS）



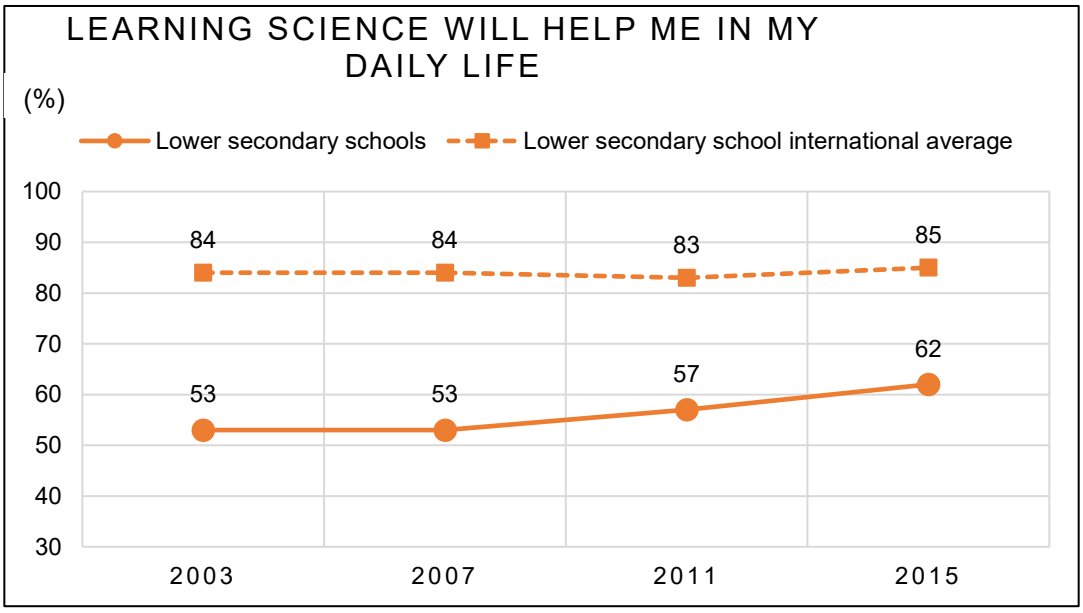


Figure 3: Changes in the percentages of children regarding their awareness of science 2015: TIMSS

Prepared by the author based on https://www.nier.go.jp/timss/2015/point.pdf

(2) Programme for International Student Assessment (PISA), Organization for Economic Co-operation and Development (OECD)

Since 2000, Japan has been taking part in the Programme for International Student Assessment (PISA) administered by the Organization for Economic Co-operation and Development (OECD). It assesses how much a 15-year-old student (first grade student in upper secondary school in Japan) who are at the end of compulsory education is able to utilize his or her knowledge and skills in various situations in real life. The survey has been conducted every three years since 2000 with a focus on the major domain set out of the three domains of reading literacy, mathematics literacy and science literacy.

Looking at the results of the 2015 survey where scientific literacy was the major domain the following characteristics were noted.

- Looking at the three scientific skills of “explaining phenomena scientifically”, “evaluating and designing scientific enquiry”, and “interpreting data and evidence scientifically”, each skill ranked highly internationally.
- Compared to other skills, the average score for the skill of “evaluating and designing scientific enquiry” was relatively low.
- In the student questionnaire, the four viewpoints of “enjoyment of science”, “instrumental motivation to learn science”, “science self-efficacy”, and “out-of-school science activities” could be compared to the 2006 survey and past surveys.
- In Japan, although the variables of the four perspectives are below the OECD average, the percentage of students who give a positive answer in the “instrumental motivation to learn science” index is increasing.

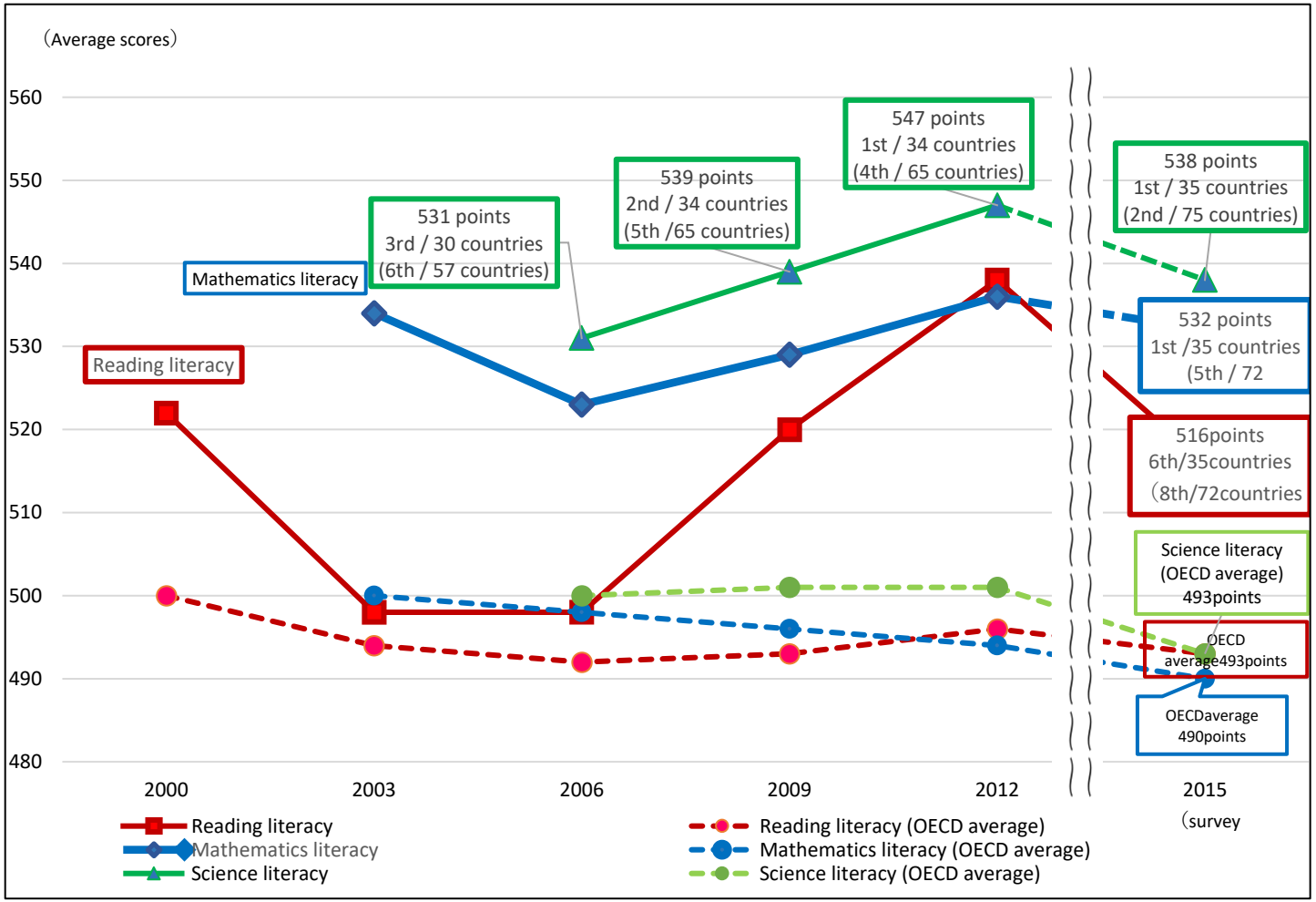


Figure 4 Average score and changes in ranking: 2015 Programme for International Student Assessment (PISA)

Prepared by the author based on https://www.nier.go.jp/kokusai/pisa/pdf/2015/01_point.pdf

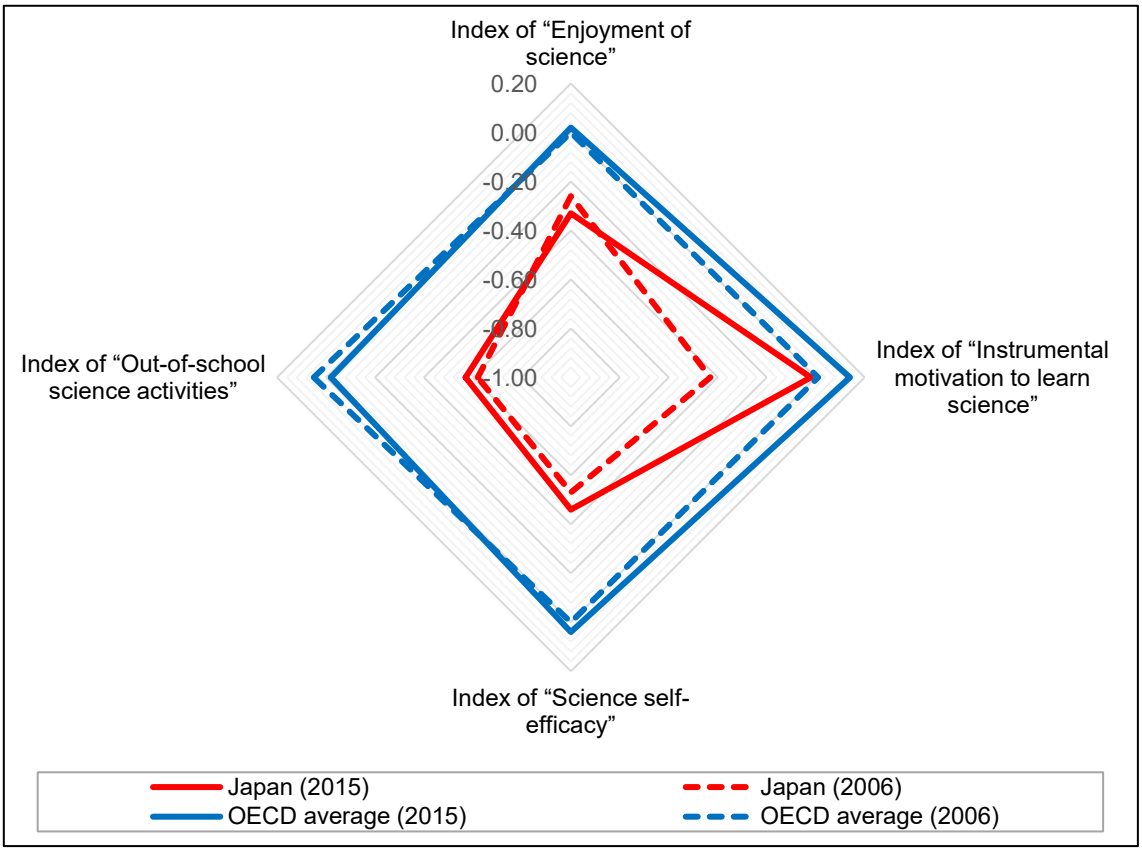


Figure 5: Changes in variables in Japan for 2015 Programme for International Student Assessment (PISA)

Prepared by the author based on https://www.nier.go.jp/kokusai/pisa/pdf/2015/01_point.pdf

(3) Implementation of the “National Assessment of Academic Ability”

Since 2007, the “National Assessment of Academic Ability” has been administered every April to ascertain the status of the academic achievement of all elementary school sixth graders and lower secondary school third graders in Japan. This survey is conducted for the following purposes.

- From the perspective of equal opportunity in compulsory education and maintenance and improvement of its level, to monitor and analyze the academic ability and learning situation of children and students nationwide, verify the results and issues of educational measures, and strive to improve them.
- Useful for enhancing educational guidance and improving learning conditions for individual students at school.
- To establish a continuous verification and improvement cycle for education through the above efforts.

The subjects are Japanese, arithmetic and mathematics, and science was also added in the

2012, 2015 and 2018 surveys. In addition to surveys on subjects asking about academic ability, surveys on students' lifestyles, learning environments, the school's teaching methods, etc. were conducted, and the correlation with academic ability was analyzed.

Some of the results of elementary school science and lower secondary school science in 2015 were as follows.

- Regarding organizing and considering the results of observations and experiments, although a considerable number of children were able to consider the obtained data in relation to the phenomenon, there were difficulties with quantitatively grasping and considering the information based on graphs showing the results of the experiments.
- The location of the problem was clarified regarding the issue "of interpreting, considering and explaining after organizing and analyzing the results of observations and experiments" that was seen in the 2012 survey.
- Regarding the questions relating to interest, motivation, and attitude towards learning, the number of positive answers tended to decline more in lower secondary school than in elementary school, but in science, there was a huge decline compared to Japanese, arithmetic and mathematics (comparing the responses of the 6th grade elementary school students in 2012 and the 3rd grade junior high school students in 2015, who were of the same generation).
- Regarding the correlation between the learning situation of students and academic ability in relation to science, in terms of explaining and presenting their views to those around them, planning observations and experiments based on their own predictions, thinking about what they had learned from the results of observations and experiments, and looking back on whether the way of proceeding and thinking about the observations and experiments were correct, the students who gave a positive response had a higher percentage of correct answers. Also, comparing these points with 2012, the number of positive responses had increased.

Not only each board of education and school, but also the Ministry of Education, Culture, Sports, Science and Technology and the National Institute for Educational Policy Research have established a detailed system for continuous verification and improvement in order to support efforts to enhance educational guidance and improve the learning situation based on the survey results. Examples are as follows.

- Creation of a "report" showing the results of analysis and points for improving teaching for each question
- Creation of "class idea examples" for matters for which problems were found
- Holding of explanatory sessions to improve teaching using the survey results
- Dispatch of academic ability officers to give advice

- Collection and dissemination by the boards of education and schools of examples of excellent school improvement efforts using the results of surveys
- Additional analysis / verification by experts, etc.
- Creation and distribution of “commentary materials” that show the purpose of the questions and points for improving and enhancing learning guidance for each question

3. Revision of the 2017 courses of study and direction of revision

In 2017, the courses of study were revised based on the current situation mentioned above. The new courses of study were fully implemented in elementary schools from 2020 and in lower secondary schools from 2021. In upper secondary schools, they will be gradually implemented from the 2022 enrollment by grade progression.

In this revision, based on the Basic Education Act, the School Education Act and other laws, while maintaining the framework and educational content of the conventional courses of study that emphasize a balance between the acquisition of knowledge and skills and the development of thinking ability, judgment ability, expressive ability, etc., there was an emphasis on further improving the quality of understanding of knowledge and developing solid academic ability. Another major feature is that the competencies to be developed were clearly shown in the courses of study.

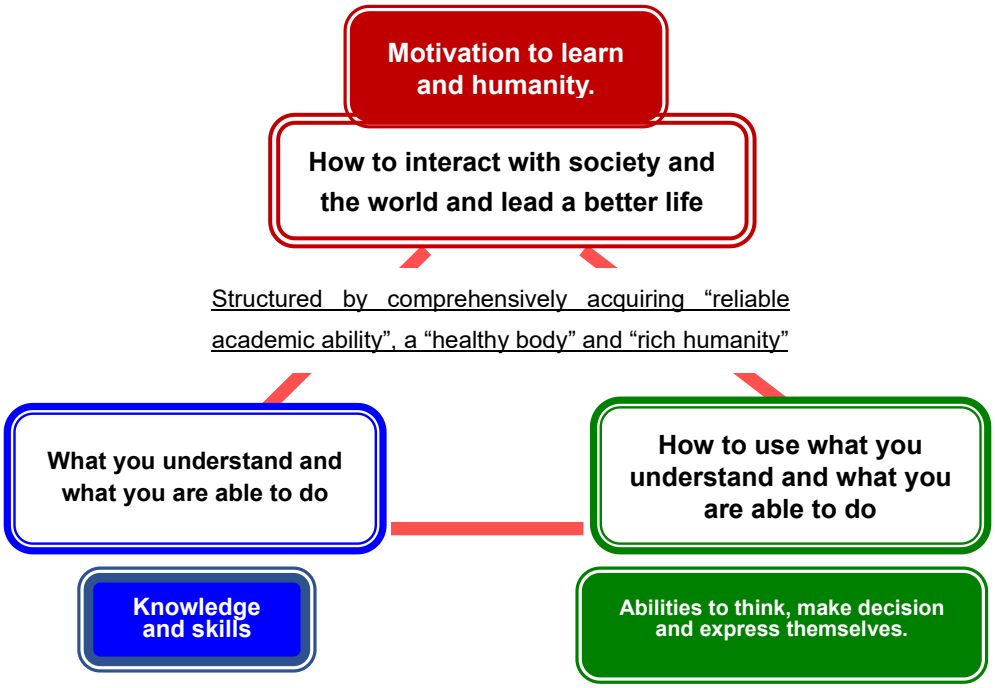


Figure 6: The three pillars of competencies to be developed

Prepared by the author based on https://www.mext.go.jp/content/1421692_7.pdf

“Independent, interactive and deep learning” to improve the quality of knowledge understanding and develop the competencies

(1) Clarify what the child “will be able to do”

In order to nurture the children’s “zest for life” across knowledge, morals, and their physical well-being, while sharing the significance of learning in the sense of “what the point is in learning”, all subjects have been rearranged into three pillars to be able to elicit creative ingenuity in lessons and improve the textbooks and other teaching materials.

(i) Acquisition of knowledge and skills to live and work in actual society and life

(ii) Development of the thinking ability, decision ability, expressive ability, etc. that enable the ability to respond to unknown situations

(iii) Cultivation of the ability to learn and sense of humanity to apply what one has learnt to one’s own life and society

The aim is to cultivate the three abilities in a well-balanced manner so that students are able to make use of what they have learned at school even after going out into the real world, and also to cultivate the competencies required in the new era and enhance learning assessments.

(2) How to learn

The aim is to improve the learning process by emphasizing “how to learn” from the perspective of independent, interactive and deep learning (active learning). The aim is to make lessons enabling acquisition of the ability to endeavor persistently with an eye to the end result, lessons enabling students to look back on their own learning and develop the ability to utilize the learning in the next set of learning and in life, lessons enabling students to think and learn with the people around them, and lessons giving birth to new discoveries and abundant ideas. The aim is to improve the quality of the learning process in order to achieve high-quality understanding without reducing the amount of knowledge.

(3) Objectives of the courses of study

The aim of science is to show specific competencies.

Elementary school science (Overall objectives)

The objectives is to foster the competencies necessary to scientifically solve problems related to natural things and phenomena by having students familiarize themselves with nature, employ scientific perspectives and ideas, and conduct observations and experiments with an eye to the end result:

(i) To understand natural things and phenomena and acquire basic skills related to observation and experiments.

(ii) To develop problem-solving skills by conducting observations and experiments.

(iii) To develop a love of nature and an attitude of proactively trying to solve problems.

Lower secondary school science (Overall objectives)

The aim is to foster the competencies necessary to scientifically explore natural things and phenomena by engaging with natural things and phenomena, applying science perspectives and ideas, and conducting observations and experiments with a sense of purpose

(i) To deepen understanding of natural things and phenomena and to acquire basic skills related to observations and experiments necessary for scientific inquiry.

(ii) To develop the ability to explore scientifically by conducting observations and experiments.

(iii) To foster an attitude of being willing to engage with natural things and phenomena and explore them scientifically.

Conclusion

In Japanese schools, by teaching through comprehensively grasping the situation of the students, results have been achieved through “Japanese-style school education” that nurtures children’s knowledge, morals, and physical well-being in an integrated manner. Underlying this, the schools, boards of education, and surveys / research collaborate to constantly strive to understand the academic ability and learning situation of students, and along with the revision of the courses of study in line with the times, it can be said that there is a deep exploration of the competencies that should be nurtured.

In the subject of “Science”, while maintaining high academic ability, the percentage of positive responses pertaining to interest, motivation, significance, and usefulness of learning science is low, and there are still problems in both elementary and lower secondary schools in relation to the competencies such as “arranging and analyzing the results of observations and experiments, and then interpreting, considering and explaining them”. Moreover, in addition to the arrival of the “Society 5.0 era”, which will dramatically change the direction of society, in times of unpredictability such as the spread of COVID-19, such issues as the need for urgent improvement, including maintenance of the educational environment necessary for utilizing computers and information and communication networks, are also apparent. However, on the other hand, there is concern that the number of experiential learning activities such as observations, experiments, and fieldwork will decline due to the emphasis on this maintenance. As is given in the objectives of science, it is necessary to emphasize

students “familiarizing themselves with nature, employing scientific perspectives and ideas, and conducting observations and experiments with an eye to the end result” (elementary science science) or “engaging with natural things and phenomena, applying scientific perspectives and ideas, and conducting observations and experiments with a sense of purpose (lower secondary school science).

In 2020, the Primary and Secondary Education Subcommittee of the Central Council for Education called for the steady implementation of the courses of study based on the thinking that each and every student should be able to recognize his or her merits and potential, respect each person as a valuable being, collaborate with diverse people, open up to a prosperous life, and become the creator of a sustainable society. We look forward to the continuous improvement and enhancement of science education.

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日本の義務教育段階における理科教育　（要約）

日本の義務教育段階における理科教育に焦点を当て、学習指導要領の変遷、子供たちの学力や意識の現状、新学習指導要領にみるこれからの方向性について述べた。

１．学習指導要領の変遷

日本全国のどの地域で教育を受けても、一定の水準の教育を受けられるようにするため、文部科学省では、学校教育法等に基づき、各学校で教育課程（カリキュラム）を編成する際の基準「学習指導要領」を定めている。およそ１０年に１度改訂が行われている。以下の改定にみられる特徴を理科の目標や授業時数などに着目し、整理した。

（１） 1947 年（昭和 22 年）
（２） 1958 年から 1960 年（昭和 33 年から 35 年）の改訂
（３） 1968 年から 1970 年（昭和 43 年から 45 年）の改訂
（４） 1977 年から 1978 年（昭和 52 年から 53 年）の改訂
（５） 1989 年（平成元年）の改訂
（６） 1998 年から 1999 年（平成 10 年から 11 年）の改訂
（７） 2003 年（平成 15 年）の一部改訂
（８） 2008 年～2009 年（平成 20 年～21 年）の改訂

２．国内外の学力調査・学習調査の状況にみる児童・生徒たちの理科の学力や意識の現状

日本では、1995 年（平成 7 年）から国際教育到達度評価学会（IEA）が進めている「国際数学・理科教育動向調査（TIMSS)」と、2000 年（平成 12 年）から「OECD 生徒の学習到達度調査（PISA)」の国際調査に参加している。また、文部科学省は 2007 年（平成 19 年）から「全国学力・学習状況調査」を実施している。今回は 2017 年（平成 29 年）の学習指導要領の改訂に最も影響を与えた 2015 年の調査結果を紹介した。

３．2017 年（平成 29 年）学習指導要領の改訂とその方向性

2017 年（平成 29 年)、学習指導要領の改訂が行われ、小学校では 2020 年度（令和 2 年度）から、中学校では 2021 年度（令和 3 年度）から新学習指導要領の全面実施がなされた。高等学校では 2022 年度（令和 4 年度）入学生から年次進行での段階的な実施である。

今回の改定では、今までの学習指導要領の枠組みや教育内容を維持した上で、知識の理解の質をさらに高め、確かな学力を育成することに重点化している。また育成すべき資質・能力が、学習指導要領に明確に示された点も大きな特徴である。

教科「理科」では、高い学力を維持しつつも、理科を学ぶことに対する関心・意欲や意義・有用性に対する認識について、肯定的な回答の割合が低いことや、小学校、中学校ともに、「観察・実験の結果などを整理・分析した上で、解釈・考察し、説明すること」などの資質・能力に依然として課題が見られる。また、予測困難な時代において、コンピュータや情報通信ネットワークなどの活用に必要な、教育環境の整備が必要なことなどの課題も明らかになった。新学習指導要領の着実な実施とともに、たゆみない更なる理科教育の改善と充実を期待する。