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OECD/JAPAN Seminar

How we learn for better science education

Improvement of science education in Japan

-Key points of the revision of National Curriculum Standards of science-

文部科学省 MINISTRY OF EDUCATION, CULTURE, SPORTS, SCIENCE AND TECHNOLOGY-JAPAN

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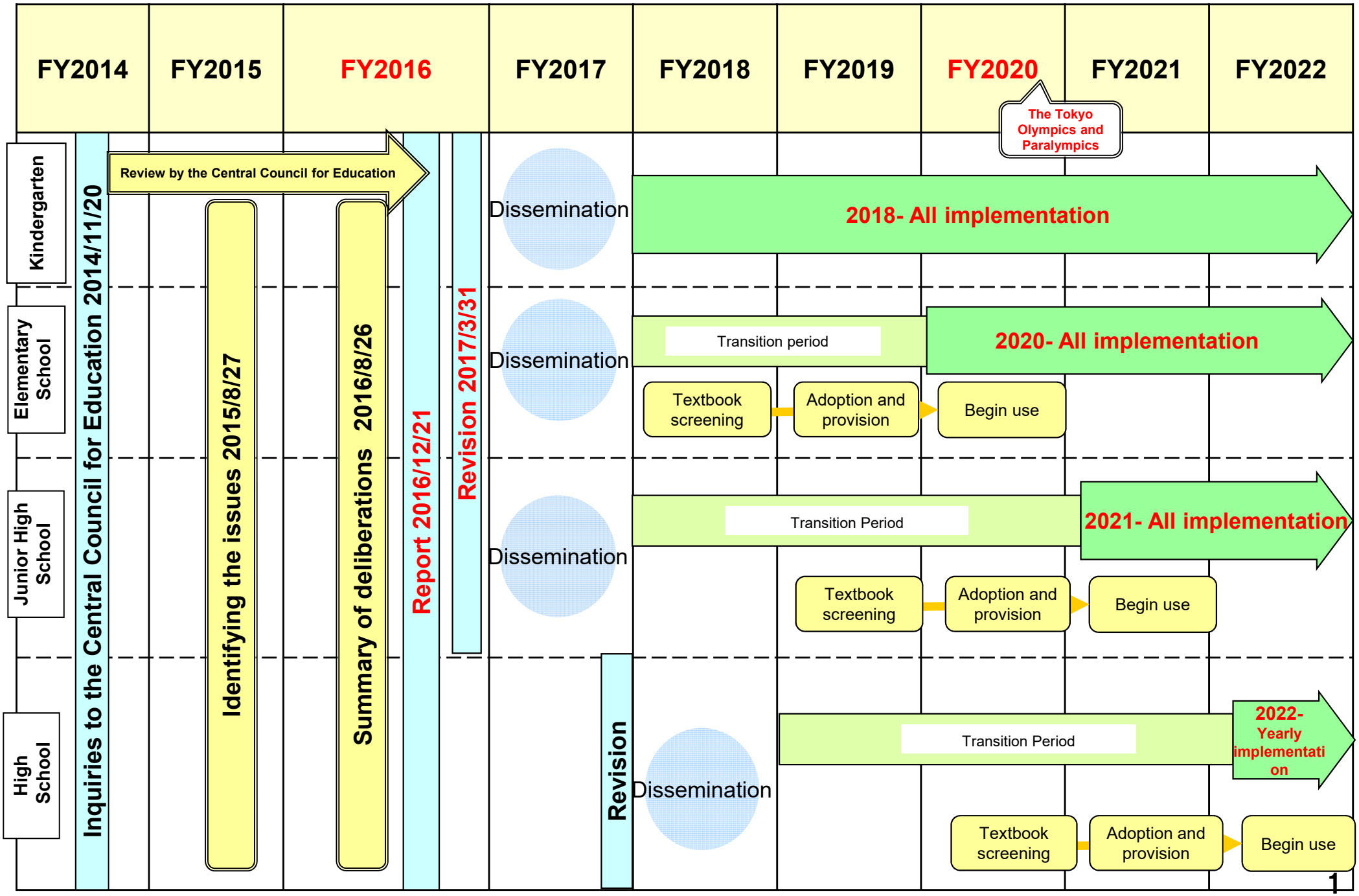
Schedule for National Curriculum Standards Revisions (Chart)



Results and issues in science education

- In science, it is important for children to have intellectual curiosity and a sense of inquiry, to be familiar with nature, and to conduct observations and experiments with sense of purpose according to their stage of development

  → In the current National Curriculum Standards, the following points are improved and teaching enhanced

  - Firm consolidation of knowledge and skills: structuring learning content in science through elementary, junior high and high schools
  - Cultivation of the ability to think / make decisions / express oneself etc.: Enhance exploratory learning etc.

- From the international academic ability survey
  - PISA 2015 - average scores in scientific literacy continue to be in the high-ranking group
  - TIMSS 2015 - best results in the survey since 1995
  - Based on the above two survey results, there is a tendency to improve concerning motivation/drive with respect to learning science and awareness of meaning/usefulness of doing so
  - On the other hand, the proportion of positive answers is low compared with other countries

- From domestic survey (national academic ability and learning situation survey)
  - Issues in “Organize/analyze the results etc. of observations/experiments, interpret/consider and explain” etc.

- Other
  - Comments such as that observation/experiments and exploratory activities are not adequately incorporated at high schools, and teaching overemphasizes knowledge/understanding etc.

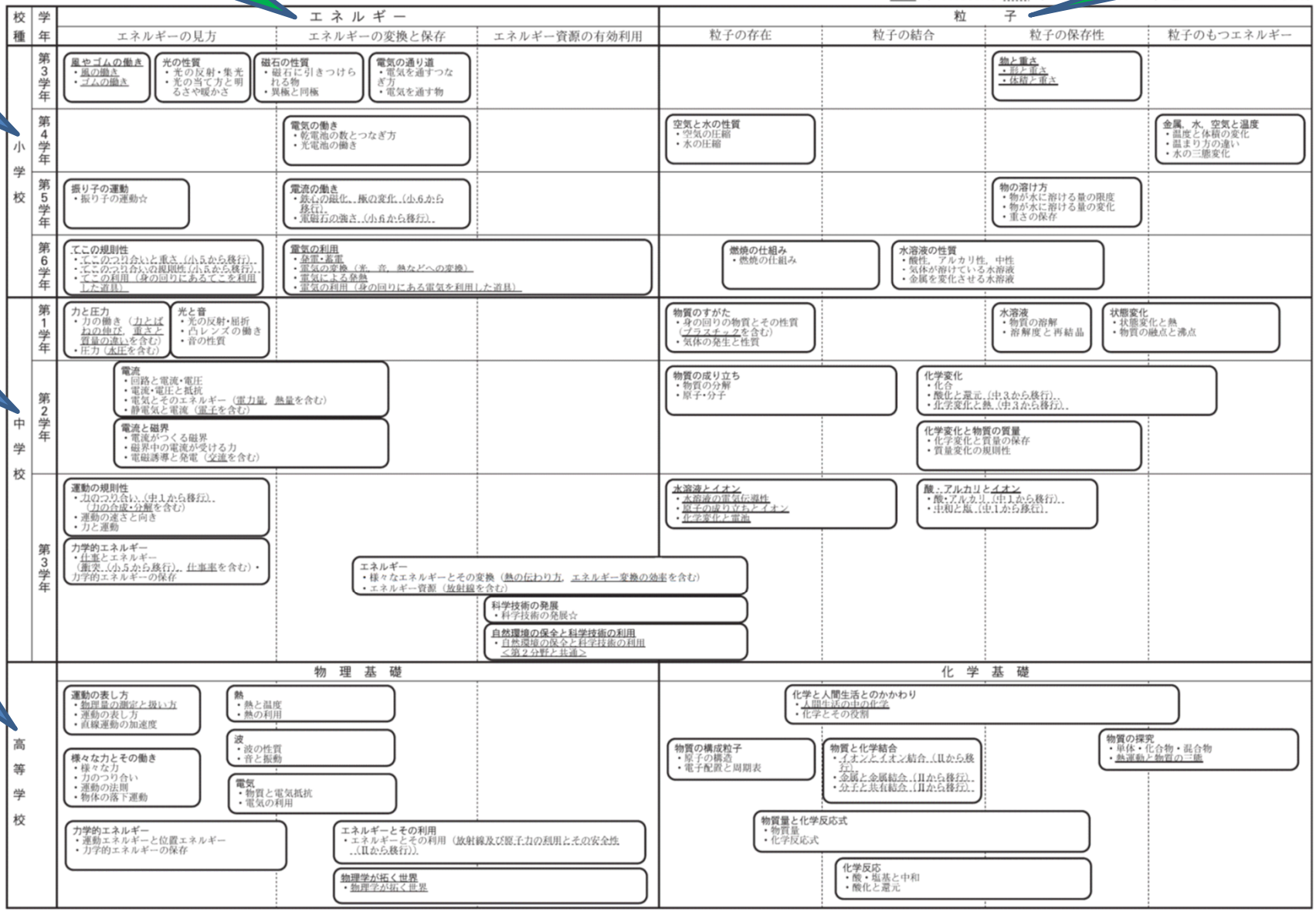
Diagram of structure of current National Curriculum Standards: learning content (1/2)
Structure of learning content centered on “energy” and “particles”

Energy

Particles

小学校・中学校理科と「物理基礎」「化学基礎」の「エネルギー」「粒子」を柱とした内容の構成

実線は，新規項目。破線は，移行項目。[ ]は，選択から必修とする項目。



Elementary school

Junior high school

High school

*** In addition, a diagram of structuring centered on “Life” and “Earth”**

Results of OECD student achievement study (PISA 2015)

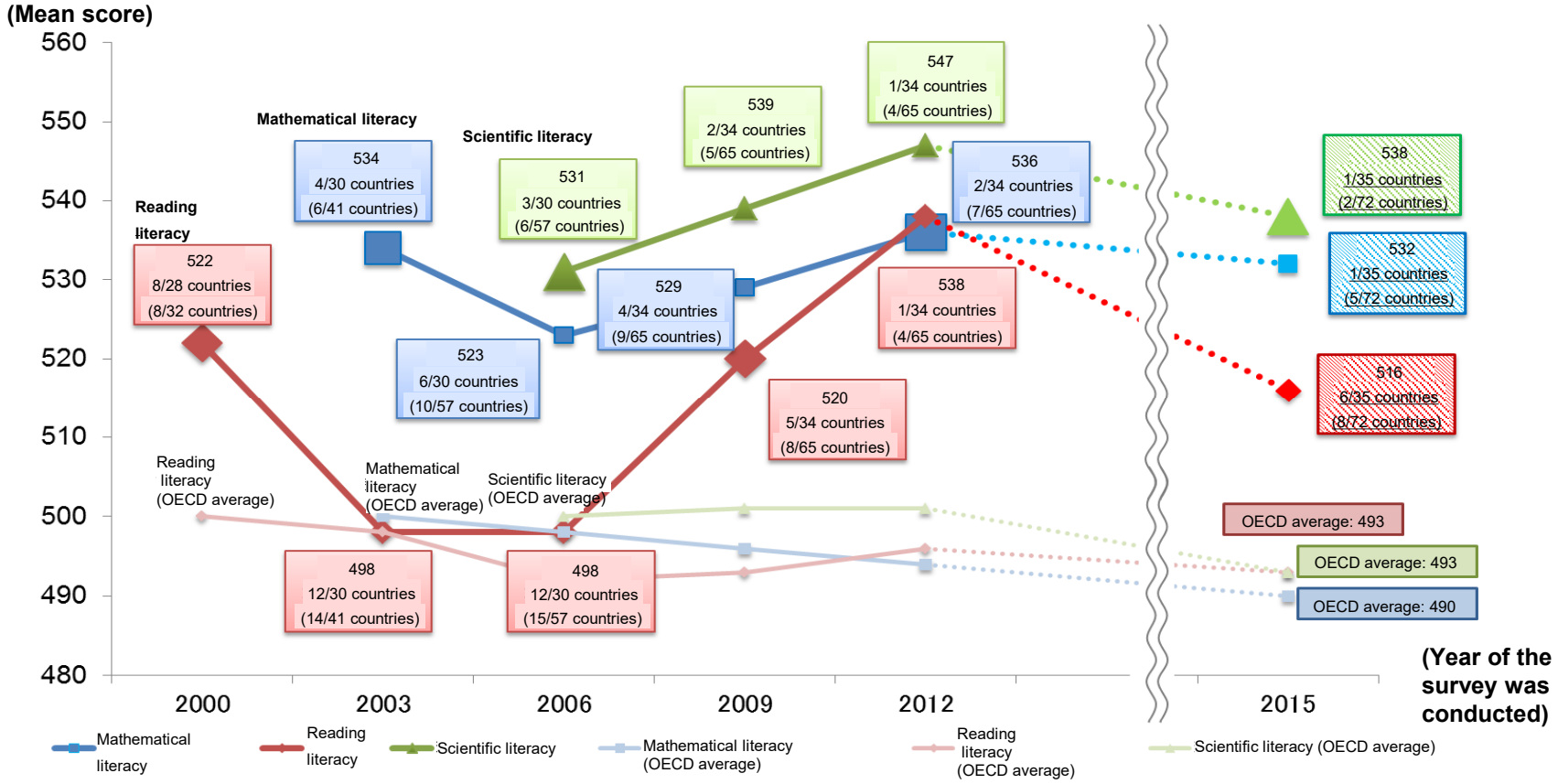
- In all the domains of scientific literacy, reading literacy and mathematical literacy, **Japan continues to place in top performing group with a high mean score from an international viewpoint**. On the other hand, compared with the PISA 2012 result, **the mean score of reading literacy has decreased significantly.** It could be deemed that shift to Computer-Based Test has certain effect on it.
- Regarding the mean score of scientific literacy, which is the major domain of 2015 assessment, students in Japan performed highly among participating countries in all three domain-specific competencies.
- Although Japanese students' positive attitudes towards science remain low compared to OECD average, some improvement is observed since PISA 2006 assessment. For example, **the percentage of students who agreed with the statement "studying science will help them n their future" has increased.**

Changes in mean score and ranking

*PISA survey: OECD conducted the survey on 15 year old students (first grader high school in Japan)

*The scores are estimated based on OECD average of 500 points when each domain first became the major domain (reading literacy: 2000, mathematical literacy: 2003, scientific literacy: 2006). The results since the survey in which mean scores can be compared over the year for mathematical and scientific literacy. The marks for the years where the literacy became the major domain are larger.

*Wave line is drawn between 2012 and 2015, due to the shift from PBA to CBA and the changes in way of scaling and scoring.



(Source) Ministry of Education, Culture, Sports, Science and Technology National Institute for Educational Policy Research "Points of the OECD student achievement study (PISA 2015)"

Characteristics of results for Japan

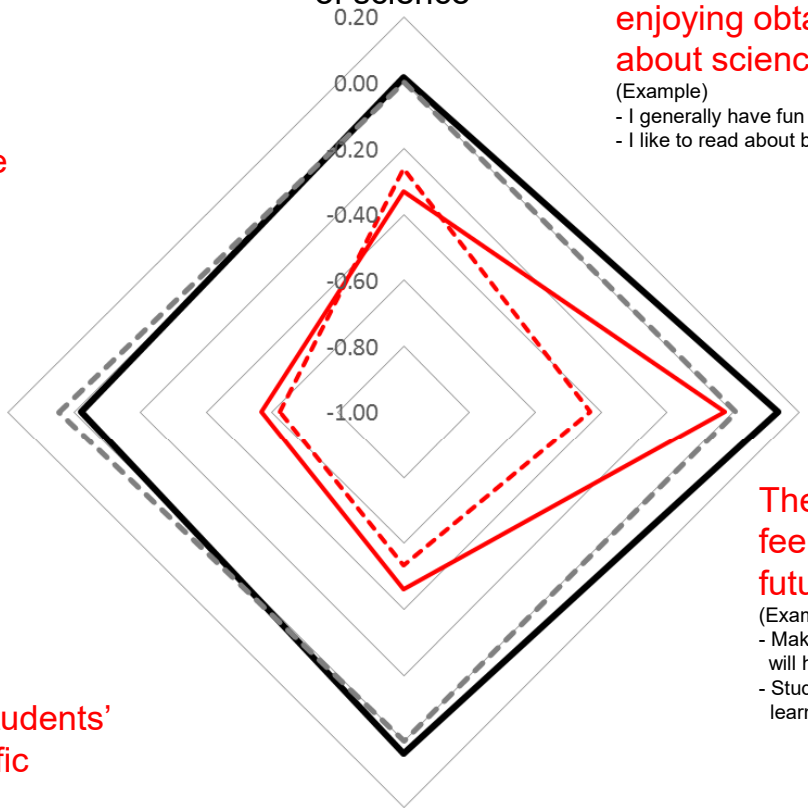
Change in index values in Japan

Index of “Enjoyment of science”

The higher the value, the more students are enjoying obtaining knowledge and learning about science.
(Example)
- I generally have fun when I am learning broad science topics.
- I like to read about broad science.

The higher the value, the more students are actively engaged in activities related to science.
(Example)
- Visit web sites about broad science topics.
- Watch TV programmers about broad science.

Index of “Science activities”



Index of “Instrumental motivation to learn science”

The higher the value, the more students feel that science study will be useful in the future.
(Example)
- Making an effort in my school science subjects is worth it because this will help me in the work I want to do later on.
- Studying my school science subjects is worthwhile for me because what I learn will improve my career prospects.

The higher the value, the greater the students’ confidence in their ability to use scientific knowledge in a certain context.
(Example)
- Explain why earthquakes occur more frequently in some areas than in others.
- Describe the role of antibiotics in the treatment of disease.

Index of “Science self-efficacy”

Japan (2015) Japan (2006) OECD average (2015) OECD average (2006)

Issues indicated by the results of the survey on science
- From the results of the FY2015 national academic ability/learning situation survey -

◆ **Concerning science, which was surveyed for the first time in 3 years, where issues lie in terms of "Organize/analyze the results etc. of observations/experiments, interpret/consider and explain" which was the issue seen in the previous survey (FY2012), was clarified.**

Science

Elementary school

○ Concerning the organization and discussion of results of observations and experiments, a considerable number of children are able to discuss the relationship between obtained data and phenomena, but there are issues **in their quantitative discussions based on the graphs showing results of experiments**.

○ There are issues in **conceiving experiments by forecasting the results** that will be obtained if predictions are correct and improving their own ideas based on the experimental results.

Junior high school

○ Although expression of substances by chemical formulas is good, issues still remain in finding the solute mass and water mass in an aqueous solution at a specific percentage by weight concentration.

○ Although analysis and interpretation from a "graph showing chemical change" and "table showing experiment results" to find changes is good, there are issues in **analysis and interpretation from tables presenting the experiment result numerically to find regularity**.

○ **There are issues in planning and discussing experiments that squarely deal with the issue.**

(Source) Ministry of Education, Culture, Sports, Science and Technology, National Institute for Educational Policy Research "Results of FY2015 national academic ability and learning status survey (overview)"

Direction of improvement of problem-based science education

- Clarify the overall picture of competencies to be acquired through science learning at the level of elementary school, junior high school, and high school in order to respond appropriately to the issues

  competencies to be fostered

  Organized according to the three pillars of “Knowledge and skills,” “Ability to think/judge/express oneself etc.” and “Ability to approach learning/human qualities etc.”

  “Knowledge and skills”

  Understand concepts, principles and laws with respect to natural things and phenomena, and the skills for the observations, experiments, etc., necessary for scientific exploration and problem solving, etc.

  “Ability to think/ make decisions / express oneself etc.”

  Scientific inquiry and problem solving capabilities, etc.

  “Ability Geared Toward learning / Human Nature”

  The attitude of attempting to independently explore and try to solve problems, etc.

- Present ideas on the process of learning necessary for fostering competencies

- Emphasize the relationship with daily living and society etc.

Improvement of presentation of curriculum

Stance on the process of learning to foster competencies

○ While conducting learning activities through the investigative process of identifying (discovering) problems, exploring issues (inquiry), and solving problems, it is necessary to improve teaching to ensure that competencies are fostered in each process

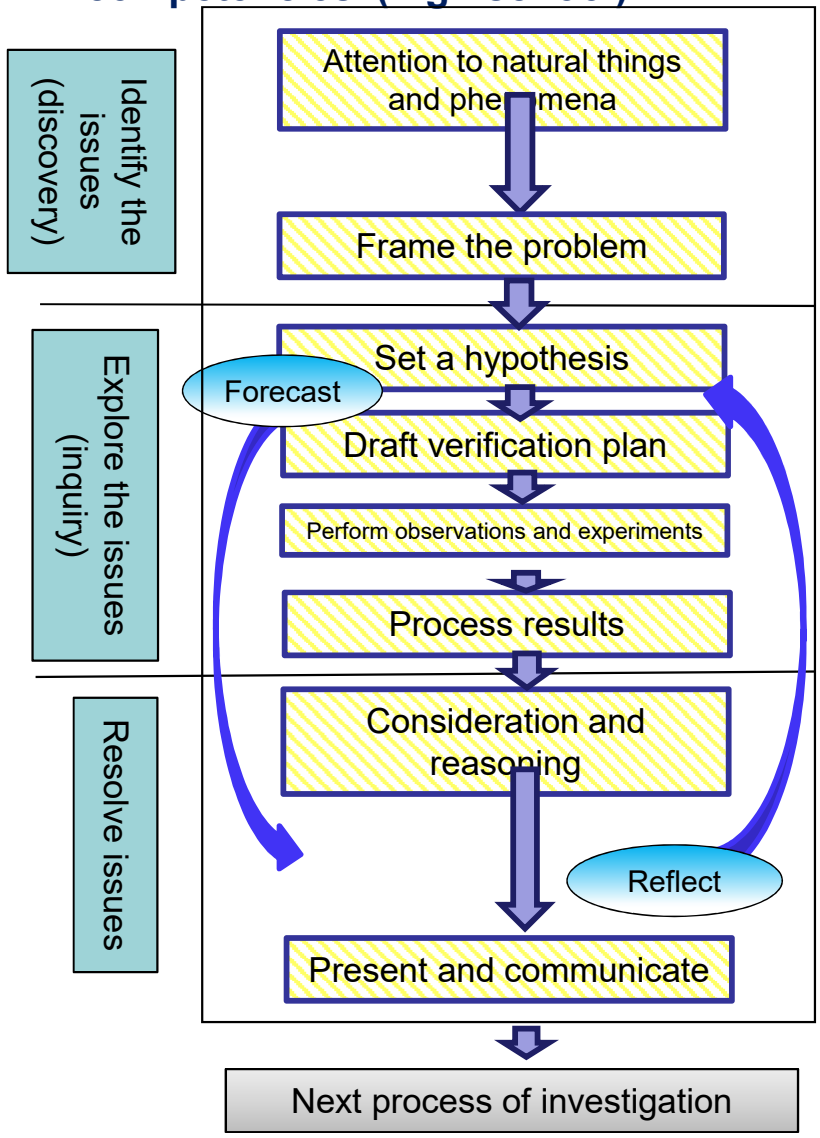
[Important points]

- Aim to enable students to carry out the entire investigation process independently
- Students should already have intellectual curiosity as they are in contact with natural things and phenomena around them
- Students should form questions from the awareness they obtain and be able to frame these as problems

[Notes]

- It may be necessary to return to or repeat the learning process
- In classes, the case may be that not all learning processes are carried out and only some of them are covered
- When appropriately incorporating interactive learning, it is important for the students to form their own ideas in advance

Image of the learning process that should be emphasized to foster competencies (high school)



* Even at elementary and junior high schools, it is necessary to think about the learning process according to the basically same flow

Characteristic description etc. related to cultivation of the ability to think / make decisions /express oneself etc. in the National Curriculum Standards

	competencies to be fostered	Details	Other description
Elementary school	[Grade 3] Primarily develop the ability to find problems based on differences and similarities.	Through activities to investigate while comparing: Find and express problems about xxx based on yyy differences and commonalities.	Regarding the abilities to think, judge and express oneself etc. that are to be cultivated at each grade level, while the primary abilities to be developed in the grade are indicated, in actual teaching, careful consideration is to be given to the cultivation of abilities targeted in other grades.
	[Grade 4] Primarily develop the ability to conceive evidenced expectations and hypotheses based on previously studied content and life experience.	Through activities to investigate while making connections: Conceive and express evidenced predictions and hypotheses on xxx, based on previously studied content and life experience while inquiring into yyy.	
	[Grade 5] Primarily develop the ability to conceive methods of solution based on predications and hypotheses.	Through activities to investigate while controlling conditions: Conceive and express a solution method based on predictions and hypotheses on xxx, while inquiring into yyy.	
	[Grade 6] Primarily cultivate the the ability to produce more reasonable ideas concerning xxx.	Through multifaceted activities: Produce and express more reasonable ideas concerning xxx, while inquiring into yyy.	
Junior high school	[1st field] Cultivate the ability to find regularity and solve problems. [2nd field] Cultivate the ability to notice variety, find regularity and solve problems.	[Grade 1] Discover problems concerning xxx, conduct observations, experiments, etc. with forecast and find and express the regularity and relationship of yyy.	While mutually connecting “knowledge and skills” and the “abilities to think, judge and express oneself etc.,” aim to foster the necessary competencies for scientific exploration over three years.
		[Grade 2] Propose solution methods with forecast concerning xxx, conduct observations, experiments, etc., analyze and interpret yyy results, and find and express the regularity and relationship of zzz.	
		[Grade 3] Conduct observations, experiments, etc. concerning xxx, analyze and interpret yyy results, and find and express the regularity and relationship of zzz. Also, reflect on the process of investigation.	

Image of education in investigative subjects spanning mathematics and science at high school

*Comprising the following two subjects

Implementation stage

"Scientific and Mathematical Inquiry"

Stage of further inquiry

- Students use the qualities and abilities gained in the foundation to set their own problems and conduct the entire process of inquiry.
- Students independently obtain the individual skills and knowledge necessary to conduct investigation according to their problem and aim for deeper inquiry.
- In the inquiry, actively utilize external institutions such as universities and companies to enhance quality.
- From the success or failure of the experiment and the analysis themselves, emphasize the process of proactively conducting trial and error while accepting the risk of failure.

Support from universities and businesses etc.

Students use what they have learned in the foundation to set their own problems and conduct the entire process of inquiry.

→ Students present the results of inquiry inside and outside the school.

Example of the learning process

Basic stage

"Fundamental scientific and mathematical inquiry"

Stage of basic learning

- Students must acquire the basic qualities and abilities to conduct the entire process of inquiry themselves.
- Students must acquire an attitude of engaging in self-led inquiry through deepening their understanding of the significance of striving in the creation of new value etc.
- Students must obtain a basic understanding of research ethics etc.

Learn about methods of inquiry

Under the guidance of teachers, students consider how to move forward with the experiment/observations and methods of analysis, and conduct an inquiry into the selected problem etc.

Learning for a basic understanding of research ethics

→ Present results in school etc.

Toward the execution of new National Curriculum Standards

<Overall>

- Foster competencies required for the new era
- Realize proactive/interactive and authentic learning
- Effectively organize, implement, evaluate, and improve educational content as a school (curriculum management)
- Creation of “next-generation schools/regions” etc.

<In science>

- Further enhancement of exploratory learning
- Establishment of new course “Advanced Science and Mathematics Research (tentative name)” (high school) etc.