Harmonious Integration of Scientific Argument into Inquiry-Based Learning

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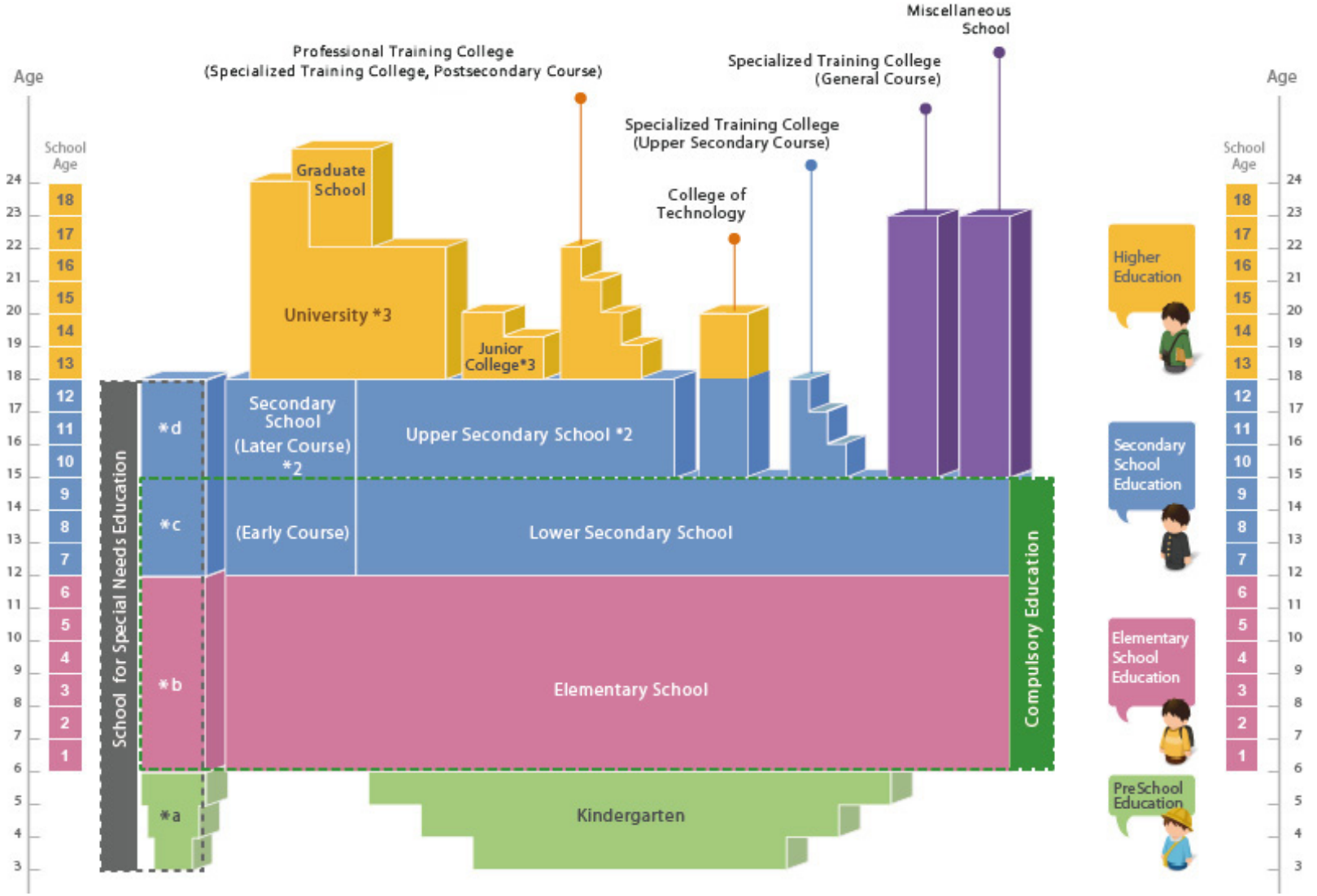
Outline

- Japanese Style Inquiry-Based Learning (JSIBL) in Elementary School
- Scientific Argument (SA) Using the CER Framework
- Conflicts Between JSIBL and SA
- Overcoming Conflicts for Harmonious Integration of SA into JSIBL
  - Inventing which types questions

JAPANESE STYLE INQUIRY-BASED LEARNING IN ELEMENTARY SCHOOL

Japanese School System



http://www.mext.go.jp/en/policy/education/overview/index.htm

Elementary Science in Japan

- Start from third grade (8 and 9 yrs.)
- Integrated science (“Rika”)
- Lesson hours per week
  - Third: 45min × 2
  - Forth: 45min × 3
  - Fifth : 45min × 3
  - Sixth: 45min × 3
- Home room teacher
- Almost schools have a science lab

Japanese Style Inquiry-Based Learning

Japanese science activity structures (Linn et al., 2000)

- 1. Connect lesson to student interest and prior knowledge
- 2. Elicit student ideas or opinions
- 3. Plan investigations
- 4. Conduct investigation
- 5. Exchange information from investigations
- 6. Systematically analyze or organize information
- 7. Reflect and revisit hypotheses or predictions
- 8. Connect to next lesson(s). Identify unanswered questions

JSIBL (Cont'd)

- 1. Connect lesson to student interest and prior knowledge
  - Teacher starts lesson with questions or activity designed to intrigue students and build on their ideas.
- 2. Elicit student ideas or opinions
  - Teacher asks students to express their ideas or opinions about a scientific phenomenon or principle.

JSIBL (Cont'd)

- 3. Plan investigations
  - Students, assisted by teacher, generate hypotheses or predictions about the topic of study and define methods for investigation.
- 4. Conduct investigation
  - Students conduct experiments or observations to test the hypotheses or predictions just built.
  - The method of investigation may have been designed by the whole class, small group, or individual.

JSIBL (Cont'd)

- 5. Exchange information from investigations
  - Students share their findings within their small groups or report them to the whole class.
- 6. Systematically analyze or organize information
  - Teachers systematically summarize or organize the information shared by students.

JSIBL (Cont'd)

- 7. Reflect and revisit hypotheses or predictions
  - Teachers encourage students to reflect on their current ideas and experimental findings in light of their earlier hypotheses or predictions.
  - Teachers may encourage students to repeat the experiment in order to check on their prior hypotheses or findings.
- 8. Connect to next lesson(s). Identify unanswered questions
  - Teachers ask students to think about or write down what they want to investigate in the next lesson(s).

The Case of JSIBL

Fifth grade physics unit “movement of pendulums”

The purpose of the unit

- To develop pupils’ ideas about the regularity of the movement of pendulums, by using weights, and by exploring the movement of pendulums in changing the weight and the length of a thread.
  - the time taken for a weight on a string to swing back and forth does not change if the weight changes, but it does change when the length of the string changes.

http://www.mext.go.jp/a_menu/shotou/new-cs/youryou/eiyaku/1261037.htm

The Case of JSIBL (Cont'd)

- 1. Connect lesson to student interest and prior knowledge
  - Teacher starts lesson by showing pendulums and asks students driving question "what affects the period of a pendulum?"
- 2. Elicit student ideas or opinions
  - Teacher facilitates whole-class discussion about factors that affects the period.
    - The weight of the pendulum ball
    - The angle of release
    - The length of the pendulum

The Case of JSIBL (Cont'd)

- 3. Plan investigations
  - Teacher asks students to generate hypotheses and predictions about factors such as
    - The weight affects the period (The lighter the weight, the shorter the period.).
    - The length affects the period (The longer the length, the longer the period.).
    - The angle affects the period (The smaller angle of release, the shorter the period.).
  - Teacher introduce the concept of variables (control, independent, and dependent) and asks students to plan investigation varying factors.

The Case of JSIBL (Cont'd)

- 4. Conduct investigation
  - Students form a group, use the experimental equipment of pendulum, and conduct an experiment to find out the factors that affects the period.

The Case of JSIBL (Cont'd)

- 5. Exchange information from investigations
  - Students writes on the blackboard their results of pendulum experimentation in cross tabular format.
    - e.g., The weight x the period
- 6. Systematically analyze or organize information
  - Teacher asks students to see similarities or differences in results of students group, and to summarize the results.
    - e.g., If the lighter the weight, the period did not be shorter.

The Case of JSIBL (Cont'd)

- 7. Reflect and revisit hypotheses or predictions
  - Teacher asks students to draw conclusions from the findings of their experiment and connect these to their earlier hypotheses.
    - e.g., The weight and the angle does not affect the period. the length affects the period.
- 8. Connect to next lesson(s). Identify unanswered questions
  - Teacher asks students to generate a set of questions or topics related to pendulums that they want to investigate in the next lesson(s).

Historical and Socio-Cultural Context of JSIBL

- Traditionally, Japanese science educators take against lecture-style teaching and value guided discovery based on “inquiry-based learning” slogan (Ogawa, 1993).
- The national curriculum in Japan encourages teachers to support students discovering scientific principle through observation and experimentation (MEXT Japan, 2017).
- Japanese science activity structures are implemented everywhere in Japanese elementary science lessons (Linn et al., 2000).

SCIENTIFIC ARGUMENT USING THE CER FRAMEWORK

Benefits of Scientific Argument for Science Education

- Understand science concepts
- Develop twenty-first-century skills
- Use evidence to support claims
- Reason logically
- Consider and critique alternative explanations
- Understand the nature of science

McNeill & Krajcik (2002)

The CER Framework (McNeill & Krajcik, 2002)

- Claim
  - A statement that answers the question
- Evidence
  - Scientific data that supports the claim
- Reasoning
  - A justification for why the evidence supports the claim using scientific principles

Example of Scientific Argument using the CER Framework

- Claim
  - The plant that received more light grew taller.
- Evidence
  - The plant with 24 hours of light grew 20 cm. The plant with 12 hours of light only grew 8 cm.
- Reasoning
  - Plants require light to grow and develop. This is why the plant that received 24 hours of light grew taller.

McNeill & Krajcik (2002)

National Curriculum Reform in Japan and Scientific Argument

- Impact of PISA and TIMSS
- Reform in 2008
  - Greater emphasis must be put on relating the results of observations and experiments to hypotheses and predictions through “language activity” such as writing and discussing.
- Reform in 2017
  - Enhancement of “language activity.”
  - Emphasis on thinking and explanation using scientific language and concepts.
  - Emphasis on discussing with others using scientific language and concepts.

CONFLICTS BETWEEN JAPANESE STYLE INQUIRY-BASED LEARNING AND SCIENTIFIC ARGUMENT

Two Approaches to Introducing Scientific Argument into Japanese Style Inquiry-Based Learning

- Add-ons approach
  - SA as extra-activity of JSIBL
- Integral approach
  - SA as intra-activity of JSIBL

Add-ons approach

- 1. Connect lesson to student interest and prior knowledge
- 2. Elicit student ideas or opinions
- 3. Plan investigations
- 4. Conduct investigation
- 5. Exchange information from investigations
- 6. Systematically analyze or organize information
- 7. Reflect and revisit hypotheses or predictions
- Additional activity: Scientific argument activity
- 8. Connect to next lesson(s). Identify unanswered questions

Integral approach

- 1. Connect lesson to student interest and prior knowledge
- 2. Elicit student ideas or opinions
  - with scientific argument activity
- 3. Plan investigations
  - with scientific argument activity
- 4. Conduct investigation
- 5. Exchange information from investigations
- 6. Systematically analyze or organize information
  - with scientific argument activity
- 7. Reflect and revisit hypotheses or predictions
  - with scientific argument activity
- 8. Connect to next lesson(s). Identify unanswered questions

Benefits of Integral Approach

- Integral approach supports students' reasoning about coordination of hypotheses and experiments or observations in whole inquiry process.
- Integral approach supports students to master scientific argument through "habituation."

Conflicts between JSIBL and SA

Homogeneity of claim and reasoning

- Driving question for JSIBL
  - Scientific argument learning task
  - Question about scientific principles
- Claim
  - A statement about scientific principles
- Reasoning
  - A justification for why the evidence supports the claim using scientific principles

Conflicts (Cont'd)

Conflicts

- Elementary students are hard to provide reasoning because of difficulty in understanding of mechanisms behind scientific principles.
- Therefore, they have difficulty in distinguishing between claim and reasoning in their scientific arguments.

Conflicts (Cont'd)

Example of "movement of pendulums"

- Scientific argument learning task
  - Driving question for inquiry
  - What affects the period of a pendulum?

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- Claim
  - A statement that answers the question
  - The length affects the period.

Conflicts (Cont'd)

- Claim
  - A statement that answers the question
  - The length affects the period.
- Evidence
  - Scientific data that supports the claim
  - When the string length of the pendulum was 40cm, the average period was 1.3 seconds, and when the string length of the pendulum was 20cm, the average period was 0.8 seconds.
- Reasoning
  - A justification for why the evidence supports the claim using scientific principles
  - The length affects the period.

OVERCOMING CONFLICTS FOR HARMONIOUS INTEGRATION OF SA INTO JSIBL: INVENTING WHICH TYPES QUESTION

Analyzing Conflicts

Driving question for JSIBL • Scientific argument learning task	Theoretical world
Claim	Theoretical world
Evidence	Real world
Reasoning	Theoretical world

Inventing Which Types Question

Driving question for JSIBL	Theoretical world
Which types questions • Scientific argument learning tasks	Real world
Claim	Real world
Evidence	Real world
Reasoning	Theoretical world

Driving Question and Which Types Questions

- Driving Question
  - What affects the period of a pendulum?
- Which Types Questions
  - When the weight has made light, will the period be short, long, or stay constant? Which do you think is right?
  - When the length of the pendulum has made short, will the period be short, long, or stay constant? Which do you think is right?
  - When the angle has made small, will the period be short, long, or stay constant? Which do you think is right?

Sakamoto et al. (2012, 2014), Yamamoto et al. (2013)

Which Types Questions and SA

- Scientific argument learning task
  - When the length of the pendulum has made short, will the period be short, long, or stay constant? Which do you think is right?
- Claim
  - The shorter the length of the pendulum, the shorter the period.
- Evidence
  - When the string length of the pendulum was 40cm, the average period was 1.3 seconds, and when the string length of the pendulum was 20cm, the average period was 0.8 seconds.
- Reasoning
  - The length of the pendulum affects the period.

Harmonious Integration of SA into JSIBL by Which Types Question

- Which types question is one of useful heuristics for harmonious integration of SA into JSIBL in elementary school.
- Students can use scientific argument in making predictions before investigation,
  - 2. Elicit student ideas or opinions
  - 3. Plan investigations
- As well as making conclusion after investigation.
  - 6. Systematically analyze or organize information
  - 7. Reflect and revisit hypotheses or predictions

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