Designing and Implementing Lessons for Fostering Students' 21 Century Skills Through Productive Discussions in Classrooms

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RECENT EDUCATIONAL INITIATIVES

21st Century Skills

Learning Skills

- Critical thinking
- Creativity
- Collaboration
- Communication

Literacy Skills

- Information
- Media
- Technology

Life Skills

- Flexibility
- Leadership
- Initiative
- Productivity
- Social Skills

STEM Education

Through STEM, students develop key skills including:

- Problem solving
- Creativity (Creativity, Curiosity and imagination)
- Critical analysis
- Teamwork & Corroborations
- Independent thinking
- Initiative
- Communication
- Digital literacy
- Inquiry Skills

Standards for Mathematical Practice (U.S.A.)

Overarching Habits of Mind

(1) Make sense of problems and persevere in solving them
(6) Attend to precision

(2) Reason abstractly and quantitatively
(3) Construct viable arguments and critique the reasoning of others

Reasoning & Explaining

(4) Model with mathematics
(5) Use appropriate tools strategically

Modeling & Using Tools

(7) Look for and make use of structure
(8) Look for and express regularly in repeated reasoning

Seeing Structure & Generalizing

Common Core State Standards for Mathematics (National Governors Association Center for Best Practices and Council of Chief State School Officers, 2010)

Effective Mathematics Teaching & Learning (1)

- Engage with challenging tasks that involve active meaning making and support meaningful learning.
- Connect new learning with prior knowledge and informal reasoning and, in the process, address preconceptions and misconceptions.
- Acquire conceptual knowledge as well as procedural knowledge, so that they can meaningfully organize their knowledge, acquire new knowledge, and transfer and apply knowledge to new situation.

Principles to Actions: Ensuring Mathematics Success for All (NCTM, 2014)

Effective Mathematics Teaching & Learning (2)

- Construct knowledge socially, through discourse, activity, and interaction related to meaningful problems.
- Receive descriptive and timely feedback so that they can reflect on and revise their work, thinking, and understandings.
- Develop metacognitive awareness of themselves as learners, thinkers, and problem solvers, and learn to monitor their learning and performance.

Principles to Actions: Ensuring Mathematics Success for All (NCTM, 2014)

Fostering 21 Century Skills Through Productive Discussion in Classrooms

IMPROVING CLASSROOM PRACTICE

- Student learning of mathematics “depends fundament on what happens inside the classroom as teachers and learners interact over the curriculum: (Ball and Forzani, 2011)

Building Common Core for Learning to Teach (Ball and Forzani, 2011)

Main Ideas for Improve Classroom Practice

- Setting up clear *Goals* that aim for developing students' 21 Century skills
- Engage students in *Teaching Thorough Problem Solving (TTPS)* approach of instruction and learning
- Enhance student discussion using *5 Practices for Orchestrating Productive Mathematics Discussions* and *bansho (board organization)*
- Provide opportunity for students to *reflect on their own learning*
- *Creating a system* that help teachers to continuously design, implement, observe, discuss, and revise classroom practice. (*Lesson Study*)

Overarching Goal:
Developing 21 Century
Learning Skills

Instructional Materials

Teacher

Students

Unit and Lesson Plans & Goals

Cognitively Challenging Tasks

Teaching Through Problem Solving (TTPS)

5 Practices for Orchestrating Productive Mathematics Discussions

Reflection/Assessments

21 Century Learning Skills

- Critical thinking
- Creativity
- Collaboration
- Communication

PLC:
Lesson Study

Expected Outcome from the Proposed Idea

- Problem-solving and mathematical thinking process
  - Use prior knowledge, thinking strategies/processes, and process skills for solving new problem effectively
  - Look for better ways (e.g., effective, efficient, simpler) to solve problems
- Presentation & communication skills
  - Using representations (words, models, expressions) to explaining ideas
  - Listening and explaining ideas
  - Learning from each other
  - Collaborative learning
- Synthesizing and generalizing ideas
  - Look for: simplicity, clearness, generalization, efficiency
- Reflection & Metacognition
  - Monitor and assess own understanding and performance
  - Awareness of own thinking and learning as learner
  - Improve attitude for learning (interest, motivation, disposition)

ESTABLISHING 0VERARCHING GOALS

Establishing Overarching Goals

- What kind of of students do we have?
- What kind of students do we want to foster?
- How do we get there?

To foster 21 Century Learning Skills among students, the skills shown to the right must be included in the overarching goals.

21 Century Learning Skills
- Critical thinking
- Creativity
- Collaboration
- Communication

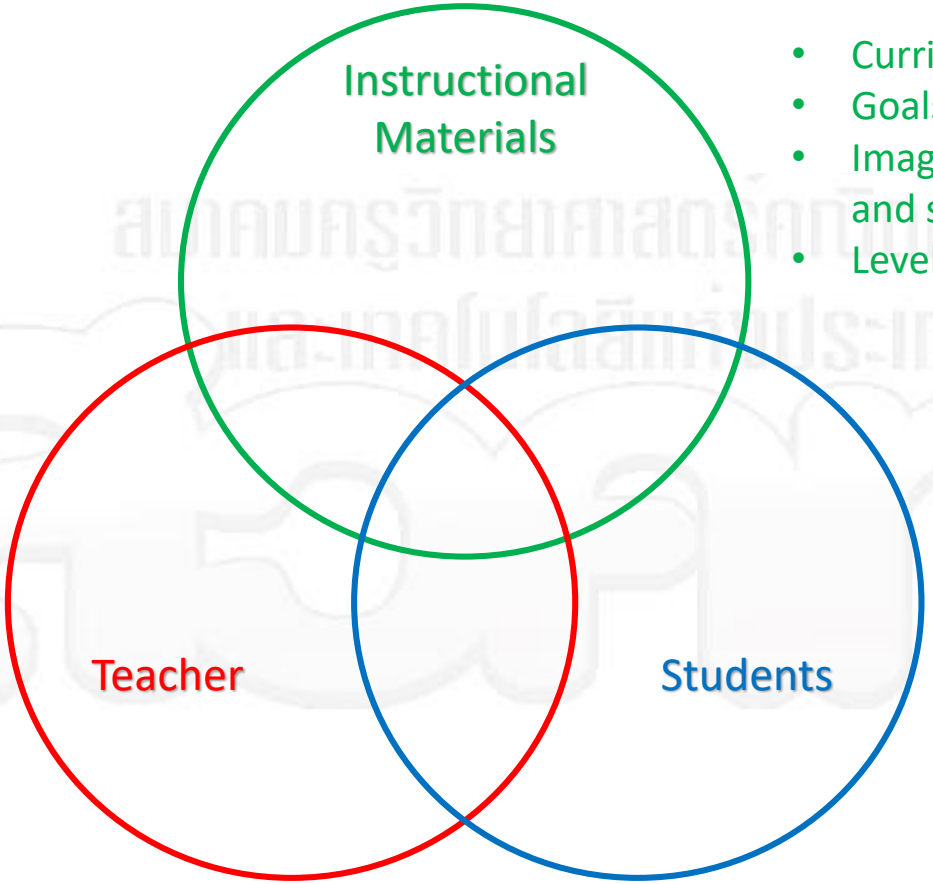
It is important to have clear goals so we can assess the student outcome precisely.

CREATE UNIT GOALS & PLANS

Unit Goals and Plans

- Unit Goals:
  - Mathematics goals
    - What mathematical concept students are learning
    - Connection to students' prior knowledge
  - Student skill goals
    - What student skill goals are developed
- Unit Plans:
  - Identify important concepts student need to learn. (Conceptual Development Lessons)
  - Allocate review and practice time (Review and Practice lessons)
  - If it is necessary, think about review lessons for prior learning

Instructional Material Investigation
Kyozai-kenkyuu



- Curriculum writer's belief
- Goals of the curriculum
- Image of student knowledge and skills
- Level of content

- Teacher's belief
- Content and curriculum knowledge
- Pedagogical content knowledge
- Knowledge about students
- Instructional skills

- Past learning experiences
- State of learning
- Interest, Eagerness
- Motivation
- Discipline
- Learning habits

Overarching Goal:
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5 Practices for Orchestrating Productive Mathematics Discussions

Reflection/Assessments

21 Century Learning Skills

- Critical thinking
- Creativity
- Collaboration
- Communication

PLC:
Lesson Study

TEACHING THROUGH PROBLEM SOLVING

Different Types of Problem Solving

- Teaching for problem solving
  - Teaching a skill first so that a student can later problem solve (apply the learned skills for problem solving)
- Teaching about problem solving
  - Teaching students how to problem solve
  - E.g., teaching process (understand, design a strategy, implement, look back) or strategies for solving a problem (draw a picture)
- Teaching through problem solving (TTPS)
  - Solve new problem students have not learned to solve before by recall and utilize previously learned knowledge
  - Students learn mathematics through real contexts, problems, situations, and models.

(see Van de Walle, 2009)

Two Types of TTPS Lessons

Conceptual Development Lesson

- Provide opportunity to explore new concepts with problem solving
- Recall prior knowledge and apply them
- Exchange and discuss ideas
- Synthesize and generalize idea discussed
- Summarize learning

Review and Practice Lesson

- Deepening understanding of what they learned in the conceptual development lesson
- Apply and practice concept with more challenging problems
- Develop procedural skills

Structure of the Conceptual Development Lessons

1. Introducing the Task (about 10 min.)
   - Recalling prior knowledge
   - Understanding task
2. Solving Problems (about 15 min.)
   - Solving problems
     - Individual problem solving
     - Pair or small group problem solving
3. Presenting and Discussing (about 25 min.)
   - Presenting and discussing solution ideas
   - Synthesizing & Generalizing ideas
4. Summarizing the Lesson (about 10 min.)
   - Summarizing the learnings
   - Reflecting learning
   - Assessing student learning

Main Body of the Lesson

Structure of the Review and Practice Lesson

1. Introducing the Task (about 10 min.)
   - Reviewing prior learning
   - Understanding problems and tasks
3. Problem Solving & Discussion for Solidifying Learning from Conceptual Development Lesson (about 20 min.)
   - Solving problem
   - Presenting
   - Discussing
4. Problem Solving with Application Problems (about 20 min.)
   - Solving problem
   - Presenting
   - Discussing
5. Summary of the Lesson (about 10 min.)
   - Summarizing the learning
   - Reflecting learning

LESSON GOALS AND PLAN

Lesson Goals and the Plan

- Lesson Goals:
  - Mathematics goals
    - What mathematical concept students are learning
    - Connection to students' prior knowledge
  - Student skill goals
    - What student skill goals are developed
- Unit Plans:
  - Use Conceptual Development Lesson structure of TTPS to develop lesson
  - Look for cognitively challenging task
  - Incorporate 5 Practices for Orchestrating Productive Mathematics Discussion

LOOK FOR COGNITIVELY CHALLENGING TASKS

Cognitively Challenging Tasks (Worthwhile Problems)

- Mathematical tasks that have the potential to provide intellectual challenges that can enhance students' mathematical development.
- Problem can promote students' conceptual understanding, foster their ability to reason and communicate mathematically, and capture their interests and curiosity.

(Hiebert & Wearne, 1993; Marcus & Fey, 2003; Van de Walle, 2003)

Criteria of Worthwhile Problems

1. The problem has important, useful mathematics embedded in it.
2. The problem requires higher-level thinking and problem solving.
3. The problem contributes to the conceptual development of students.
4. The problem creates and opportunity for the teacher to assess what his or her students are learning and where they are experiencing difficulty.
5. The problem can be approached by students in multiple ways using different solution strategies.

(NCTM, 1991)

Criteria of Worthwhile Problems

6. The problem has various solution or allows different decisions or positions to be taken and defended.
7. The problem encourages student engagement and discourse.
8. The problem connects to other important mathematical ideas.
9. The problem promotes the skillful use of mathematics.
10. The problem provides an opportunity to practice important skills.

(NCTM, 1991)

FIVE PRACTICE FOR ORCHESTRATING PRODUCTIVE MATHEMATICAL DISCUSSIONS

Five Practices for Orchestrating Productive Mathematics Discussions

1. ***Anticipating*** likely student responses to challenging mathematical tasks
2. ***Monitoring*** students' actual responses to the tasks (while students work on the tasks in pairs or small groups)
3. ***Selecting*** particular students to present their mathematical work during the whole-class
4. ***Sequencing*** the student responses that will be displayed in a specific order;
5. ***Connecting*** different students' responses and connecting the responses to key mathematical ideas.

Five Practices for Orchestrating Productive Mathematics Discussions, NCTM (2011)

3 ways to use 5 practices

- Planning Lessons
- Teaching Lessons
- Observing and Discussing Lessons

AN EXAMPLE OF USE OF USE OF 5 PRACTICES IN MATHEMATICS

Lesson: Addition of Fractions with Unlike Denominators

- Student Prior knowledge:
  - Basic fraction concepts (fraction notation, unit fraction)
  - Equivalent fractions
  - Addition of fractions with like denominators (e.g., $\frac{2}{5} + \frac{1}{5} = \frac{3}{5}$)
  - Comparing fractions (fraction with like and unlike denominators

Problem & Task

Problems:

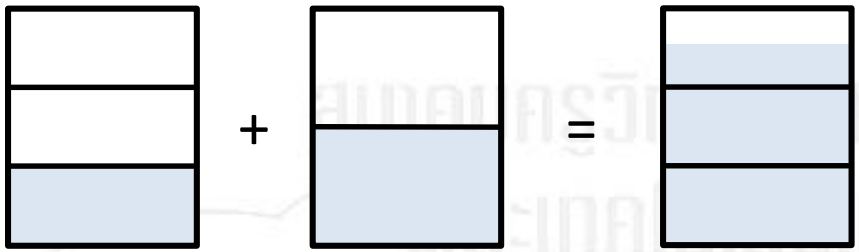
There are $\frac{1}{3}$ *liter* of milk in a bottle and $\frac{1}{2}$ *liter* of milk in a carton. How many *liters* of milk do we have altogether?

Task:

Let's think about how to calculate $\frac{1}{3} + \frac{1}{2}$.

Anticipating Student Solutions

A. Thinking about the solution using diagram:



B. $\frac{1}{3} + \frac{1}{2} = \frac{2}{5}$ (wrong answer)

C. $\frac{1}{3} + \frac{1}{2} = \frac{2}{6} + \frac{3}{6} = \frac{5}{6}$

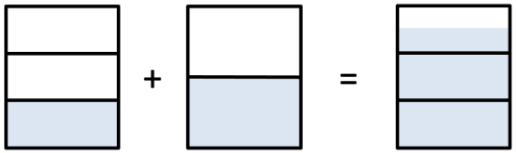
D. Having difficulty

Monitor Students During Independent Problem Solving

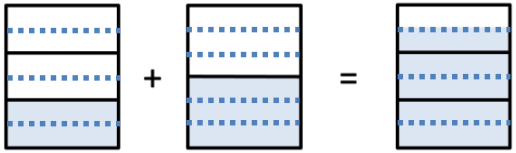
- What anticipated solutions are they using?
- Which anticipated solution is more common?
- When majority of students are having difficulty:
  - Think about why students are having difficulty
  - Does discussion help students to think the problem solution?

Selecting, Sequencing, Connecting

1. Ask to present $\frac{1}{3} + \frac{1}{2} = \frac{2}{5}$
   - Ask students to think what they think
2. Ask to present diagram



   - Compare the diagram with the answer $\frac{2}{5}$
3. Ask to present $\frac{1}{3} + \frac{1}{2} = \frac{2}{6} + \frac{3}{6} = \frac{5}{6}$
   - Clarify the process and the reason
   - Make connection with the diagram



   - Make connection with equivalent fractions and learn about idea of finding common denominator

AN EXAMPLE OF USE OF USE OF 5 PRACTICES IN SCIENCE

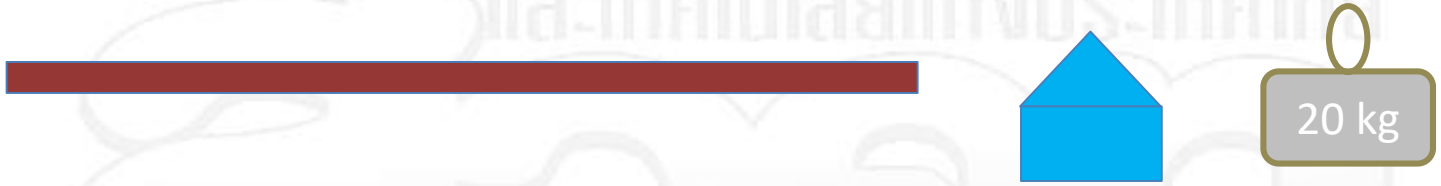
Lesson: Lifting Up a Heavy Object with a Stick

- Student Prior knowledge:
  - Experience with balance scale
  - Playing with seesaw

Problem & Task

Problems:

Here is a 20 kg bag of sand. We want to lift it up easily using a stick and a supporting object.

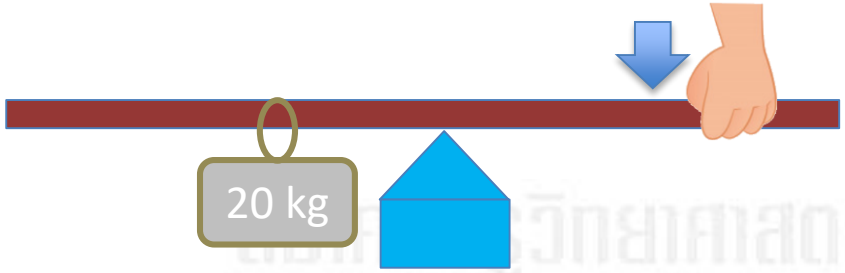


Task:

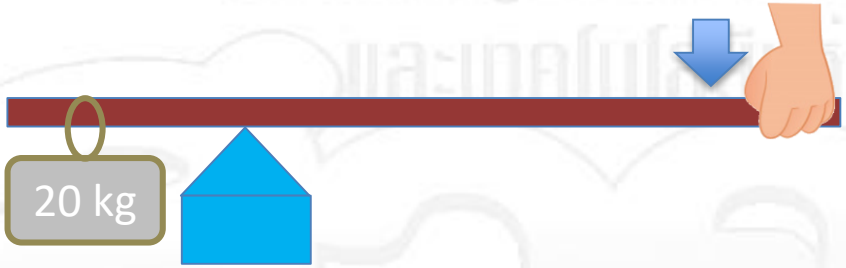
Let’s think about how we can use the stick and the supporting object to lift a heavy object easily.

Anticipating Student Solutions

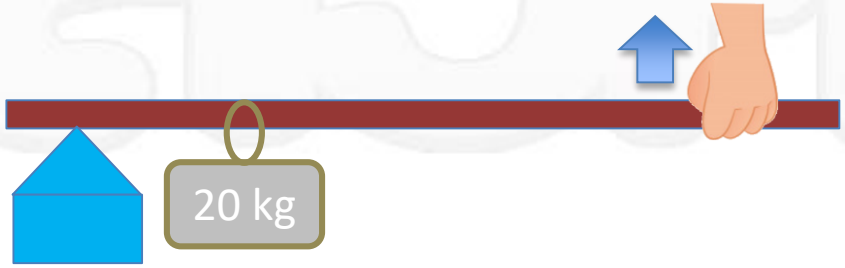
A.



B.



C.

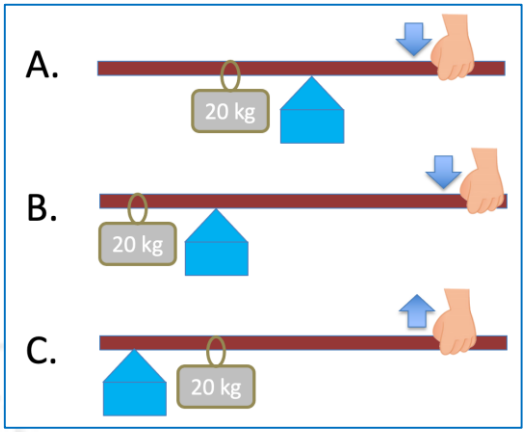


D. I wonder why the weight of sand changes?

Monitor Students During Independent Problem Solving

- What anticipated solutions are they using?
- Which anticipated solution is more common?
- How are they describing why the sandbag can be lifted easily using the stick and the supporting objects.
  - Location, relationship, and distance of the sandbag, the support object, and the hand.
  - Light, heavy, easy, difficult, etc.

Selecting, Sequencing, Connecting



- Ask to present A
  - I could lift the sandbag.
- Ask to present B
  - I could lift it easily
  - Discuss the difference between A and B
  - Clarify what is making easier to lift the sandbag
- Ask to present C
  - Discuss how it is similar or different from A and B.
  - Compare with A and B by lifting the method.
  - Discuss and clarify what is making easier to lift the sandbag.
  - Lean about fulcrum, effort, load. And summarize some ideas that help lifting sandbag easily.

REFLECTION AND ASSESSMENT

Reflection and Assessment

- Reflection
  - In corporate a time to reflect on learning during the lesson
  - Ask students to write reflection of learning
- Assessment
  - Formative Assessment
  - Summative Assessment

Formative Assessment

Formative Assessment

- More diagnostic way to evaluate children's learning
- Ongoing observation to monitor learning progress
- Descriptive notes and data collecting, qualitative data analysis, and descriptive feedback
- Critical for teacher to adjust instruction to help children improve their learning.
- Other form of formative assessments
  - Short quizzes, quick all-student voting during and at end of instruction
  - During-lesson reflections or exit tickets

Summative Assessment

Summative Assessment

- Formally collects benchmark data (tests & quizzes)
- Collect numeric data and analyze quantitively.
- Often administered at the end of a unit of study
- Suited for identifying gaps among curriculum, instruction, and student learning
- Often used for grading
- Used for big-picture adjustments and improvements to instruction and curriculum design

The Goal of Assessments

The goal of assessment is not rating children's performance, rather the goal of assessment is to provide an ongoing diagnostic tool to improve every child's learning.

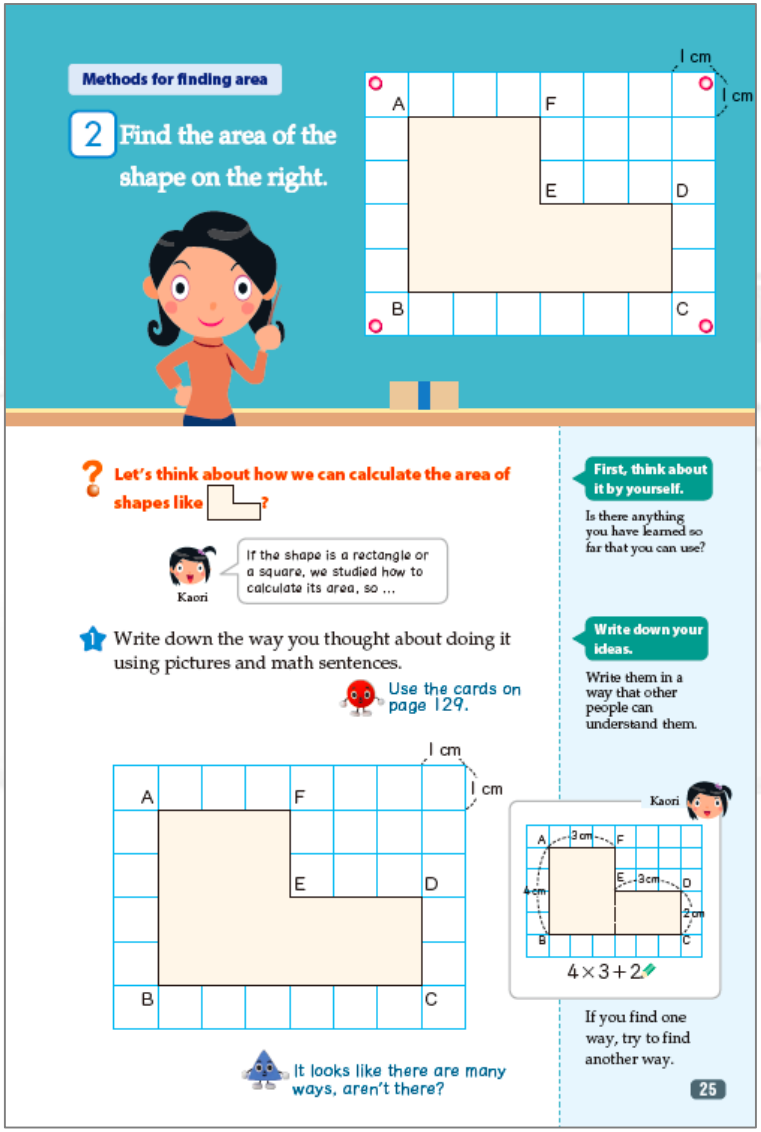
BANSHO (BOARD ORGANIZATION) AND NOTE TAKING

Bansho (Board Organization) to Facilitate Student Discussions

Contribution of *Bansho* for Student Learning:

- Organizing learning
  - Connection and , coherent flow of the lesson
  - Problem/task, student solution ideas, discussions, summary
- Facilitating discussions
  - Work with 5 Practices for Orchestrating Productive Mathematics Discussions to deepen discussions
  - Comparing solutions (similarities, differences, categorizing)
  - Highlighting and summarizing findings through discussion
  - Synthesizing and generalizing solution ideas (better way, simplicity, efficiency, effective, accuracy, generalizable)
- Fostering students' organized note-taking skills by modeling good *bansho*

Problem Solving and Board Organization



Methods for finding area

2 Find the area of the shape on the right.

1 cm
1 cm
A F E D B C

Let's think about how we can calculate the area of shapes like ?

Kaori: If the shape is a rectangle or a square, we studied how to calculate its area, so ...

1 Write down the way you thought about doing it using pictures and math sentences.

Use the cards on page 129.

1 cm
1 cm
A F E D B C

It looks like there are many ways, aren't there?

First, think about it by yourself.

Is there anything you have learned so far that you can use?

Write down your ideas.

Write them in a way that other people can understand them.

Kaori

3 cm
4 cm
3 cm
2 cm
A F E D B C

$4 \times 3 + 2$

If you find one way, try to find another way.

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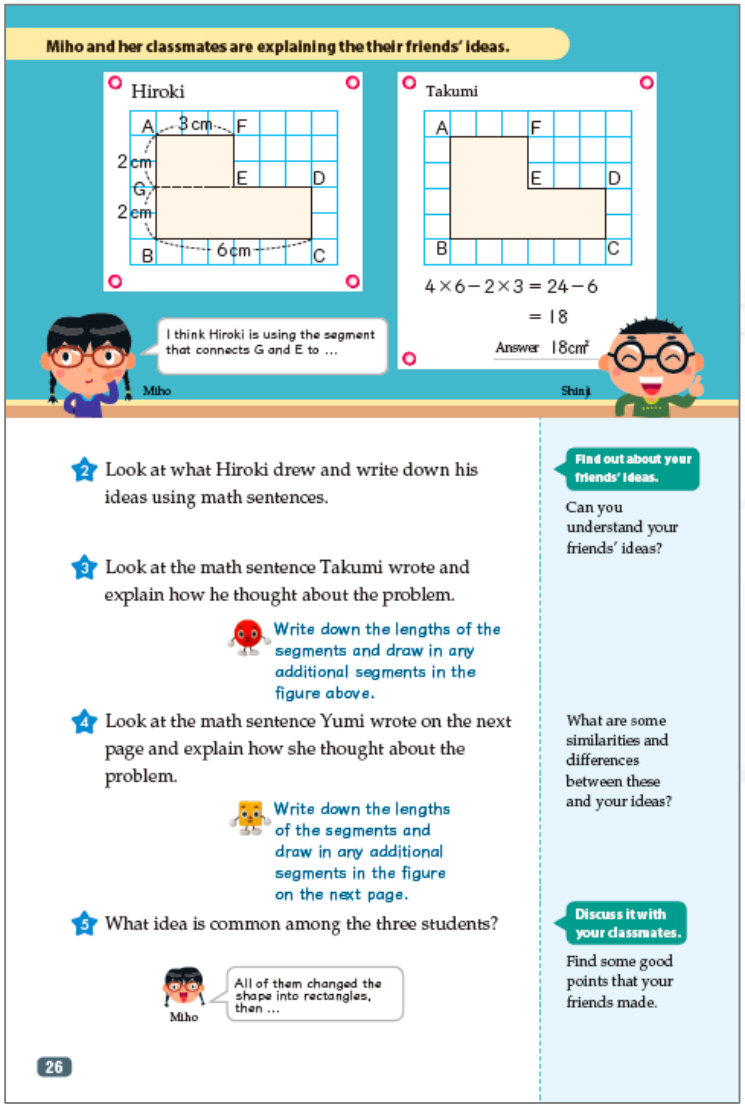
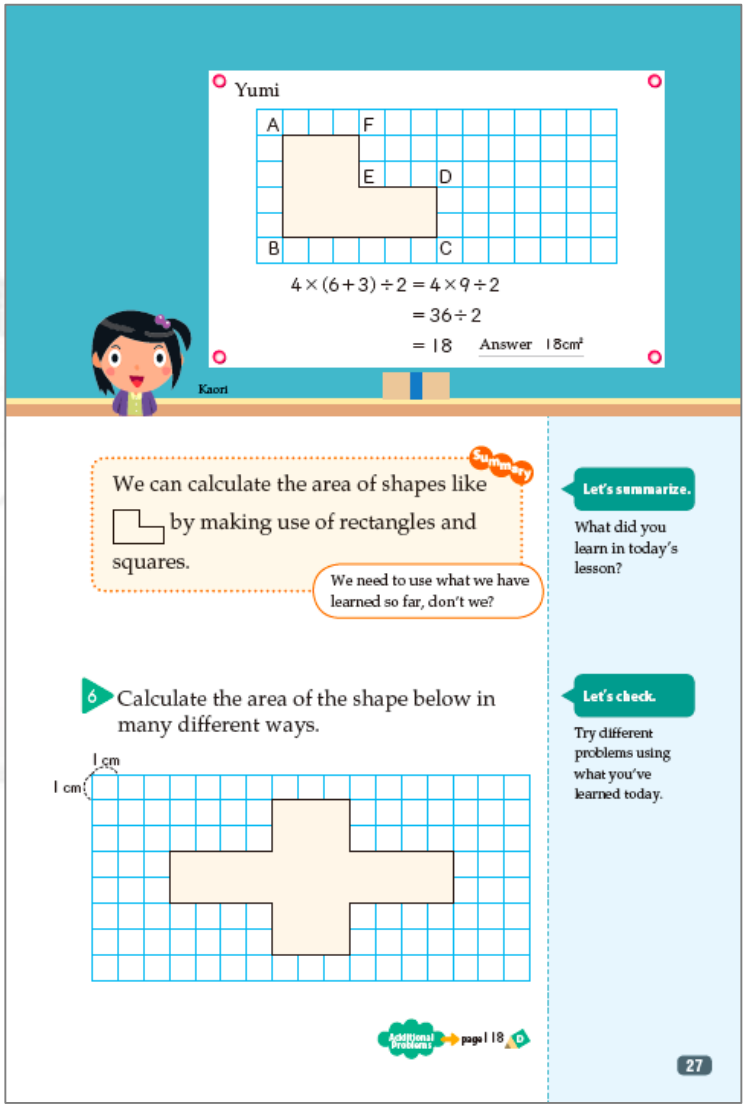
Grade 4 Textbook, Tokyo Shoseki (2011)

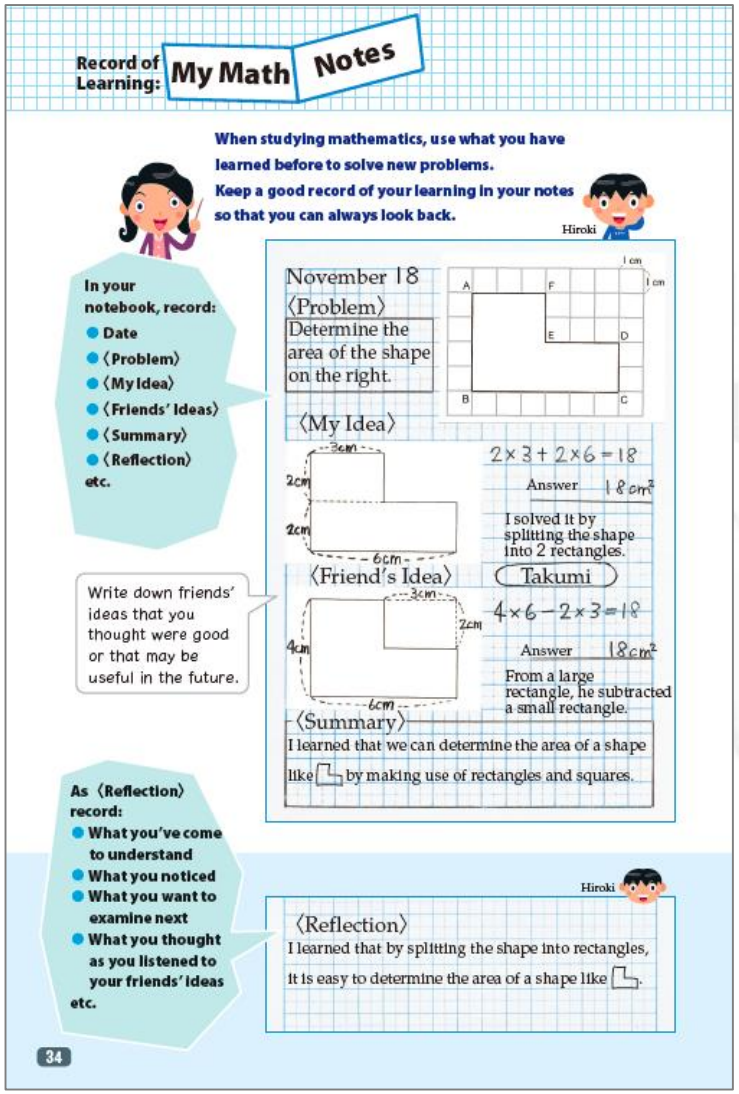
Problem Solving and Board Organization





Grade 4 Textbook, Tokyo Shoseki (2011)

Note Taking



Record of Learning: My Math Notes

When studying mathematics, use what you have learned before to solve new problems.
Keep a good record of your learning in your notes so that you can always look back.

In your notebook, record:
- Date
- 〈Problem〉
- 〈My Idea〉
- 〈Friends' Ideas〉
- 〈Summary〉
- 〈Reflection〉

etc.

Write down friends' ideas that you thought were good or that may be useful in the future.

As 〈Reflection〉 record:
- What you've come to understand
- What you noticed
- What you want to examine next
- What you thought as you listened to your friends' ideas

etc.

Hiroki

November 18

〈Problem〉
Determine the area of the shape on the right.

〈My Idea〉
$2 \times 3 + 2 \times 6 = 18$
Answer $18\,cm^2$
I solved it by splitting the shape into 2 rectangles.

〈Friend's Idea〉 Takumi
$4 \times 6 - 2 \times 3 = 18$
Answer $18\,cm^2$
From a large rectangle, he subtracted a small rectangle.

〈Summary〉
I learned that we can determine the area of a shape like by making use of rectangles and squares.

Hiroki

〈Reflection〉
I learned that by splitting the shape into rectangles, it is easy to determine the area of a shape like .

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Think about ways to improve your notes

I don't erase an incorrect answer. Instead I write the correct answer and where I made the mistakes.

Miho

$4 \times 6 - 2 \times 3 = \cancel{16}$ 18
mistake

$2 \times 3 + 2 \times 6 = 18$
I used the formula we learned about on November 18th to find the area of a rectangle.

Shinji

When we use an idea that we learned before, I write down the date of that lesson from My Math Note.

I write down things I thought about or points to be careful about in a balloon.

Yumi

Check where the vertical and horizontal sides of a rectangle are before writing a math sentence.

See what your friends wrote in their Reflection.

Shinji
〈Reflection〉
Everyone used 2 rectangles to find the area. Using what we studied today, I want to try lots of different problems.

Kaori
〈Reflection〉
I was impressed because Takumi thought about subtracting a small rectangle from a large one. I want to be able to think like that too.

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Grade 4 Textbook, Tokyo Shoseki (2011)

Professional Learning Communities

LESSON STUDY

Chaining Instruction and Learning is NOT Easy

Teaching is a Cultural Activity

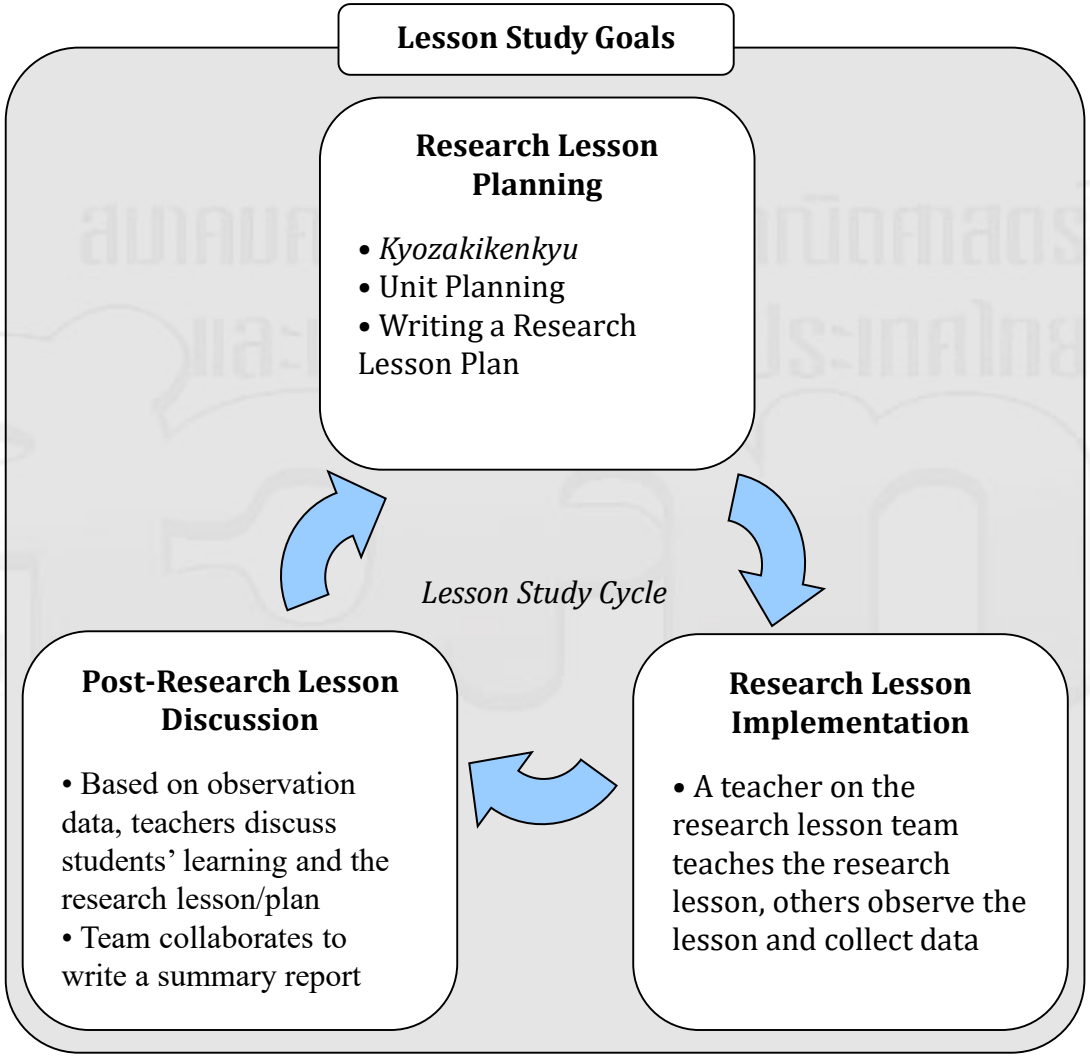
"Cultural Scripts are learned implicitly, through observation and participation- not by deliberate study."

Teaching is a Cultural Activity (Stigler & Hiebert, 1998)

Conducting Lesson Study with PLC

- In Lesson Study teachers collaboratively:
  - Discuss and establish overarching goals
  - Study instructional materials
  - Create unit plans and lessons
  - Implement and observe the lessons
  - Collect data of student learning (observation, presentation, writing in notebooks, etc.)
  - Discuss the lesson observed based on student observation and their work
- Lesson Study create important opportunities for teachers to reflect on and refine their instructional practice

Lesson Study Cycle



Lesson Study Cycle