JAPAN’S ONGOING REFORM IN MATHS: WILL ‘MODELLING’ HELP?

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Outline

1. Japanese maths education: overview
   • Lesson Study – ‘key’ for all good features
     • Lesson study creates a ‘research community’ to think and experiment together
   • Key issues

2. modelling in Japan - journey of my ‘research community’
   • The lonely 90s
   • Pisa Shock and the 2000s
   • Towards ‘mathematical decision making’

3. Ongoing reform: including the entrance examination
   • Huge opportunity but also key issues
1. Maths education in Japan
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Japanese Secret 1:
Problem Solving Approach
– a typical lesson structure

1. Introducing a single key problem
2. Student solving the problem on their own
3. Whole class discussion orchestrated by the teacher - designed to deepen student understanding
4. Summarizing

Share and compare with others. Then, based on students’ ideas, summarize such ideas mathematically.
Japanese secret 2: Lesson Study

Research objective based on:
What should students learn?
What do students already know?

Lesson study is joint research about lessons
Japanese secret 2: Lesson Study

Lesson study is joint research about lessons.

Anticipating student responses, and Planning teacher actions.
Japanese secret 2: Lesson Study

Lesson study is joint research about lessons.

One team member teaches the lesson, others observe and collect data.

1. Study Curriculum and Formulate Goals

2. Plan

3. Conduct Research Lesson

4. Reflect
Japanese secret 2: Lesson Study

Lesson study is joint research about lessons

Discuss student responses, effectiveness of lesson design, and any broader issues in teaching and learning.
Focusing lessons and Neriage

- Lesson study helps ‘focus’ the lesson
  - What is the objective of the lesson?
  - For that, what should students take away from the lesson?
  - So, what ‘discussion’ should they have?

- **NERIAGE** – orchestrating to ensure the desired discussion takes place with the whole class listening
  - planned carefully
  - Anticipating all possible student responses
  - With ‘teacher responses’ prepared for all contingencies

- VERY detailed planning – nothing left to chance!
Key consequences of systemic Lesson Study

• Professional development of teachers
  • eg., Problem solving approach – in classrooms

• Improved curriculum/teaching/materials/textbooks
  • What are the essential concepts/skills which must be taught?
  • In what order should they be taught?

• Linkages between academic researchers and teachers

• Mechanism to introduce new ideas
What combination should we teach to use subtraction?
13 – 9

= 13 – 3 – 6
= 10 – 6
= 4

= 10 + 3 – 9
= 10 – 9 + 3
= 1 + 3
We are thinking about what things we can make with acorns.

There are 13 acorns.
We used 9.
How many acorns are left?
How many Maths Research Lessons do you attend each year?

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<th>0%</th>
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<th>3~4%</th>
<th>5~6%</th>
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<td>21.1%</td>
<td>11.5%</td>
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<td>49.1%</td>
<td>24.7%</td>
<td>6.2%</td>
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<td>48.4%</td>
<td>13.9%</td>
<td>5.1%</td>
<td>5.4%</td>
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(IMPULS, 2013)
International Math-teacher Professionalisation through Lesson Study (IMPULS) project

News

- 2015.06.22
  Lesson Study Immersion Program 2015 has started!

- 2014.07.14
  Immersion Program is picked up by

http://www.impuls-tgu.org/en/
Key issues in maths education in Japan

- Problem solving approach stops at junior secondary (will discuss later)
  - University entrance exams encourage cramming
- Students interest and motivation in maths is low
- Student ability to apply maths in real life is limited
BUT OUR STUDENTS ARE NOT INTERESTED/MOTIVATED
Percentage of students who reported having seen real-world problems in their mathematics lessons frequently or sometimes
Students twitter about maths

- Why do complicated calculations always have ‘1’ as an answer?

- Why was he buying it when he didn’t know its price?

- Most of them make fun of ‘maths questions’ which feel ‘odd’ and unreal.
2. modelling in Japan
The lonely 90s

• A small group of enthusiast-teachers and researchers doing lesson study on application-oriented modelling
  • Modelling totally neglected in curriculum

• What we learned;
  • Modelling makes students think ‘deeply’
  • Common assumption that student can apply maths simply is not true
    • They often could not even apply simple maths
  • Need to teach how to apply maths specifically

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One example of problems we developed

We are on a school trip going to an island by ferry. Some students want to take pictures of the jet foil, which runs the same route but on a different timetable. When can we take a picture next? How many chances will we have?
Today this problem is used in a textbook used by 300,000 students.
PISA shock helped influence our policies...
National Assessment Test Items
(2007~)

- For years 6 and year 9
- Decision to include in the tests two types of problems to test:
  - Knowledge; and
  - Application

Curricular focus on application for the first time!

The curriculum guidelines were revised to emphasize “Mathematical Activities” in secondary level.
Typical problems used today

Sec. 2 Uses of systems of equations

(1) Uses of systems of equations

Q

Yoshihiro bought some 300-yen pieces of cake and some 350-yen pieces of cake. Altogether he bought 10 pieces of cake and paid 3300 yen. How many of each did he buy?
Another example...

Let's use the Pythagorean Theorem in problems from our surroundings.

At Mt. Hakodate Ropeway, the horizontal distance between the station at the base and the station at the summit is about 800 m and the vertical distance is about 300 m.

If we assume the cable of the ropeway is straight, about how many m will it be?
But still not authentic...

“Textbook”
Concept tasks

Mathematical topic
Exercises and Applications

“Authentic”
Problem solving tasks
tasks

Problem
Choose appropriate mathematical tools

Who chooses the mathematical ideas to employ?

Malcolm Swan, 2012
Our ongoing work: two approaches

- Mathematical modelling competency
  - For the curriculum change
  - Centres around specific maths concepts

- Ability for decision making using mathematics
  - Using modelling
  - But more open ended problems with multiple strategies
  - Using maths for creating the basis for decision making
  - Solution must be satisfactory to a larger number of people
Lesson Study example on modelling

Students set up a weeklong campaign to collect donations. On day 3, they want to make an announcement about how well they are doing.

How much do you think they have in the box?

How can we figure it out?
Lesson Plan

• How do they decide what to teach and how?
  • Examine what knowledge/skills their students have about ‘functions’
  • Consider how they could build on students’ existing knowledge and instincts to explore and apply their use of ‘functions’
What students learned at the elementary Level

How long is the wire on the right?

It’s going to be a chore to measure the whole length of the wire.

I wonder if we can use the idea of proportional relationships.

Think about how to figure out the total length of the wire shown above without measuring the whole length.

The length of the wire above is proportional to what quantity?

The weight of the wire shown above is 240g. When 3m of the same wire was weighed, it was 48g. Using this information, find the total length of the wire.

<table>
<thead>
<tr>
<th>Length $x$ (m)</th>
<th>3</th>
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<tbody>
<tr>
<td>Weight $y$ (g)</td>
<td>48</td>
<td>240</td>
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Make a Plan for Solving the Problem

Teacher: How will you estimate?

Anticipated responses

Student 1:
Divide coins by type
Count each type
Calculate the total amount

Student 2:
Divide coins by type
Weigh each type as a group
Weigh one coin of each type
Calculate the total amount

Student 4:
Weigh the box as a whole
Mix the coins well and take a sample
Count the sample to see how much
Weigh the sample
Use the proportion to calculate the total
After the lesson, what went wrong and how to improve is discussed – but using observation as hard evidence.

This was a public lesson in a university model school – many observers.
Towards mathematical decision making: Bowland Shock

Many problems with realistic contexts, open-ended, involving “values” and subjective judgement.
The World Water Resources Board (WWRB) needs to decide which country has the greatest need: Algeria, Jordan, and Turkey. What would be your recommendation?

Starting point for our research group

We thought this was just right to cultivate skill critically lacking in Japan.
Towards “mathematical decision making”

• We now know how to show different approaches and how to improve them. But is that enough?

• Our research group was not satisfied
  • We want students to walk away with clear experience of critiquing and improving their own answers
  • Loosely comparisons – not powerful enough for student learning – need a proper ‘NERLAGE’

• Can we learn better if the class made a decision as a whole?
In cognitive psychology

• Decision making is about selecting one or more options from several alternatives. (Takemura, 1996, p.81)

• It is important for a person to explain easily the reasons behind the selection to oneself and others to support the correctness. (Kobashi, 1988, p.49)
“Mathematical Decision Making”

• More than modelling,
  • Includes social consensus building
  • Need to develop and examine options
  • Understand assumptions
  • Social values must be reflected in criteria for final decisions

• Require students to
  • Deeply examine options
  • Understand the meaning of indicators
  • Repeat the modelling process
We have developed a framework

Problems which require decision-making

- Review the problem.
- Working in groups to develop options
- Assess options.
- Deciding one option as a class
- Decision / Solution
- Check the effect.

Problem solvers must constantly think about social values behind decision making.
Developing teaching materials

• Central work for our research group now
• 6 groups developing different ‘tasks’ through lesson study
• One example “Selecting Cute character”
  – “Cuteness” or “Amiability” – subjective judgement
  – What does it mean?
  – Can we use data to describe people’s preferences in terms of ‘eye’ position, which is critical for making it ‘cute’?
  – Use such data to make a decision about which character to use
“Cute” Character

“As part of the campaign to have healthy teeth, the school has decided to award a “good teeth badge” to the pupils who have good teeth. The badge must be appealing to students. Can we select a ‘cute character’ to be put on the badge this year?”

This task was designed for primary students – so we simplified to focus on the eye position.
The first phase: Moomin
Comparing the original Finnish version and the Japanese version of Moomin

They started to notice that ‘cuteness’ is related to factors such as the position of the eyes and the outline of the face, etc.

They developed a hypothesis that “the position of the eyes is the key in friendliness.”
First phase: creating characters and testing popularity via questionnaire
Why do some ‘eyes’ look more ‘friendly”? Can you describe the friendly eyes?

They examined the position of eyes individually.
Using distance

Creating a grid

Using proportions

1 : 1.4 : 1
1 : 3.1
Problems which require decision-making

Review the problem.

Options

Assess options.

Decision/Solution

Check the effect.

Deciding one option as a class

Working in groups to develop options

Context

Problems which require decision-making

Problem solvers must constantly think about social values behind decision making
Still a big gap between:
The maths students are supposed to know and
the mathematics that the pupils use in decision-making.

Maths content taught in Japan may need to change
  E.g. Need more statistics and simulation?
Our findings so far

• It is not easy to make ‘explicit’ what students should learn in mathematical decision making
  • Tried to use student reflection
  • But teachers (who are not researchers) often do not understand what the pupils should learn
  • Guidance on assessments and teacher training are essential (↔ Bowland has this.)
Mathematical decision making: next steps

• What sequence should be followed in introducing key ideas and skills? What kind of tasks at what grade?

• How do we do NERIAGE - a whole ‘class’ discussion for mathematical decision making?
  • so that students experience rigorous evaluation and judgement process

• Develop tasks

• Training teachers
3. Ongoing reform in Japan
Japan’s ongoing reform

- Large scale reforms led by the Abe cabinet
  - Moving from teaching knowledge to teaching competencies
  - Changing both university entrance examinations as well as senior high school curriculum – very unusual in Japan
  - Moving to computer-based tests
  - In maths, improved use of ICT (calculators and computers)
Our aspirations

• Moving from efficient assessment of subject based knowledge

• To developing problems with appropriate contexts to push students to think, evaluate, judge and communicate

• Cross-disciplinary teaching to cultivate skills
  • Thinking AND Judging
Our challenges

• Though ‘modelling’ is most likely to be introduced in the entrance exam:
  • We cannot use interviews/reports because of the large number of applicants
  • Exam items must have simple solutions

• Can we develop problems to test modelling/decision making for large scale assessment?
  • If not, we fear that senior high schools may continue with superficial cramming of similar problems
Our challenges

• We must change teacher culture – through lesson study.

• What else can we do to induce them to focus on real competency building?
Open questions related to modelling

• What is the right balance between ‘mathematical content’ and ‘modelling’ or more broadly mathematical processes?
  • What do global experts say? What do teachers in classrooms from around the world say?
  • Japan comes from a strong tradition of focussing on mathematical contents – but want to avoid overreacting?
• How can we introduce ‘assessment’ in large-scale for modelling?
• What other ways can we push for change?

GOOD IDEAS AND COMMENTS MOST WELCOME!
We established Bowland Japan to introduce similar problems in Japan
Thank you