ICM 2018
SECTION 18
Panel18.6: Mathematics Education and Popularization of Mathematics

Use of lesson study to support quality mathematics teaching: practical and theoretical issues raised within the community of mathematics educators and mathematicians

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Khon Kaen University, Thailand

**Mercy Kazima,**
University of Malawi

**Moderators:**

**Akihiko Takahashi**
DePaul University, USA and Tokyo Gakugei University, Japan
(Stigler and Hiebert, 1999)
The study samples included 231 eighth-grade mathematics classrooms:

81 in the US, 100 in Germany, and, 50 in Japan.

These samples were designed as a nationally representative sample of eighth-grade students in the three countries.

Percentage of lessons rated as having low, medium, and high quality of mathematical content.
Average Percentage of TIMSS Mathematics Topics Taught in School and the Achievement (Average Scale Score) of the TIMSS 2003

Grade 4

Japan
54% taught, 565 (69% Correct)

Singapore
82% taught, 594 (74% Correct)

United States
82% taught, 518 (58% Correct)

Int. Ave.
73% taught, 495 (53% Correct)

Source TIMSS 2003 International Mathematics Report
Grade 8: Exhibit 5.7 (p.192), Exhibit C. 1 (p.400)
Grade 4: Exhibit 5.7 (p.193), Exhibit C. 1 (p.402)
Average Percentage of TIMSS Mathematics Topics Taught in School and the Achievement (Average Scale Score) of the TIMSS 2003

**Grade 8**

- **Japan**: 74% taught, 570 (64% Correct)
- **United States**: 83% taught, 504 (48% Correct)
- **Singapore**: 84% taught, 605 (71% Correct)
- **Int. Ave.**: 78% taught, 467 (41% Correct)

Source TIMSS 2003 International Mathematics Report
Grade 8: Exhibit 5.7 (p.192), Exhibit C. 1 (p.400)
Grade 4: Exhibit 5.7 (p.193), Exhibit C. 1 (p.402)
• Listening to experts during special professional development days does not translate into improved teaching. Effective teacher learning must be built into teachers’ daily and weekly schedules. Schools must become the places where teachers, not just students, learn.

(Closing the Teaching Gap, 2009)
Lesson study (授業研究)

- Lesson study is a popular professional development process that Japanese teachers engage in to systematically examine their practice.
- It is a widespread practice in Japan with a long history, particularly in elementary and junior high schools.
Typical Process of the Lesson Study

• Set up a team of teachers to develop a lesson plan

• Defining the theme, such as:
  – To awaken students’ interest in using mathematics in their daily life.
  – Improve students’ understanding of basic concept of multiplication.

• Planning the lesson
  – Referring Course of study (National Curriculum), teacher reference books, and journal articles.
  – Writing a lesson plan
    • The most important part of writing a lesson plan is predicting students solutions.
• Research lesson
  – One teacher teach the lesson based on the lesson plan developed by his/her group.
  – The research lesson is observed by the other teachers.
  – The research lesson is recorded
    • Videotape
    • Observation notes
    • Copies of student work

• Discussion
  – Typically the discussion begins by the teacher who taught and co-planned the lesson.
  – Followed by the discussion; sometimes an outside authority, such as researcher, university professor, district advisor and master teacher, comments on the lesson.
Lesson Study is an ideal Phase 2 Professional Development

Traditional Workshop

• Begins with answer
• Driven by outside “expert”
• Communication flow: trainer to teachers
• Hierarchical relations between trainer & learners
• Research informs practice

Lesson Study

• Begins with question
• Driven by participants
• Communication flow: among teachers
• Reciprocal relations among learners
• Practice is research

Contrasting methods of professional development (reprinted from Lewis, 2002, p.12)
What is the major focus of Lesson Study, developing exemplary lessons or teacher learning?

1. Does Lesson study need specific instructional guiding theories?
2. Is repeated teaching of the same lesson optional or necessary?
3. Is perfecting a research lesson not one of the goals of LS?
4. Does knowledgeable other need intervene the process of LS?
5. What is the specificity of LS in terms of teacher learning?
Examining Teacher Learning in Lesson Study:
Mathematical Knowledge for Teaching and Levels of Teacher Activity
Theoretical Framework

Ball et al. (2008)

Margolinas et al. (2005)

Lewis and Hurd (2011)
Theoretical Framework

Research question:

What type of Mathematical Knowledge for Teaching appears in what phase of a lesson study cycle and in which level of teacher activity?
LS group in Lausanne
— Switzerland, French speaking
— 8 primary teachers (grades 3-4)
— 2 LS facilitators
— First experience of LS
— 2 years
— 8 research lessons, 37 x 1h30 meetings (approx. 55 hrs)

Video transcriptions of all meetings and lessons
— Teachers’ material
— Students’ material
— Data analysis
— NVivo utilising proposed framework
The coding process

0 Consider issues and formulate general goals
1 Study curriculum and formulate content specific goals
3 Values and conceptions about learning and teaching
2 The global didactic project
1 The local didactic project
0 Didactic action and observation
-1 Observation of pupils' activity
-2 Student critical lens

3 Do research lesson
4 Reflect
Valentine: maybe, participating in this lesson study cycle, maybe it has changed my… , like, I mean it has modified some approaches in my teaching, on reflection, in the subject. I think of other things.

Other teacher: hum. Like what?

Valentine: Well, for example, it's a bit like what Edith said, I think of different perspectives. I do extra activities. For example "in pieces", which is an activity of the book, I did it a second time. I do my usual things, , but I also try to visualize more. I am aware, here I am more attentive to some, ah, to some of the difficulties that I wouldn’t have noticed before.
Marius: *Hit*, page 97.
Oceane: *Hit?* Oh yeah, it's with the calculator.
M: it is the same as we said before …
O: we can go further, yeah.
M: since we are already up to three digits …
O: Yeah.
M: this reinforces the difficulty because it will multiply more … And we are doing more operations.
O: they just have to do addition or …?
M: they must do those …
O: okay yeah, agreed. three and zero. Yeah, then …
M: yeah actually the thing is, they should do … Uh …
O: up to … and they can’t do … If they can do thirty times thirty … Thirty times three …
M: it would make nine hundred divided into …
O: no: three times … it's thirty and then it makes ninety.
M: plus thirty times three.
O: Yeah, yeah.
M: but they must already see that it’s three hundred and ninety.
O: subtract three.
M: subtract three. They have to see that already and see how we get to three hundred and how we get to ninety. Sixty they can do it easily.
O: Yes.
M: so they can make three hundred plus ninety …
O: Three hundred plus thirty plus thirty plus thirty.
Propose de changer
1 a en 9 a et 10 u

Suggests to change
1 H into 9 T and 10 U
MKT expressed in one cycle of lesson study
MKT expressed according to Levels

- Level 3
- Level 2
- Level 1
- Level 0
- Level -1
- Level -2

CCK
HCK
SCK
KCS
KCT
KCC
Conclusion

Values and conceptions about learning and teaching

- The global didactic project
- The local didactic project
- Didactic action
- Observation of students' activity
- Student lens

Formulate Goals

Study curriculum

Reflect on lesson

Conduct observe lesson

Plan lesson
Chinese Lesson study: Deliberate practice, research methodology, and improvement science

Rongjin Huang,  Middle TN State University, USA

ICM 2018, August 1-9

Rio Centro Convention & Event Center, Brazil
What is Chinese LS?

Japanese LS (Lewis, 2016)

1. STUDY CURRICULUM & FORMULATE GOALS
   Consider long-term goals for student learning and development. Study curriculum and standards, identify topic of interest.

2. PLAN
   Select or revise research lesson. Write instruction plan that includes:
   - Long-term goals
   - Anticipated student thinking
   - Data collection plan
   - Model of learning trajectory
   - Rationale for chosen approach

3. CONDUCT RESEARCH
   One team member conducts research lesson, others observe and collect data.

4. REFLECT
   Formal lesson collegium in which observers:
   - Share data from lesson
   - Use the data to illuminate student learning, disciplinary content, lesson and unit design, and broader issues in teaching-learning.
   Documentation of cycle, to consolidate and carry forward learnings, new questions into next cycle of lesson study.

Chinese LS (Huang & Bao, 2006)

New design: Focusing on the new design of the lesson

New action: Focusing on the new classroom practice

Existing action: Focusing on personal previous experience

Updating ideas
   Reflect 1: Finding the gap between existing ideas and innovative ones

Improving action
   Reflect 2: Finding the gap between innovative design and implementation

Through engaging in Keli (Exemplary Lesson Development), the participants of the community collaboratively learn innovative ideas, make a new lesson design, implement the design, reflect on their actions and change their practice.

Differences:
- Repeated teaching of the same topic
- Content-focused and pedagogy-oriented
- Knowledgeable others involvement
- Comparing and contracting exemplary lessons (Huang & Bao, 2006; Huang & Han, 2015; Huang et al., 2017).
Why it works

Conceptions of teachers, teaching, and teachers’ learning
(Ranking system/ Cultural value system (Huang et al., 2016a))

1. Equipping strong subject knowledge
2. Reform-oriented curriculum training
3. Master Degree Programs
4. Master teacher training programs

University-based programs

Master Teacher

Senior teacher

Level 1 Teacher

Level 2&3 Teacher

1. Apprenticeship
2. Teaching research activities
3. Lesson contests;
4. Master teacher studio

Practice-Based programs

Teaching: publicly scrutinized enterprise;

Learning:
(1) unity of knowing and practicing;
(2) practical reasoning in deliberate practice;
(3) emulating those better than oneself
How it works

Case 1: Deliberate practice and research methodology (Huang et al. 2016b)

Planning:
- Identify learning goals
- Select variation problems
- Anticipate students’ responses

Assessment and reflection:
- Evidence of student learning
- Effect of instruction regarding student learning

Instruction:
- Elicit student thinking
- Monitor, and conduct whole class discussion
- Build connections of multiple representations

LTs and TV
A case study

• Setting: school, teacher developers, teachers, and the lesson study group.
  – A key elementary school (1500 students, 45 classes, 24 mathematics teachers) in a medium-sized city in South East China;
  – A university professor (P), two specialists (S1 and S2), two experienced teachers (ET1 and ET2) and young teacher (DT);
  – The young teacher, Ms. Lu, who taught the research lessons, had 5 years of teaching experience in math, with a bachelor’s degree in engineering.

Research question: How a learning trajectory-oriented and variation task-informed LS could improve student learning and develop theories as well.
## Methods: Data Collection

<table>
<thead>
<tr>
<th>Research lesson</th>
<th>Teaching 1</th>
<th>Teaching 2</th>
<th>Exemplary lesson</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Class: 602(27)</td>
<td>Class: 604(28)</td>
<td>Class: 607 (39)</td>
</tr>
<tr>
<td>Lesson 1: A fraction divided by a whole number</td>
<td>Date: 10-9-2014</td>
<td>Date: 10-10-2014</td>
<td>Date: 10-15-2014</td>
</tr>
<tr>
<td>Lesson 2: A fraction divided by a fraction</td>
<td>Date: 10-11-2014</td>
<td>Date: 10-14-2014</td>
<td>Date: 10-17-2014</td>
</tr>
</tbody>
</table>

- Lesson plans
- Videotaped research lessons
- Videotaped post-research lesson debriefs
- Videotaped pre-lesson interviews with the teachers
- Post-lesson quiz and selected student interview immediately after classes
- Reflection journals of demonstrating teachers and teacher developers
- Audio recorded post-lesson study interview with teachers and teacher developers.
<table>
<thead>
<tr>
<th>Learning trajectory</th>
<th>First teaching</th>
<th>Second teaching</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. 1 divided by a unit fraction (e.g. $1 \div \frac{1}{5}$)</td>
<td>T1: How many $\frac{1}{5}$-liter glasses are there in 2 liters of milk?</td>
<td>T1a: How many $\frac{1}{5}$-liter glasses are there in 1-liter of milk?</td>
</tr>
<tr>
<td></td>
<td>T1b: How many $\frac{1}{4}$-liter glasses are there in 1-liter of milk?</td>
<td>T1c: How many $\frac{1}{3}$-liter glasses are there in 1-liter of milk?</td>
</tr>
<tr>
<td></td>
<td>T1d: How many $\frac{1}{6}$-liter glasses are there in 1-liter of milk.</td>
<td></td>
</tr>
<tr>
<td>2. 1 divided by a fraction (e.g., $1 \div \frac{2}{5}$)</td>
<td>T2: How many $\frac{2}{5}$-liter glasses are there in 1 liter of milk?</td>
<td>T2a: How many $\frac{2}{5}$-liter glasses are there in 1-liter of milk?</td>
</tr>
<tr>
<td></td>
<td>T2b: How many $\frac{2}{7}$-liter glasses are there in 1 liter of milk?</td>
<td>T2c: How many $\frac{3}{4}$-liter glasses are there in 1-liter of milk.</td>
</tr>
<tr>
<td></td>
<td>T2d: How many $\frac{3}{5}$-liter glasses are there in 1-liter of milk.</td>
<td></td>
</tr>
<tr>
<td>3. A whole number divided by a fraction (e.g., $3 \div \frac{2}{5}$)</td>
<td>T3: How many $\frac{2}{5}$-liter glasses are there in 3 liters of milk?</td>
<td>T3a: How many $\frac{2}{5}$-liter glasses are there in 2 liters of milk?</td>
</tr>
<tr>
<td></td>
<td>T3b: How many $\frac{2}{5}$-liter glasses are there in 3 liters of milk?</td>
<td>T3c: How many $\frac{2}{5}$-liter glasses are there in 4 liters of milk?</td>
</tr>
<tr>
<td></td>
<td>T3d: How many $\frac{2}{5}$-liter glasses are there in 100 liters of milk?</td>
<td></td>
</tr>
<tr>
<td>4. A fraction divided by a fraction (e.g., $\frac{3}{4} \div \frac{2}{5}$)</td>
<td>T4: How many $\frac{1}{3}$-liter glasses are there in $\frac{1}{2}$ liters of milk?</td>
<td>T4a: How many $\frac{2}{5}$-liter glasses are there in $\frac{3}{4}$ liters of milk?</td>
</tr>
<tr>
<td></td>
<td>T4b: How many $\frac{2}{5}$-liter glasses are there in $\frac{5}{8}$ liters of milk?</td>
<td>T4c: How many $\frac{3}{4}$-liter glasses are there in $\frac{4}{5}$ liters of milk?</td>
</tr>
</tbody>
</table>
Increase of means in overall performance (mean difference=.85), visual representation (mean difference=.18) and proportional reasoning (mean difference=.81) from the first teaching (26 students) to the second teaching (28 students). A t-test further detects that the changes of mean in overall performance ($t=2.57$, $p=.0$) and proportional reasoning ($t=2.2$, $p=.04$) are statistically significant, but not in visual representation ($t=0.45$, $p=.65$).
Conclusion

Chinese LS is

- a deliberate practice for developing instructional expertise,
- a research methodology for linking research and practice, and
- an improvement science for instruction and school improvement system wide. (Huang et al., 2017)

Potential:

- Adaption in other countries;
- Enrichment of studies on LS.
Thank you so much

Email: rhuang@mtsu.edu
References


How lesson study and open approach can improve teaching school mathematics?

Maitree Inprasitha, PhD

Director, Center for Research in Mathematics Education, Khon Kaen University, Thailand
Dean, Faculty of Education, Khon Kaen University, Thailand
Acting Director, Institute for Research and Development for Teaching Profession for ASEAN
President, Thailand Society of Mathematics Education (TSMEd)
One of his major concerns was the perceived gap between school mathematics and university mathematics which from the 1890s lead him to engage in the improvement of mathematics education. (Felix Klein, 1902-1908, 2004 cited in Biehler & Peter-Koop, 2008)
“Problem solving approach is the central issue for school mathematics around the world.”

Singapore, 1990s
“metacognition as a driving forces of mathematical problem solving” (Lester, 1985), articulated by Lesh, Schoenfeld, and Silver (1982).
Teaching

In the 20th Century for active learning
Cone of Learning (Dale, 1969)

People generally remember... (learning activities)

- 10% of what they read
- 20% of what they hear
- 30% of what they see
- 50% of what they see and hear
- 70% of what they say and write
- 90% of what they do.

People are able to... (learning outcomes)

- Define
- Describe
- List
- Demonstrate
- Apply
- Practice
- Analyze
- Define
- Create
- Evaluate

Behavioral Learning Dimensions
What is active learning?

• Bonwell and Eison (1991) define active learning as “instructional activities involving students in doing things and thinking about what they are doing.”
Metacognition roughly means "awareness of their own thinking" or, "Thinking of Thinking“ (Flavell, 1975)

Metacognition is a driving force while students are solving the problem. (Lesh, Silver, Schoenfeld, 1982)
Distinguishing between mathematical tasks and students’ authentic problem or real problem
Figure I shows a typical approach the teachers deliver problems to each student.

Student 1

- Task 1
- Task 2
- Task 3
- Task 4
- Task 5
- Task 6
Figure II: a lesson study team collaboratively design task/problem situation based on students’ ideas (kyozai kenkyu)
Figure II shows an innovation for engaging a number of students in a class with a particular task or problem.
According to figure II, teachers have much more time in the class to engage students to collaboratively solving a particular problem and provide time for teachers to invest in students’ individual differences.
Students’ Ideas as an Origin of Mathematical Problem Solving
Subtraction with 0

1. How many goldfish are left?

   - If she takes out 2 goldfish:
     \[ 3 - 2 = \square \]

   - If she takes out 3 goldfish:
     \[ 3 - 3 = \square \]

   - If she cannot take out any fish:
     \[ 3 - 0 = \square \]

There are 3 goldfish in all.
Jaophorluangupathatham 5 School, Chiang Rai
การทดลองการเลี้ยงปลา 4 ตัว

1. ปลาในถ้วย 2 ตัว
2. ปลาในถ้วย 1 ตัว
3. ปลาในถ้วย 3 ตัว
4. ปลาไม่ได้เลี้ยง

ผลการทดลอง:

- ปลาในถ้วย 2 ตัว:
  ประโยคสัญลักษณ์: \(3 - 2 = 1\)
  ตอบ: 1 ตัว

- ปลาในถ้วย 3 ตัว:
  ประโยคสัญลักษณ์: \(3 - 2 = 1\)
  ตอบ: 3 ตัว

- ปลาไม่ได้เลี้ยง:
  ประโยคสัญลักษณ์: \(5 - 2 = 3\)
  ตอบ: 3 ตัว
Open Approach Lesson Study: Focusing on Japanese Mathematical Textbooks
Weekly cycle of Open approach Lesson Study (Inprasitha, 2003; 2006; 2011; 2016; 2017)
Lesson study in Malawi primary mathematics teacher education

Mercy Kazima, University of Malawi
Arne Jakobsen, University of Stavanger
Janne Fauskanger, University of Stavanger

Presentation at the ICM meeting, Rio, Brazil
4 August 2018
Research question

How do mathematics teacher educators in Malawi understand Lesson Study?
Lesson study challenges for new inexperienced participants developing research lessons include:

- a research question is not always point of departure (Bjuland and Mosvold, 2015; Fujii, 2016)
- the importance of prediction is overlooked (e.g. Lewis, Perry and Hurd, 2009)
- lack of emphasis on planned and focused observation of students’ learning (Bjuland and Mosvold, 2015; Fujii, 2016)
- students’ learning not visible (Bjuland and Mosvold, 2015)
Methods

- Data collected from 5 teacher education colleges
  (i) Draft lesson plans for research lessons
  (ii) Final lesson plan after revising based on comments from ‘knowledgeable others’
      (authors acted as knowledgeable others)
- Qualitative content analysis was used
- Data analysis focusing on
  (i) Research question
  (ii) Prediction
  (iii) Observation
## Findings

<table>
<thead>
<tr>
<th></th>
<th>Draft plan</th>
<th>Revised plan</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Research question</strong></td>
<td>Only 2 had research question but not explicit. 2 had lesson title, and 1 had none</td>
<td>4 more explicit research question 1 still no research question</td>
</tr>
<tr>
<td><strong>Prediction</strong></td>
<td>Only 1 had prediction, 2 had assumptions of students knowledge, and 2 had neither</td>
<td>The one had more specific prediction, 2 had same assumptions, 2 still had neither</td>
</tr>
<tr>
<td><strong>Observation</strong></td>
<td>4 had few points of observation, 1 had no explicit observation</td>
<td>3 of the 4 had more and well focused points of observations, 1 not revised, 1 still not revised</td>
</tr>
<tr>
<td>Findings</td>
<td></td>
<td></td>
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<tr>
<td>---------------</td>
<td>---------------------------------------------------</td>
<td></td>
</tr>
<tr>
<td>Research question</td>
<td>Not clearly understood as necessary starting point, when probed some became more explicit</td>
<td></td>
</tr>
<tr>
<td>Prediction</td>
<td>Importance of prediction not well understood; only one had prediction about students’ responses and became more specific after revisions.</td>
<td></td>
</tr>
<tr>
<td>Observation</td>
<td>Fairly understood and became more focused and specific after revisions</td>
<td></td>
</tr>
</tbody>
</table>
Conclusion and Implications

- Findings support earlier findings that lesson study in new contexts with inexperienced participants can be challenging.
- Some similarities and differences across the colleges highlight complexity of lesson study in new contexts.
- Improvements in lesson plans suggest lesson study can be used as model for capacity building in teacher education in Malawi.
- Role of ‘knowledgeable others’ is important and needs to be well defined for such contexts.
Thank you
What is the major focus of Lesson Study, developing exemplary lessons or teacher learning?

1. Does Lesson study need specific instructional guiding theories?
2. Is repeated teaching of the same lesson optional or necessary?
3. Is perfecting a research lesson not one of the goals of LS?
4. Does knowledgeable other need intervene the process of LS?
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