Lesson Study: A Promising Means to Support the Learning of Students, Teachers, and Mathematicians?

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www.lessonresearch.net

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Sybilla Beckmann calls for

- a community of *all* mathematics teachers that is as vibrant and effective as the community of mathematicians

- enlivening math teaching from *within* through peer interactions rather than from *without* through external evaluations…

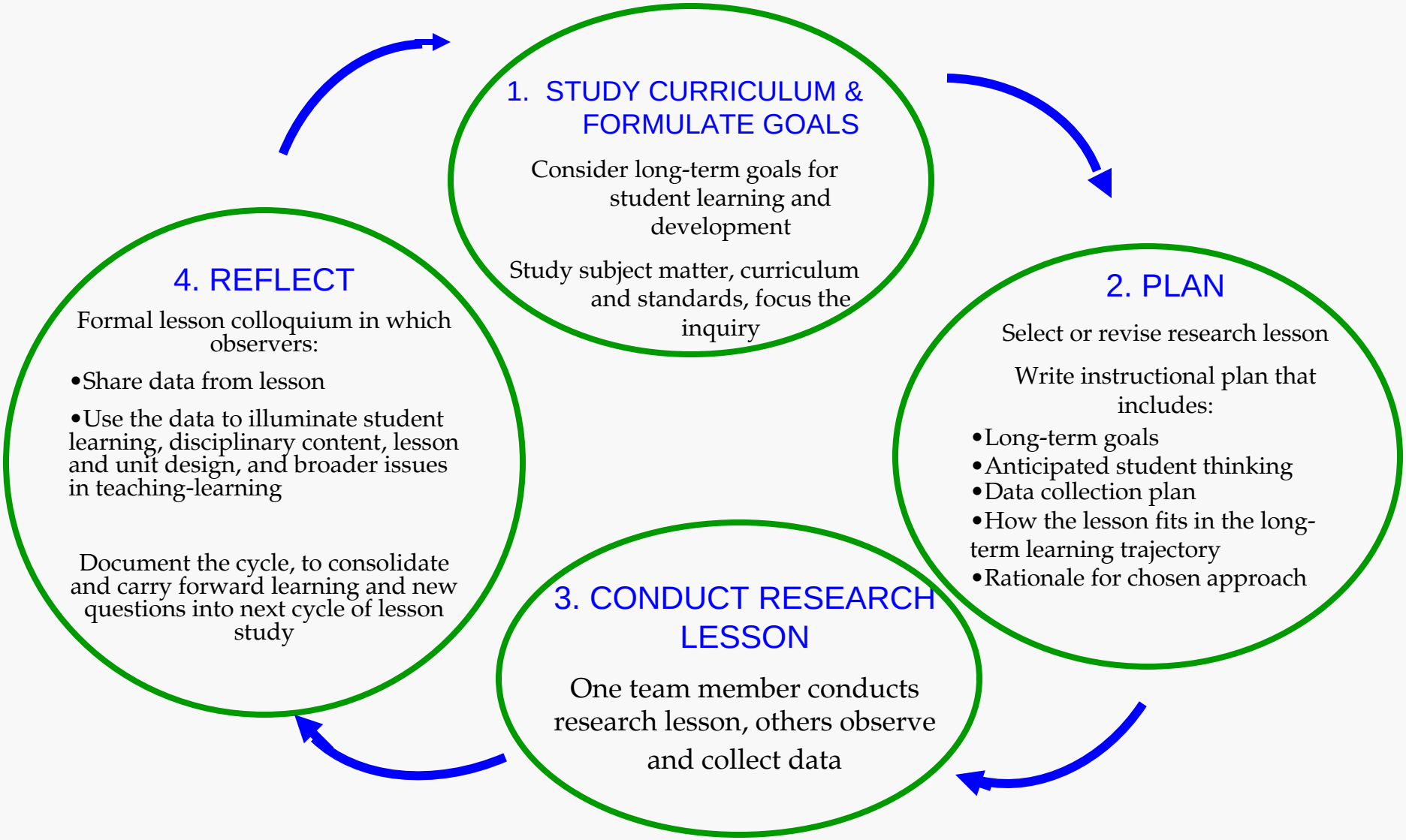
Can lesson study help create such a community?

The process of looking closely at what others have done, trying to make improvements upon prior work, and bringing new ideas and insights to this work is precisely the process by which a field advances

- Sybilla Beckmann, *Mathematics Educator*

This is a good description of lesson study.

Lesson Study Cycle

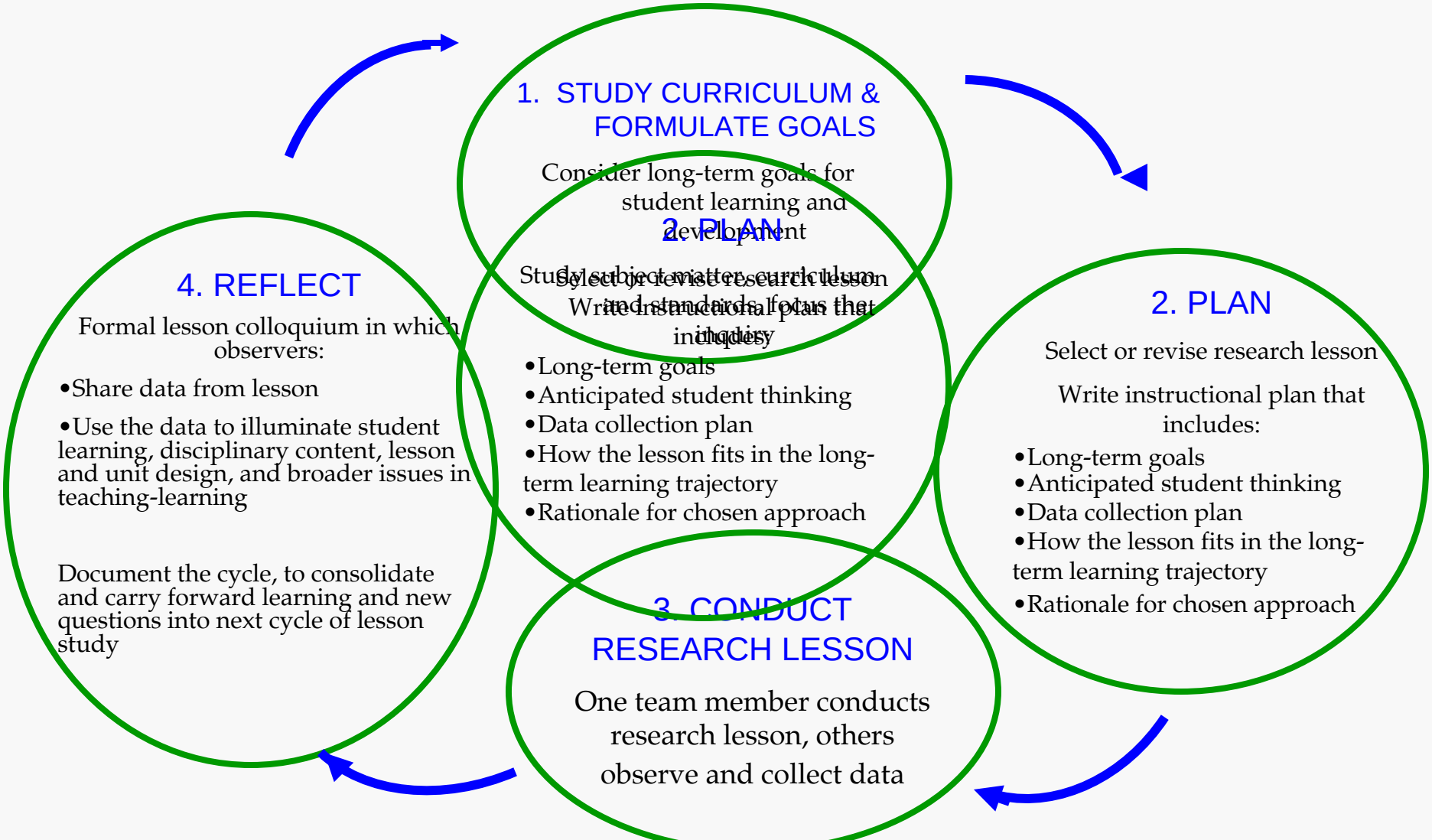


"How Many Seats?" Step 1: Study

- Studied standards & curricula, solved mathematics problems involving recursive & functional patterns
- What can we do in elementary school to lay the groundwork for success in algebra?
- Decided to focus on building students' capacity to identify and mathematically represent patterns

Example from "How Many Seats?"DVD available at www.lessonresearch.net or in Lewis & Hurd (2011) *Lesson Study Step By Step*, Heinemann Publishers.

Lesson Study Cycle

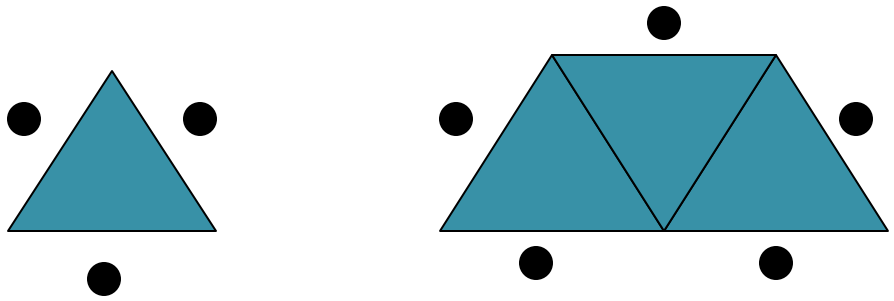


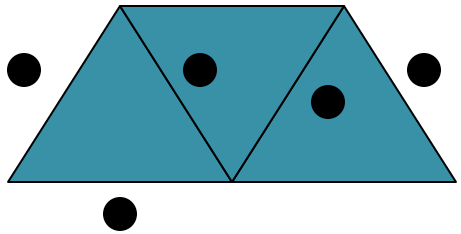
Step 2: Plan.

- Chose lesson from *Navigations,* solved problem themselves to anticipate student solution methods. This revealed
  - Different solution methods
  - Challenges for teachers in the mathematics
- Wrote lesson plan, surfacing different understandings of terms (e.g., “formula,” “equation”) and of goals

Can patterns help us find an easy way to answer the question:

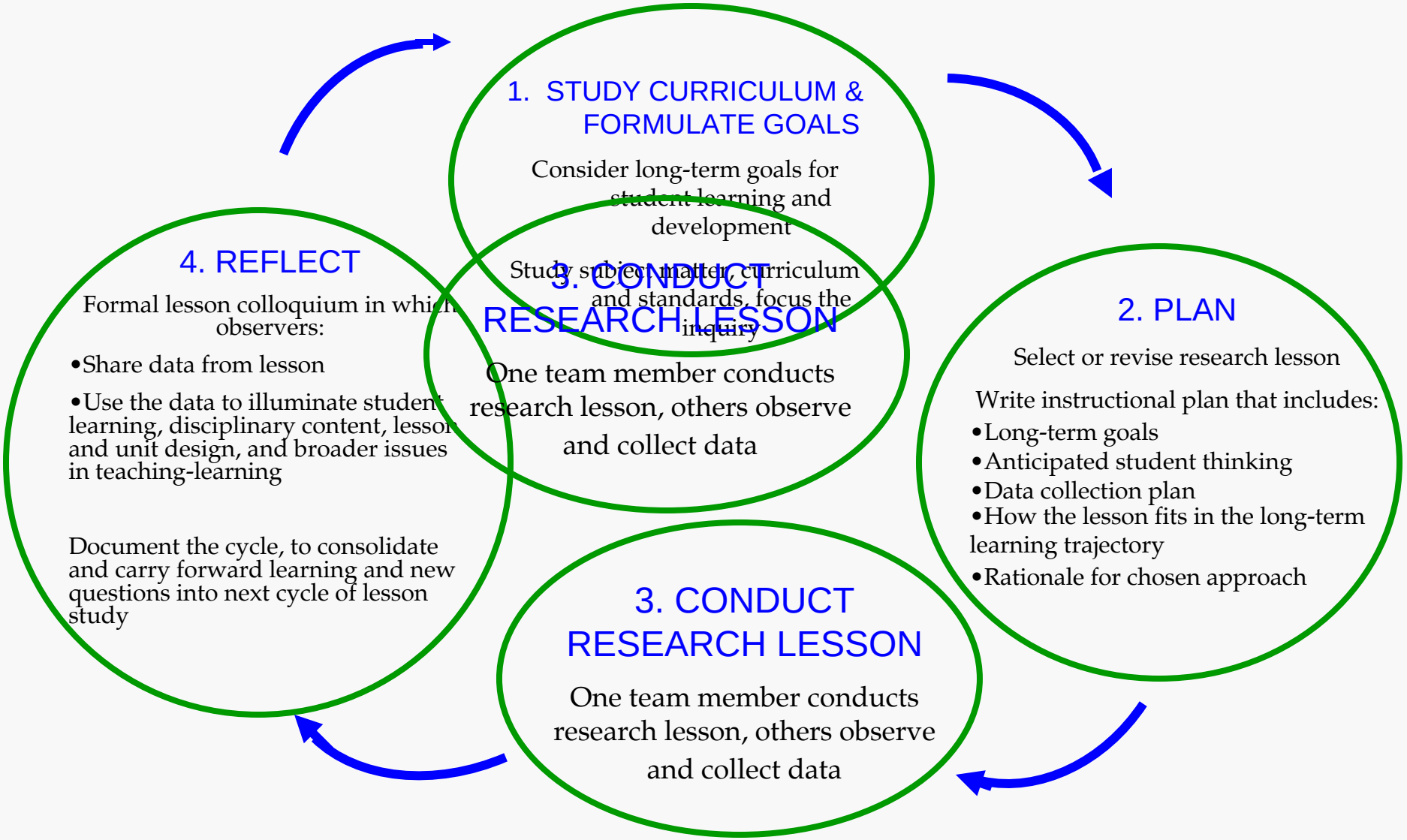
How many seats fit around any number of triangles, arranged in a row as shown?





INPUT Number of Triangle Tables	OUTPUT Number of Seats
1	3
2	4
3	
4	
5	
6	

Lesson Study Cycle

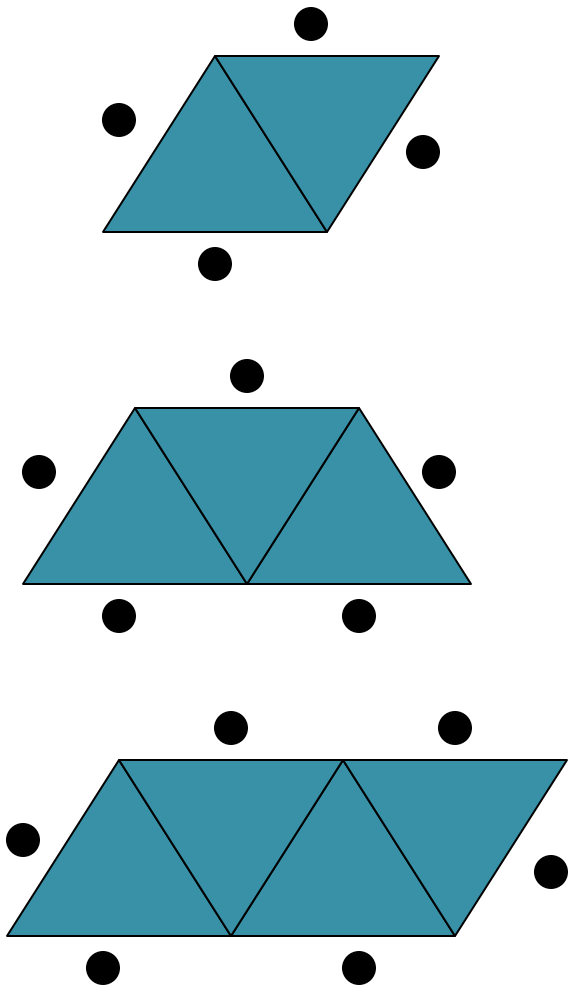


First teaching of lesson
August 12, 2002

Guest teacher:
Ms. Linda Bauld
Grade 4

Step 3: Do Research Lesson

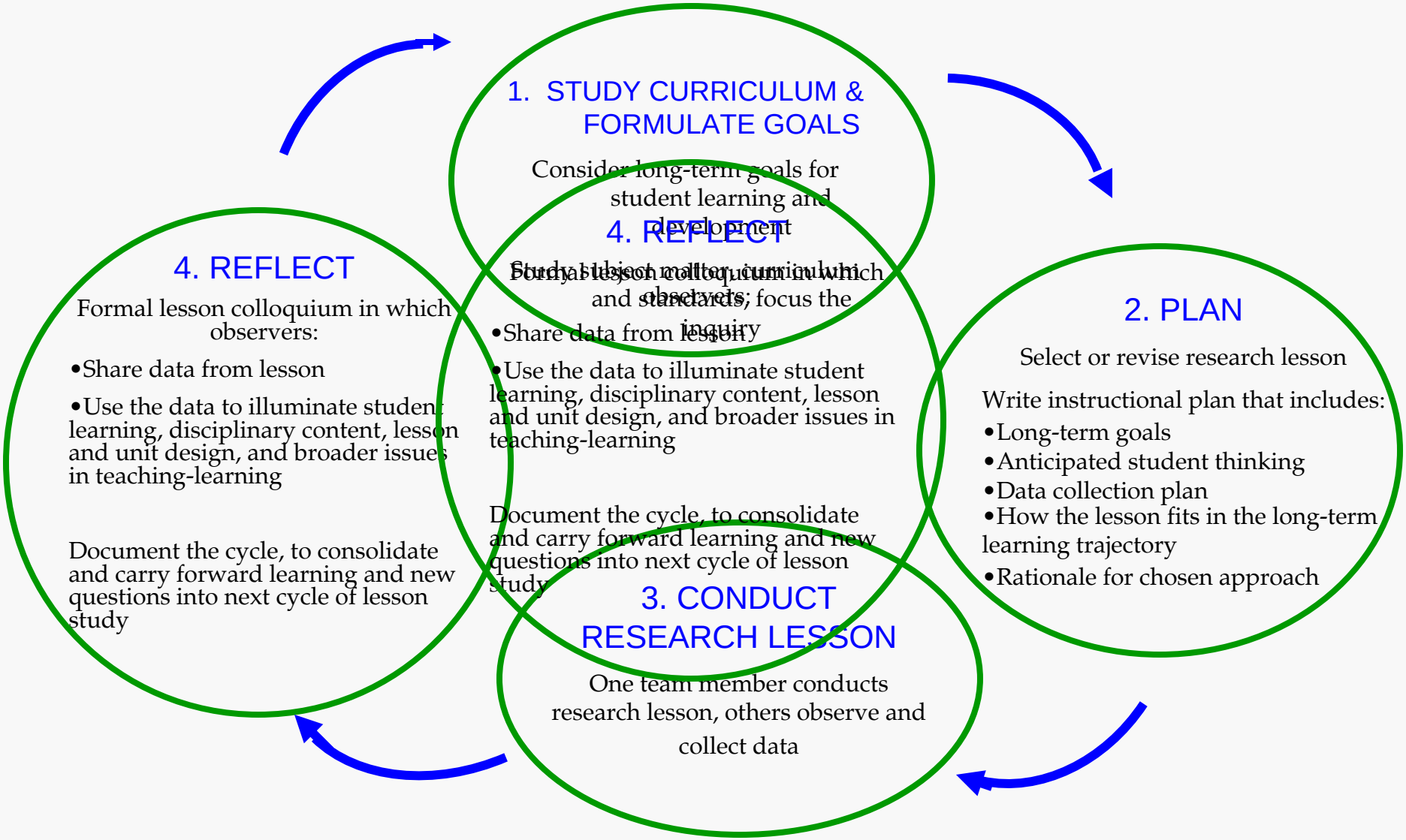
- All students filled out chart correctly but few could verbalize meaning of +2 pattern…"They could fill out the worksheet, but that didn't really tell us what they knew about the pattern."
- Students' counting methods revealed their thinking



Research Lesson 2 (Different class)

- Eliminated the chart
- Students solved individual problems, shared findings
- Students showed their counting methods early in the class
- Most students could verbalize meaning of +2 pattern

Lesson Study Cycle



4. Reflect (After each lesson and at end of cycle)

- "Just because it's in there [textbook] doesn't mean it's the best way"
- "Students need to do the work, not the teacher"
- "In all this math…we're only as good as our own level of understanding, so we have to keep pushing ourselves.."
- Teachers self-initiated continued study of the impact of t-charts on student thinking

A story about introduction of solar energy in the Japanese elementary science curriculum in the 1990's…

- Hundreds of elementary schools applied for small grants as "designated research schools" on how to teach solar energy

- After about a year of experimentation, often in collaboration with university-based colleagues, schools brought to life their thinking in large public research lessons

Solar energy, cont'd

- Thousands of educators saw these research lessons and questioned teachers about why they chose these approaches, what had worked and hadn't

- Knowledge quickly spread about the science content itself, good teaching materials (what toys work and don't to illuminate the principles), and student thinking

Solar energy, cont'd

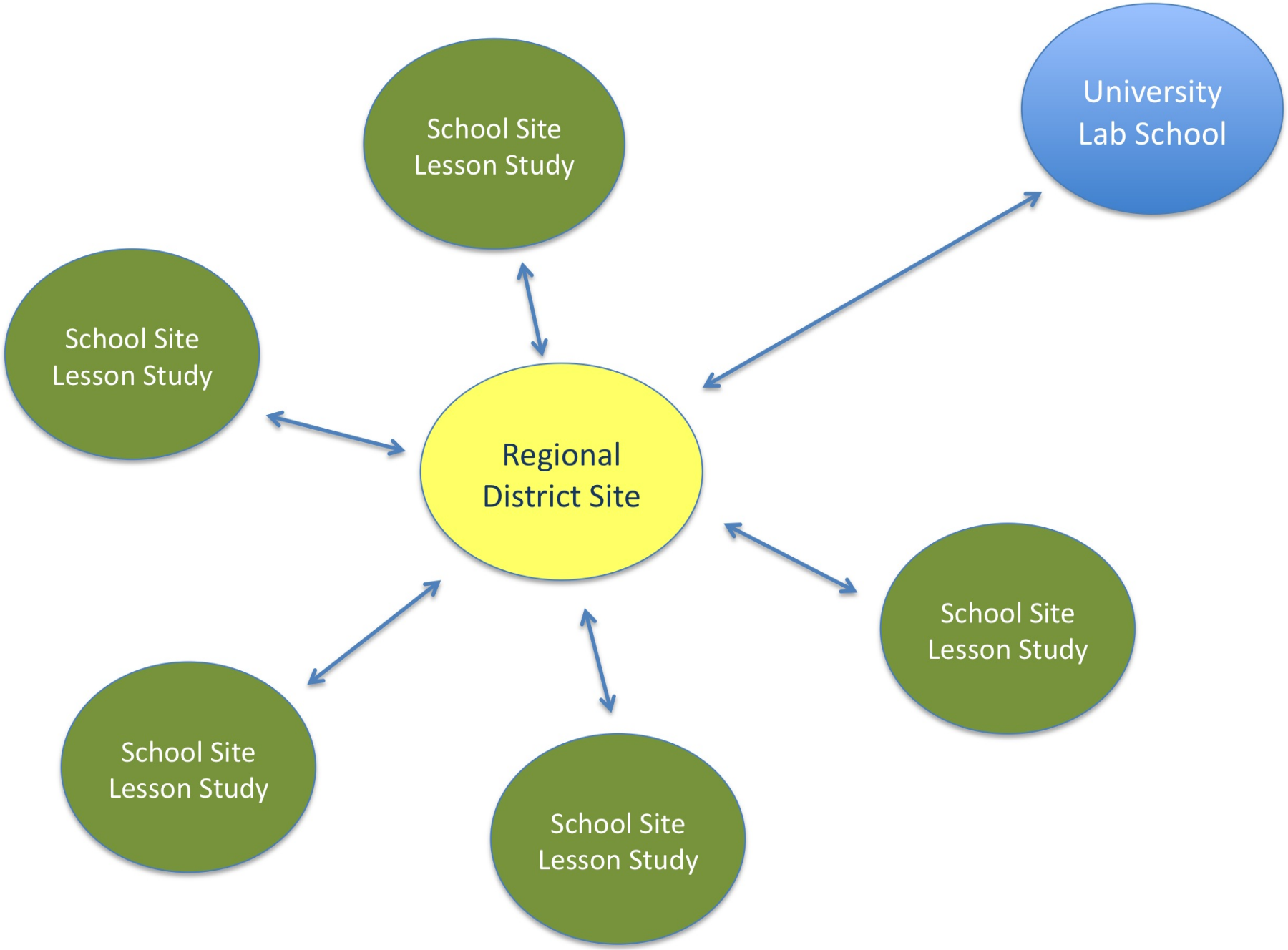
A teacher observing a public research lesson asked about three student strategies she saw:

- moving a solar cell closer to a light source
- adding a second light source
- using a magnifying class to "concentrate" light

"I want to know whether the three conditions the children described -– 'to put the solar cell closer to the light source,' 'to make the light stronger' and to 'gather the light – would all be considered the same thing by scientists. They don't seem the same to me. But I want to ask the teachers who know science whether scientists would regard them as the same thing."

"The way to improve…is to see many good actual examples. We can do that by going to lots of schools that are doing presentations and research lessons…. Many people from this school have gone. Each school has its own way of approaching the new subject. Some are appropriate for your school, some aren't. What works elsewhere might not work at your school because the children are different. So you need to see lots of examples."

– A Japanese Principal


School Site
Lesson Study
University
Lab School
School Site
Lesson Study
Regional
District Site
School Site
Lesson Study
School Site
Lesson Study
School Site
Lesson Study
School Site
Lesson Study

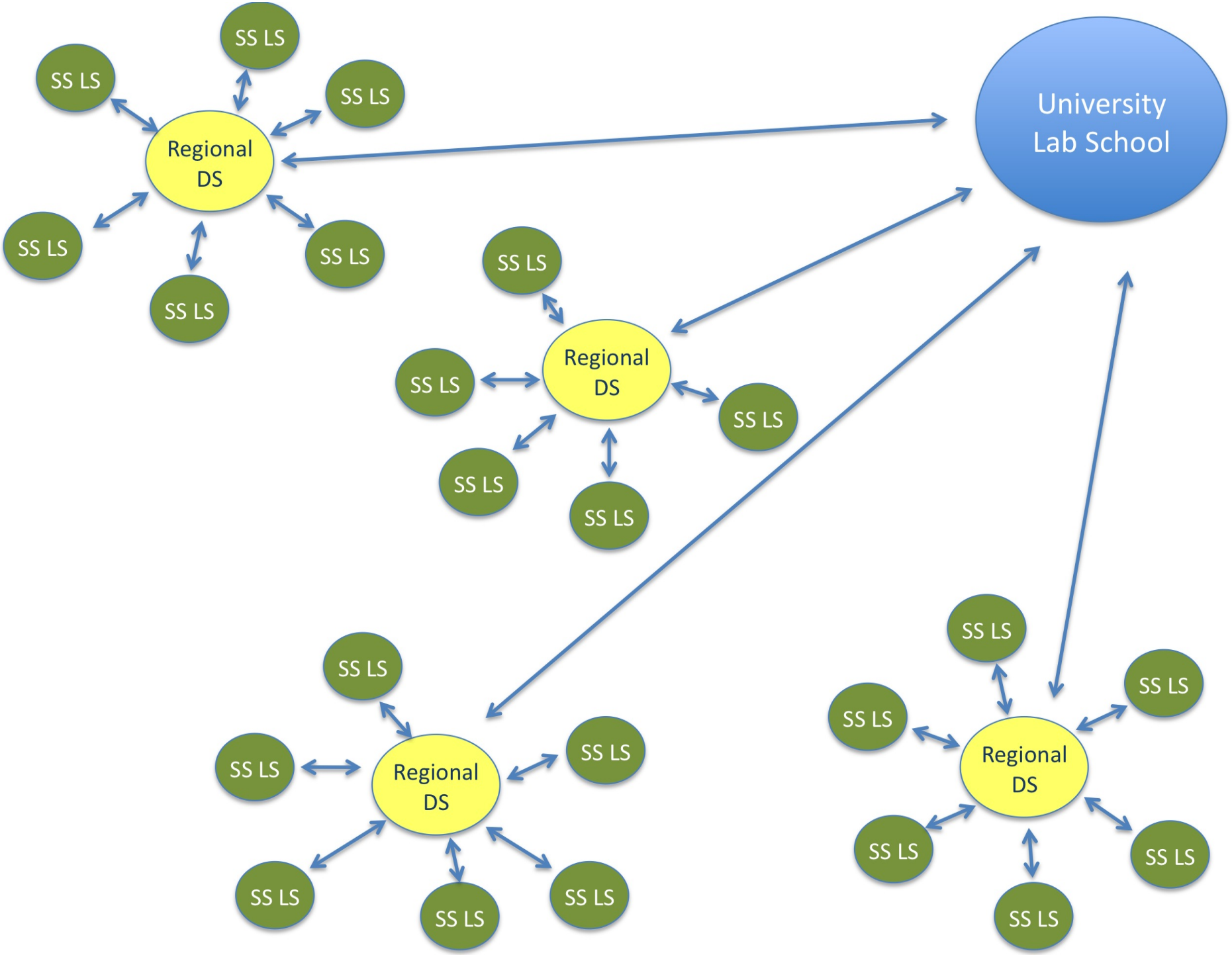
Local, regional, national lesson study groups in Japan

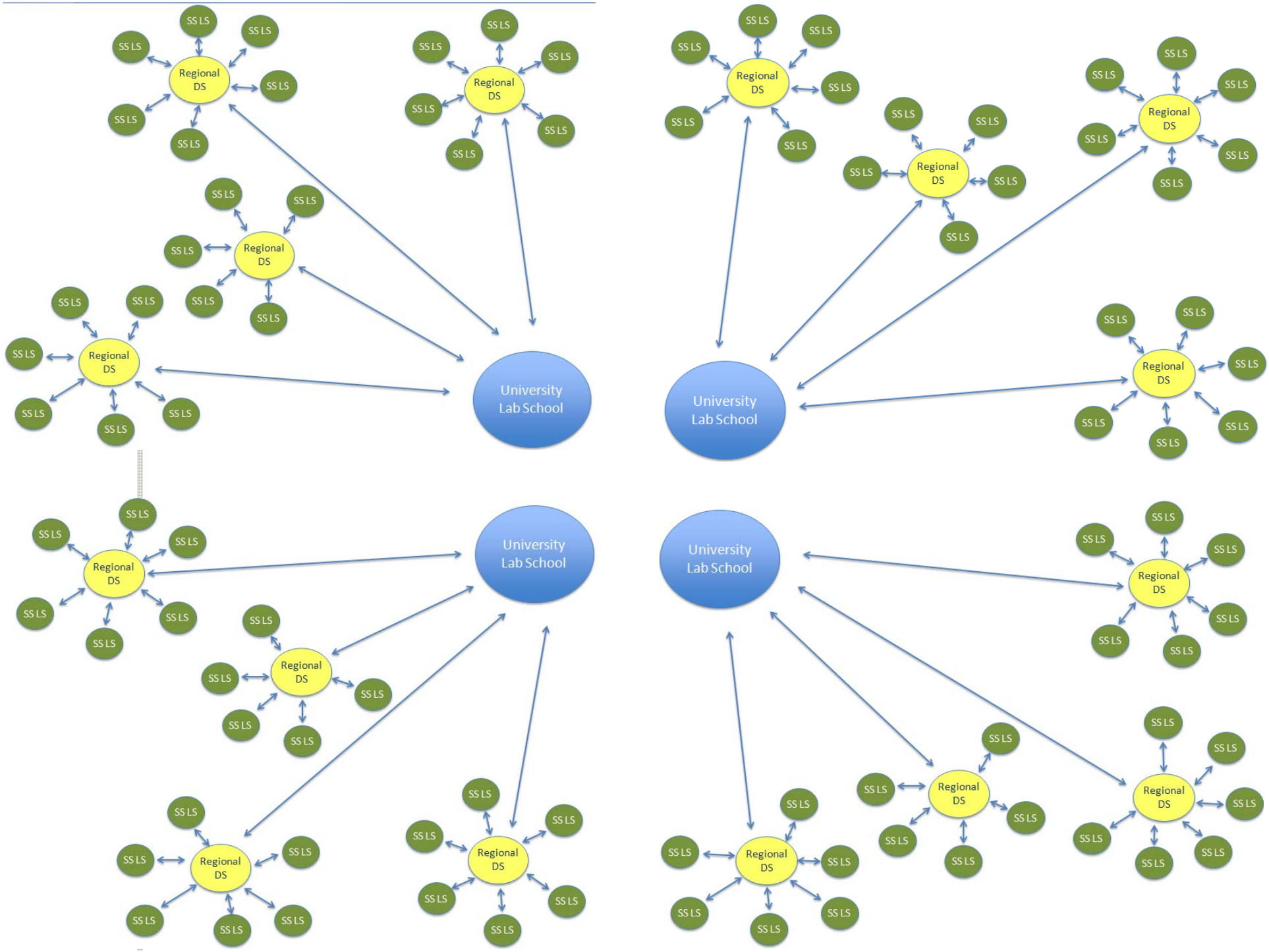
- School-wide lesson study focuses on the needs of local students. Strong collegial relations and focus on "our" students tends to bring in reluctant teachers.
- At least one teacher from every school takes part in district-based mathematics lesson study.

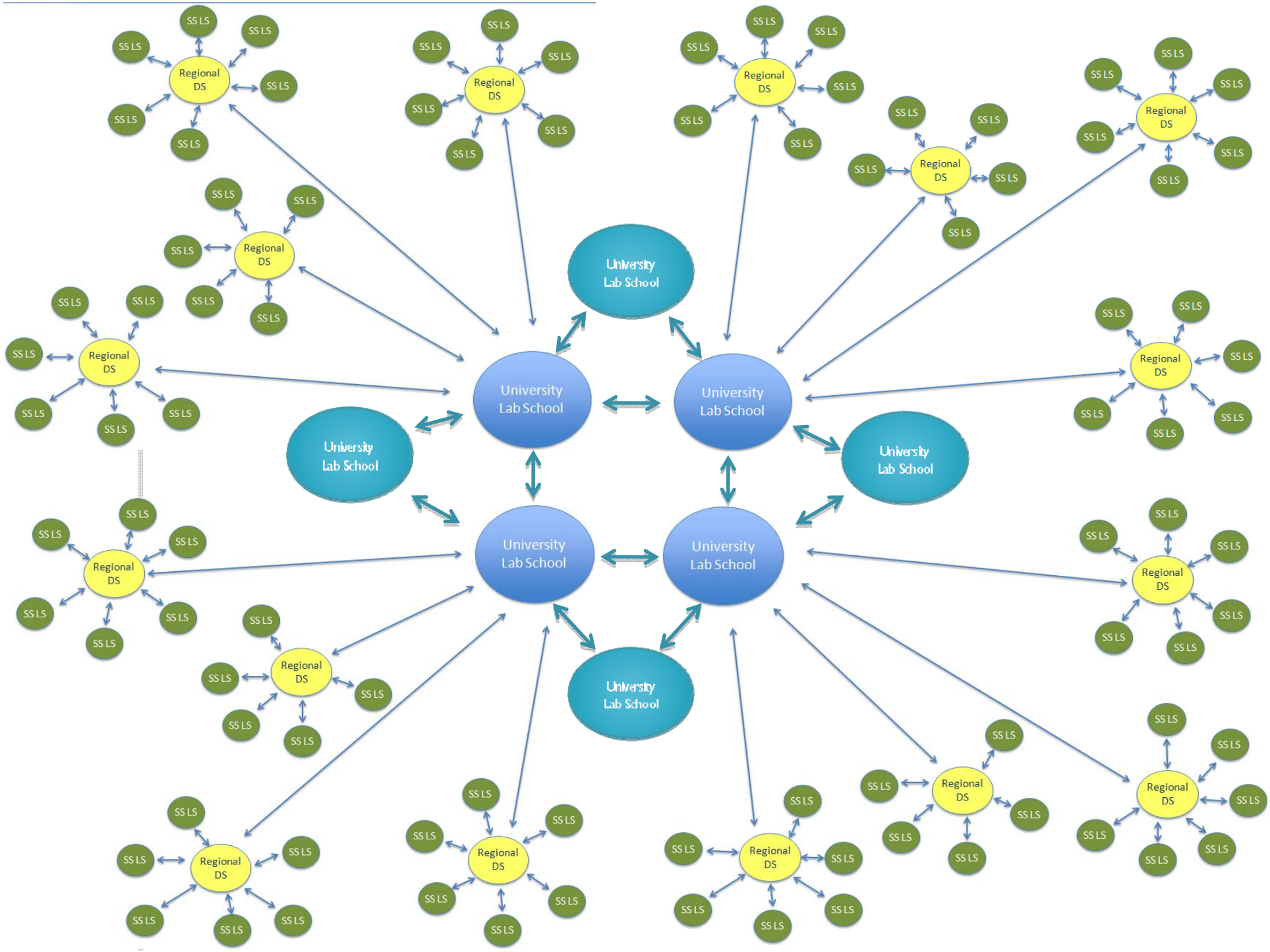
Local, regional, national lesson study groups in Japan

"Boundary-crossing" individuals carry knowledge back and forth from individual schools and regions to national venues–they share what is working and *not* working. Often these individuals are:

- University-based mathematicians or mathematics educators who serve as advisors to lesson study groups
- Regional teacher-leaders
- K-12 teachers with a particular interest in math


University
Lab School
Regional
DS
SS LS


Regional DS
SS LS
University Lab School


University Lab School
University Lab School
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University Lab School
University Lab School
Regional DS
SS LS

Local, regional, national lesson study groups in Japan: A network of educator-led improvement & dissemination

- Universities (with lab schools) hold large public research lessons that show innovations (e.g., bring to life in elementary schools Polya's ideas about problem-solving)

- Interested teachers attend the public research lessons and bring back ideas, materials, perspectives that inform their local lesson study work

Could we imagine a similar process for Common Core State Standards in the U.S.?

Elements of such a network are emerging in the U.S.

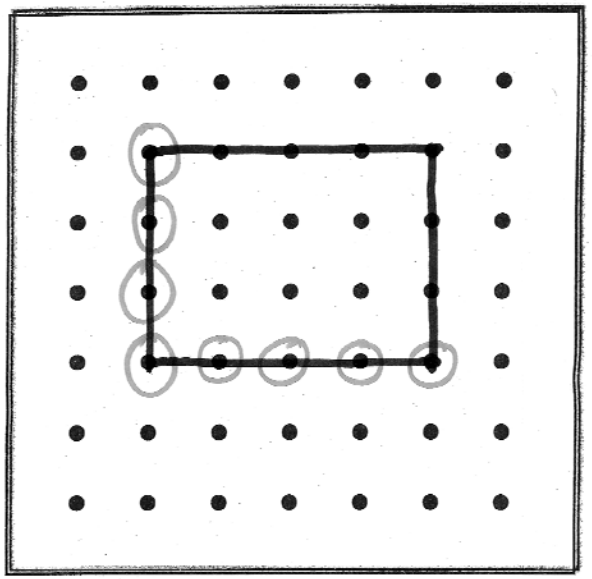
- School-wide lesson study
- District-based lesson study
- Regional networks (such as the Silicon Valley Mathematics Initiative)
- Lesson study integrated into pre-service education

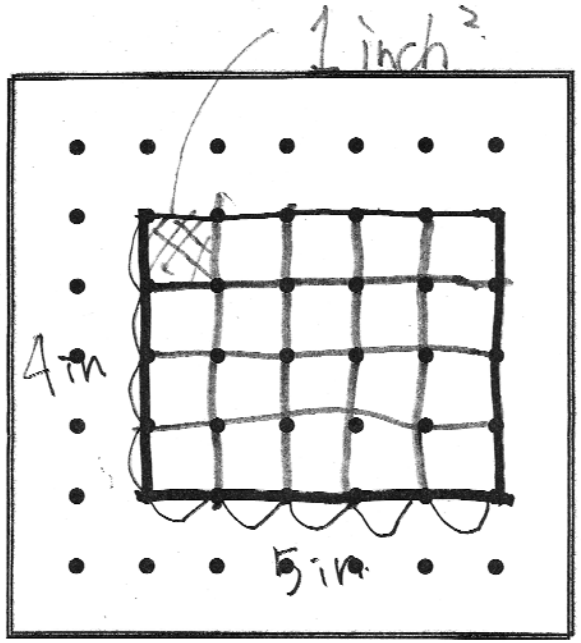
Evidence is accumulating that U.S. lesson study builds teachers' knowledge, professional community, and dispositions to improve, as well as student learning

Example 1: Spread of knowledge for teaching: "Re-engagement" as a way to make student thinking visible, available to revisit and refine

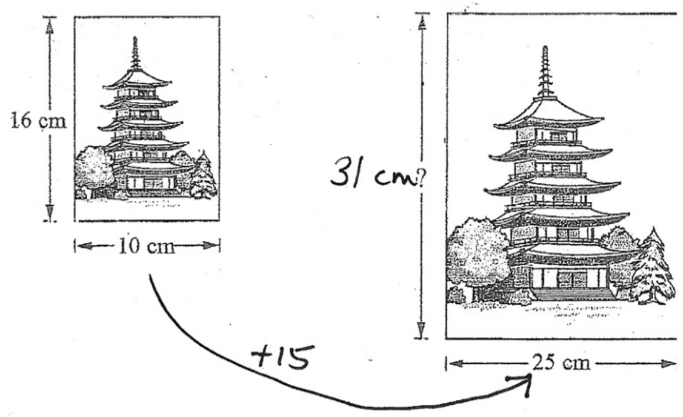
Teachers spread the idea of "re-engagement" across at least 7 districts, elementary and secondary classrooms, and across subject areas through the Silicon Valley Mathematics Initiative

Which is a 4 X 5 rectangle? What was each student thinking? (During lesson by Akihiko Takahashi, 2002)

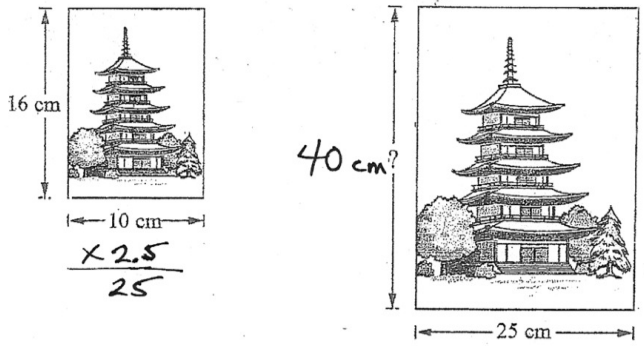




Re-introducing Selected Student Work At the Beginning of a Lesson (Middle School participating in SVMI, 2007)



I JUST ADD 15 TO 10 cm TO GET TO 25 cm SO THEN I ADDED 15 TO 16 cm TO GET 31 cm



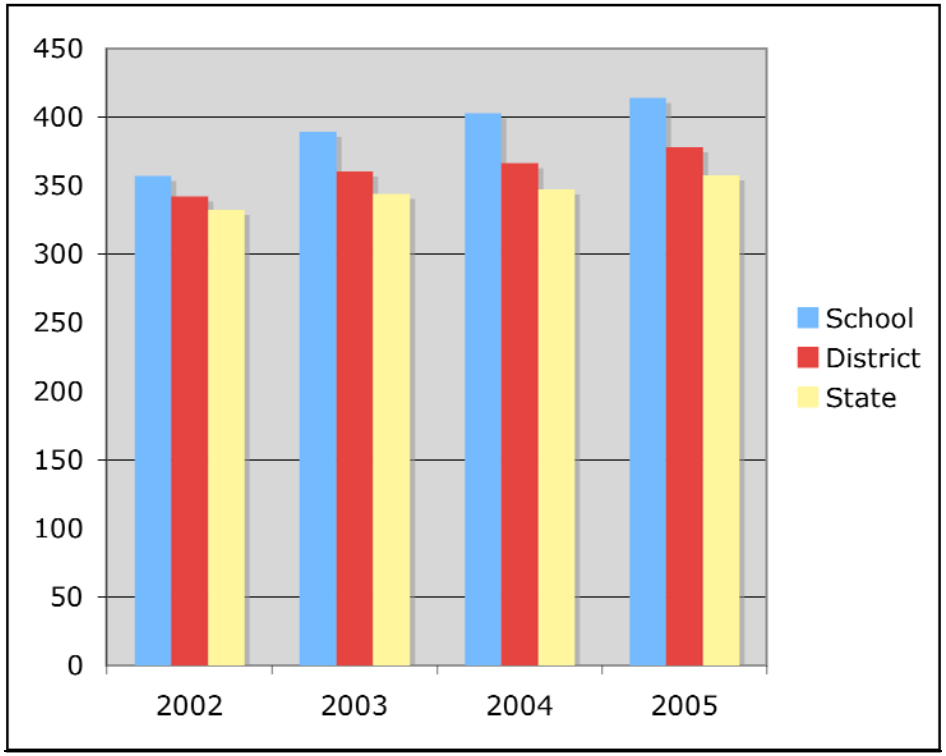
I FOUND THIS BY DIVIDING 25 BY 10 TO SEE WHAT RELATIONSHIP THEY HAD $25 \div 10 = 2.5$ SO $10 \times 2.5 = 25$ SO I MULTIPLIED 16×2.5 AND GOT 40 cm.

Example 2: School-wide Lesson Study

Teachers develop research theme as whole school, then lesson study groups research the theme and bring it to life in research lessons.

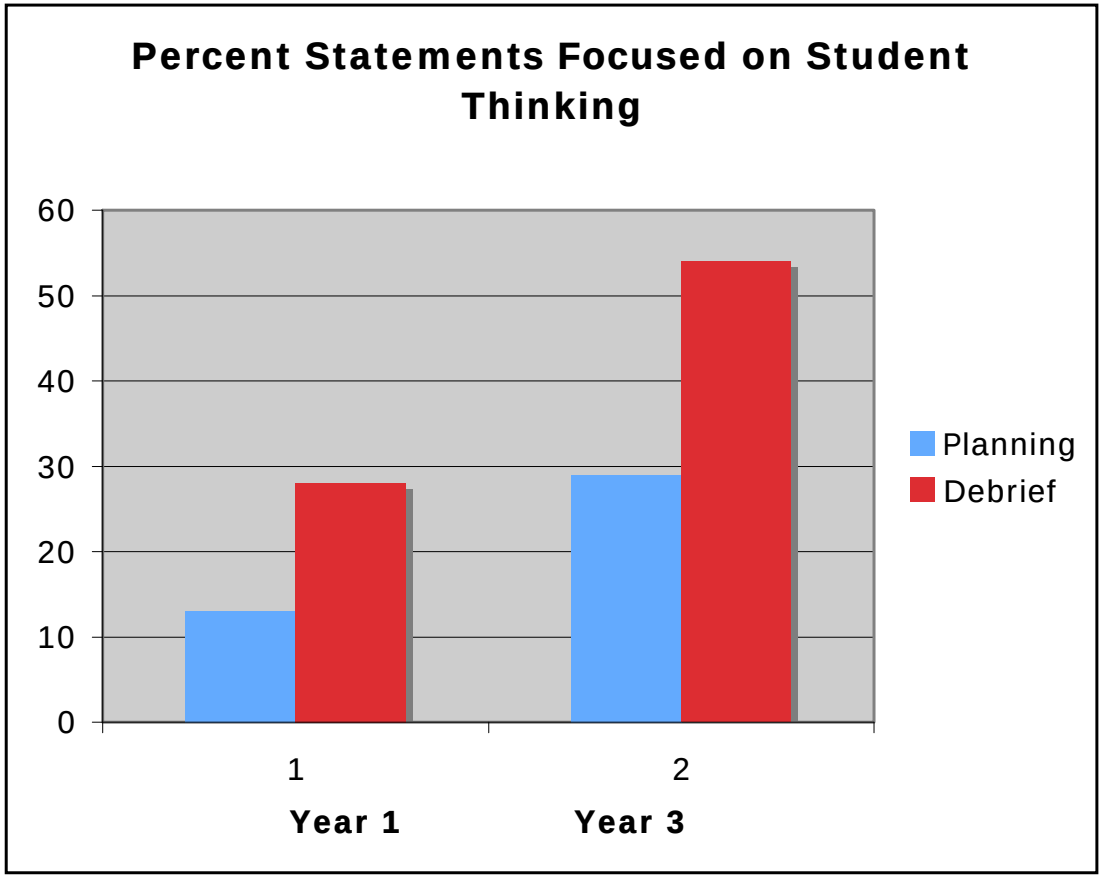
Example of theme: Using differentiation strategies to reduce achievement gap.

Highlands (SMFCSD) School-wide Lesson Study

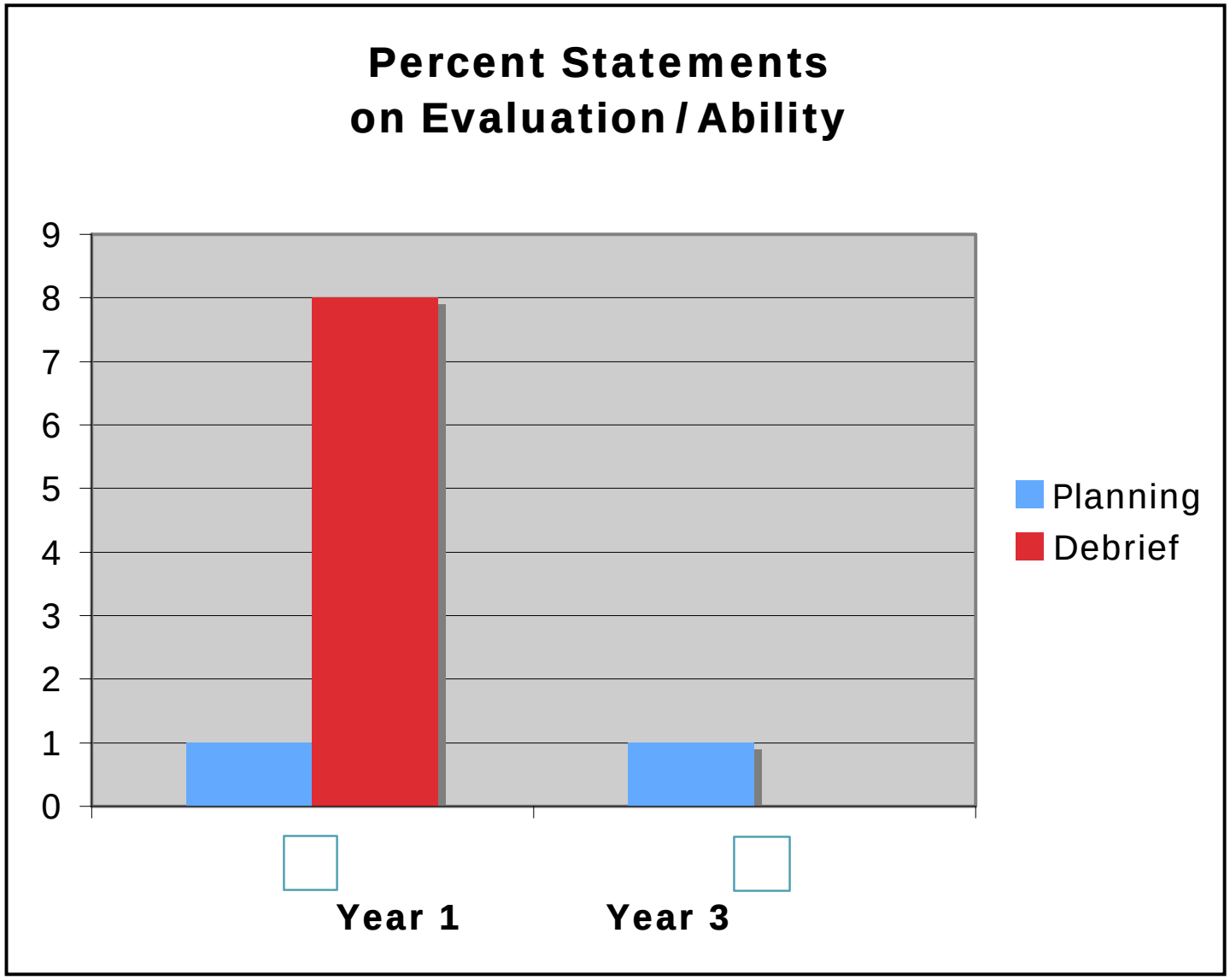


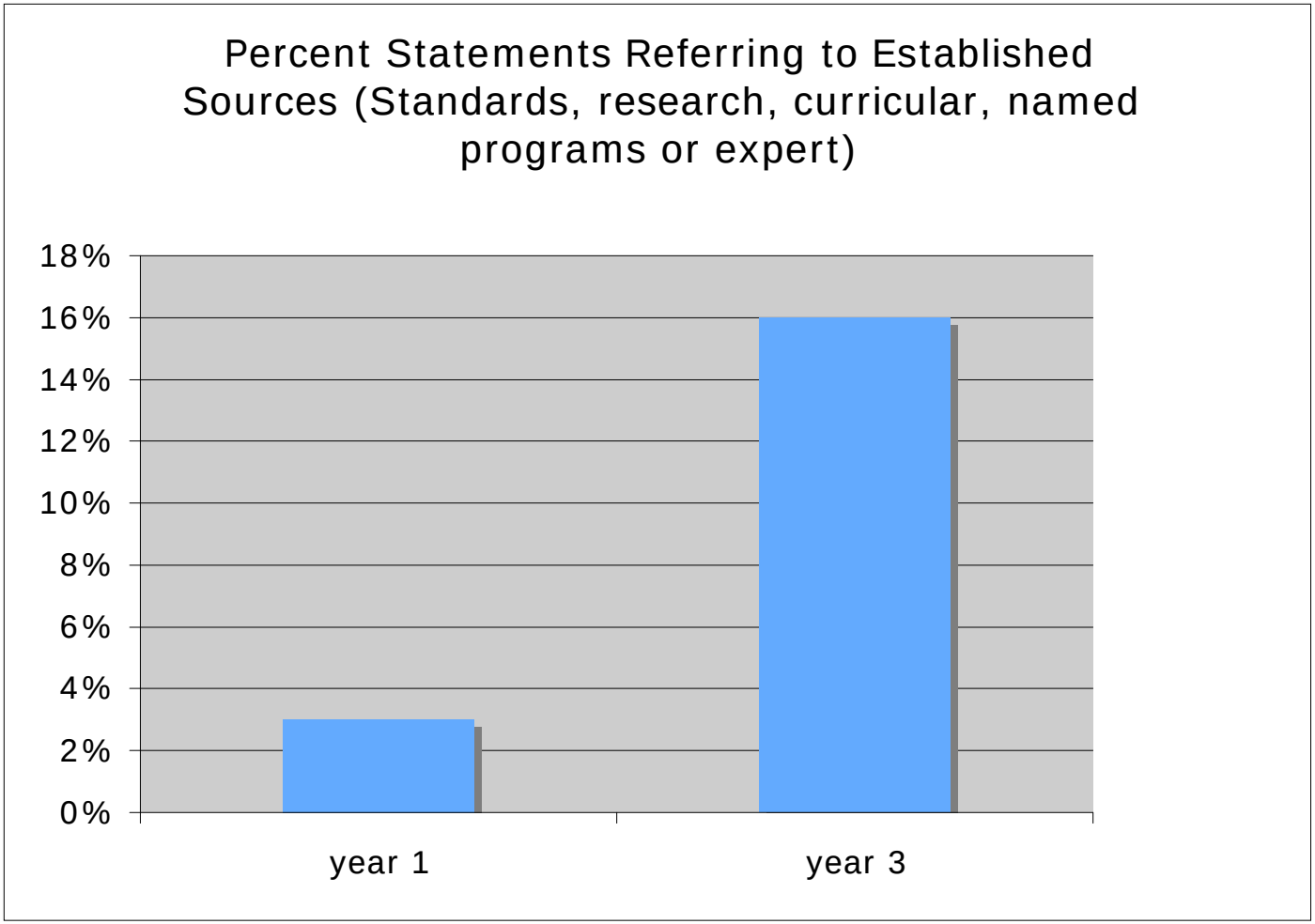
California Standards Test in Mathematics: Mean Scale Scores, Grades 2-5, Highlands School and SMFCSD

3-year net increase for school more than triple that for district (F=.309, 845df p<.001) (Lewis, Perry, Hurd, O'Connell, Phi Delta Kappan, 2006, 88:4)



Example 2: School-wide Lesson Study School


Percent Statements
on Evaluation / Ability
9
8
7
6
5
4
3
2
1
0
Year 1
Year 3
Planning
Debrief


Percent Statements Referring to Established Sources (Standards, research, curricular, named programs or expert)
18%
16%
14%
12%
10%
8%
6%
4%
2%
0%
year 1
year 3

Example 3: Randomized Controlled Trial of Lesson Study Supported by Fractions Resource Kit

3 conditions:

1. Lesson study with resource kit
2. Lesson study but **no** resource kit, **not** focused on fractions
3. Locally-chosen professional development

Roughly 5 month study period

Sample Characteristics

- 13 Groups per condition
- 213 Teachers
  - 41% New to Lesson Study
  - 78% Elementary Teachers
- 1061 Students (Grades 2-5)

Impact Assessment

Teachers' Knowledge of Fractions

33-item teacher assessment, from Univ. of Michigan LMT (21 items); Univ. of Louisville; New Zealand, etc.

Students' Knowledge of Fractions

17-41 item (grade 2-5)student assessment (NAEP, California standards, curriculum materials, research studies)

Teachers' Beliefs and Dispositions, e.g.

effectiveness of collegial learning

expectations for student achievement

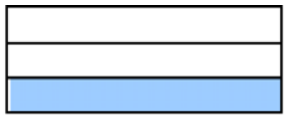
research relevance for practice

Common Challenges in Understanding Fractions

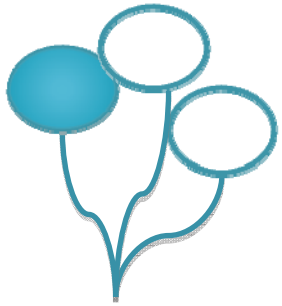
- **Seeing fraction as number** ("I can't put 2/3 on number line because it's two different numbers")
- Understanding **the meaning of the denominator** (that 1/6 is smaller than 1/5)
- Knowing **what is the whole** (construct whole from a fraction)
- Seeing that fractions can be **greater than one**

Area of circle

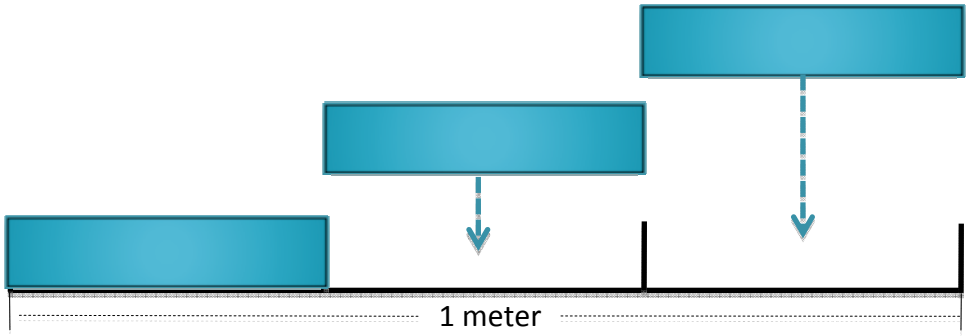
Area of rectangle



Part of a set



Linear measurement



Research Literature & Field Studies Suggested Affordances of Linear Measurement Context for Learning Fractions

- Davydov & Tsvetkovich (1991)
- Saxe et al., (2007, 2009)
- Dougherty (2008)
- Watanabe (1996, 2002, 2006, 2007)

Comparison of U.S & Japanese Texts

Compared

2 US elementary math series

- Investigations (2007)
- Harcourt California (2002)

- 2 Japanese elementary math series
- Tokyo Shoseki (Hironaka & Sugiyama)
- Gakkou Tosho (Hitotsumatsu et al.)

	US: Harcourt	US: Investigations	Japan: TS	Japan: GT
Grade 5	Volume Measure Number Line Area: Rectangle Set Fraction bar, strip Bar Graph Money Linear Measure: Data Report 3-D Objects Weight	Number Line Area: Rectangle Area: Circle Set Clock Linear Measure: Data Report Fraction track	Linear Measure: Fraction Meaning Volume Measure Number Line Area: Rectangle	Linear Measure: Fraction Meaning Volume Measure Number Line Area: Rectangle
Grade 4	Volume Measure Number Line Area: Rectangle Area: Circle Area: Other Figure Set Fraction bar, strip Weight Bar Graph Linear Measure: Data Report Music Notes Money	Volume Measure Number Line Area: Rectangle Set Money	Linear Measure: Fraction Meaning Volume Measure Number Line Area: Rectangle	Linear Measure: Fraction Meaning Volume Measure Number Line Area: Rectangle
Grade 3	Volume Measure Number Line Area: Rectangle Area: Circle Area: Other Figure Set Fraction bar, strip Weight Money Linear Measure: Data Report	Area: Rectangle Area: Circle Area: Other Figure Set Weight Money	Linear Measure: Fraction Meaning Volume Measure Number Line	
Grade 2	Volume Measure Number Line Area: Rectangle Area: Circle Area: Other Figure Set Fraction bar, strip	Volume Measure Area: Rectangle Area: Circle Area: Other Figure Set 3-D Object Volume Linear Measure: Data Report		
Grade 1	Area: Circle Area: Other Figure Set			

Some Dramatic Differences

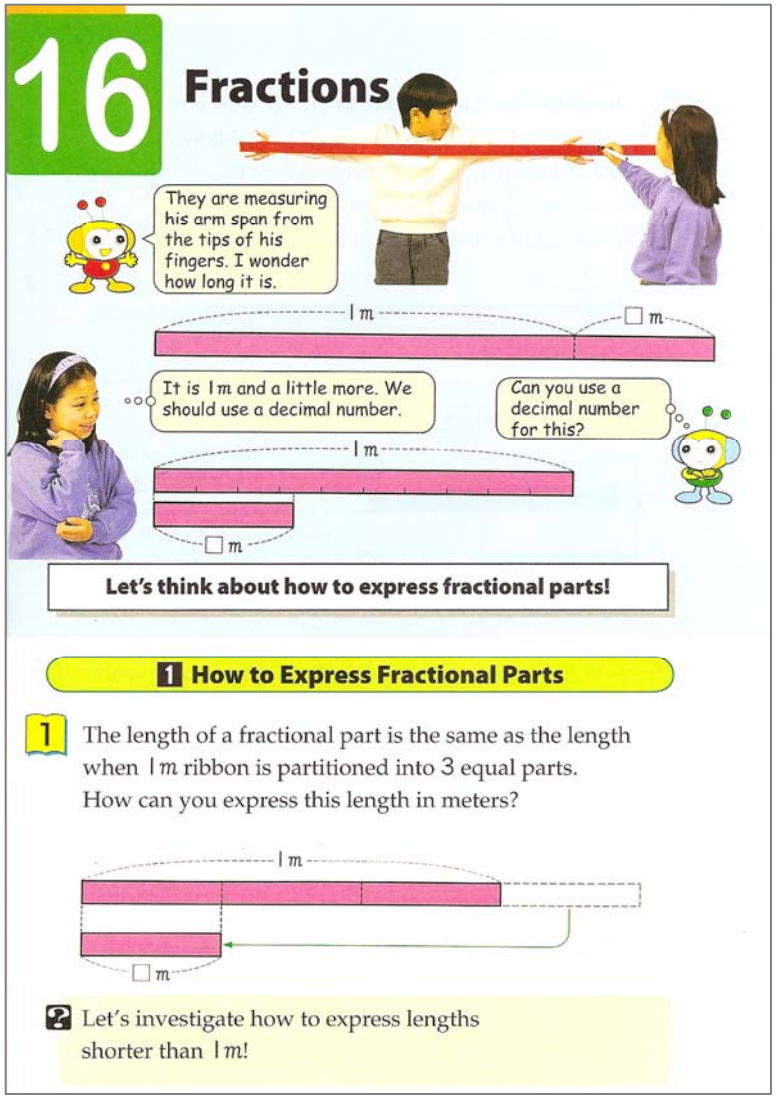
Earlier Introduction of Fractions in US

More representations in US (15) than Japan (4)

***Different* representations**

- Linear measurement in Japanese texts
- Circle area (and many others) in US texts

Fraction Understanding Using Linear Measurement: Japanese Ex.



16 Fractions

They are measuring his arm span from the tips of his fingers. I wonder how long it is.

1 m

□ m

It is 1 m and a little more. We should use a decimal number.

Can you use a decimal number for this?

1 m

□ m

Let's think about how to express fractional parts!

1 How to Express Fractional Parts

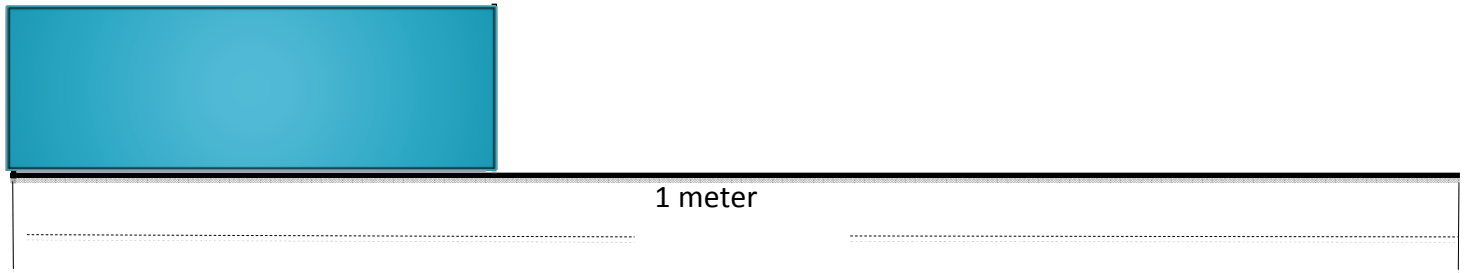
1 The length of a fractional part is the same as the length when 1 m ribbon is partitioned into 3 equal parts. How can you express this length in meters?

1 m

□ m

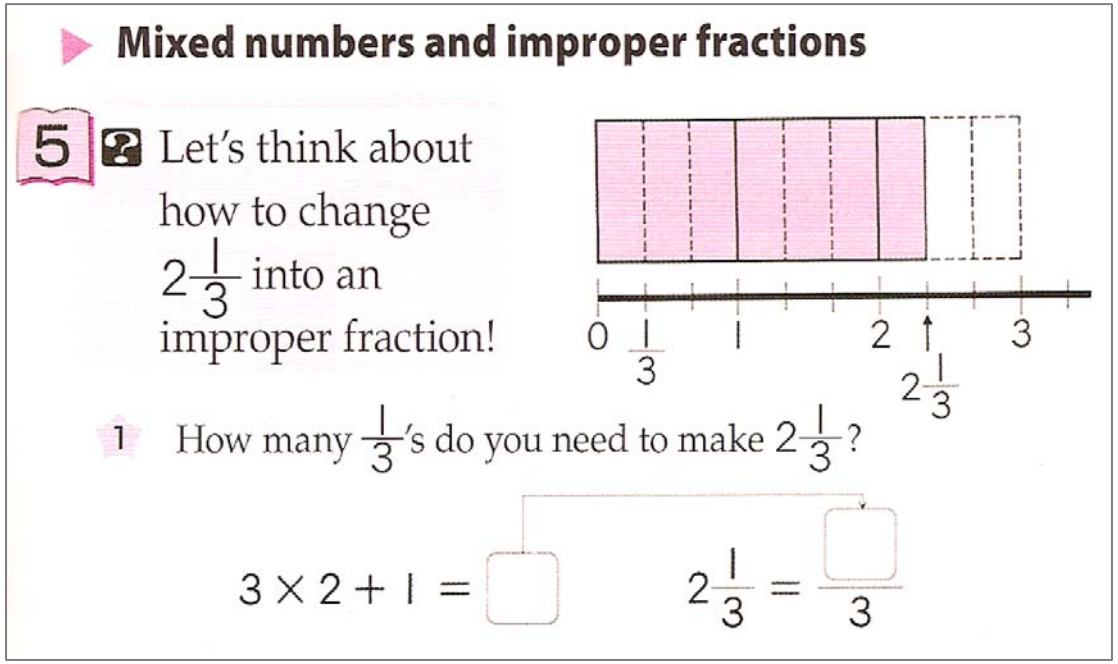
? Let's investigate how to express lengths shorter than 1 m!

How Can We Describe the Blue Mystery Piece in Terms of One Meter?



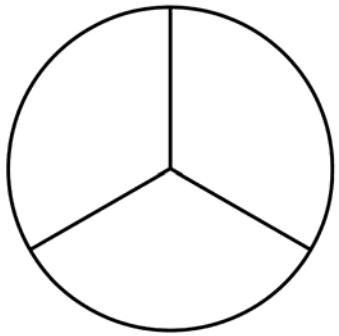
Seeing Fraction as Number

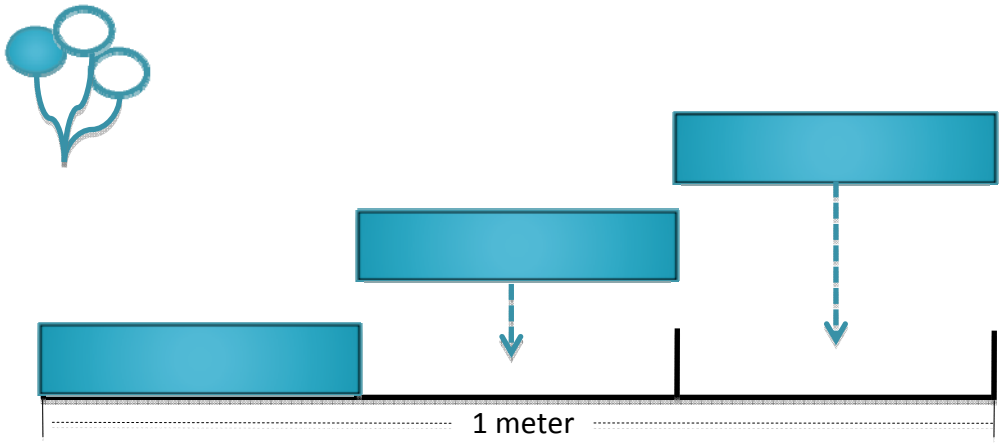
Linear measurement context helps students transition to see fractions as *numbers* on number line, not just as *pieces* or as *situation*



How Linear Measurement Context Might Help

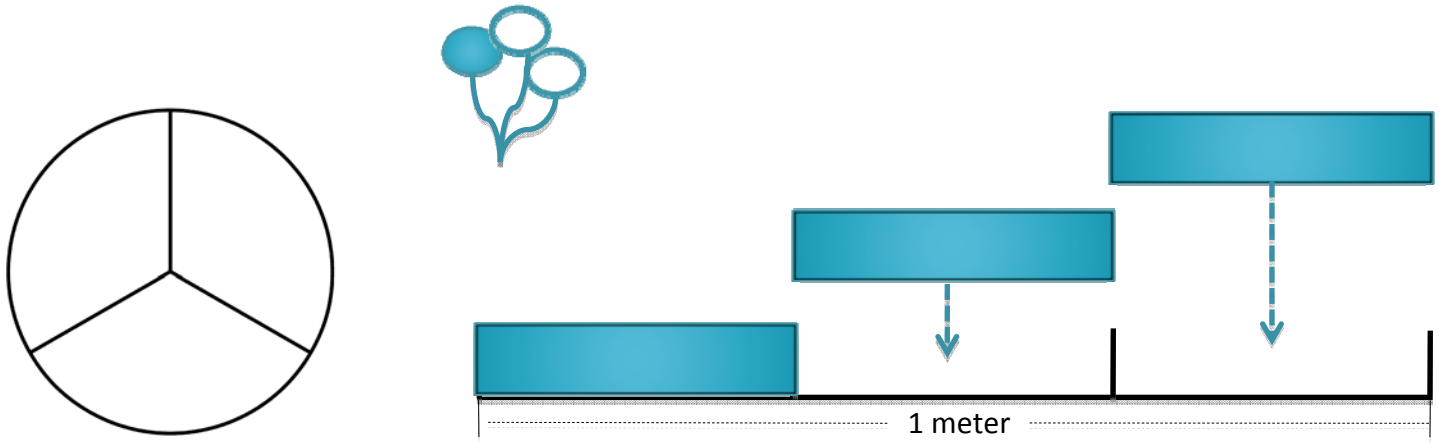
Length helps students attend to magnitude of fractions (how *much*) rather than just count pieces (how *many*)





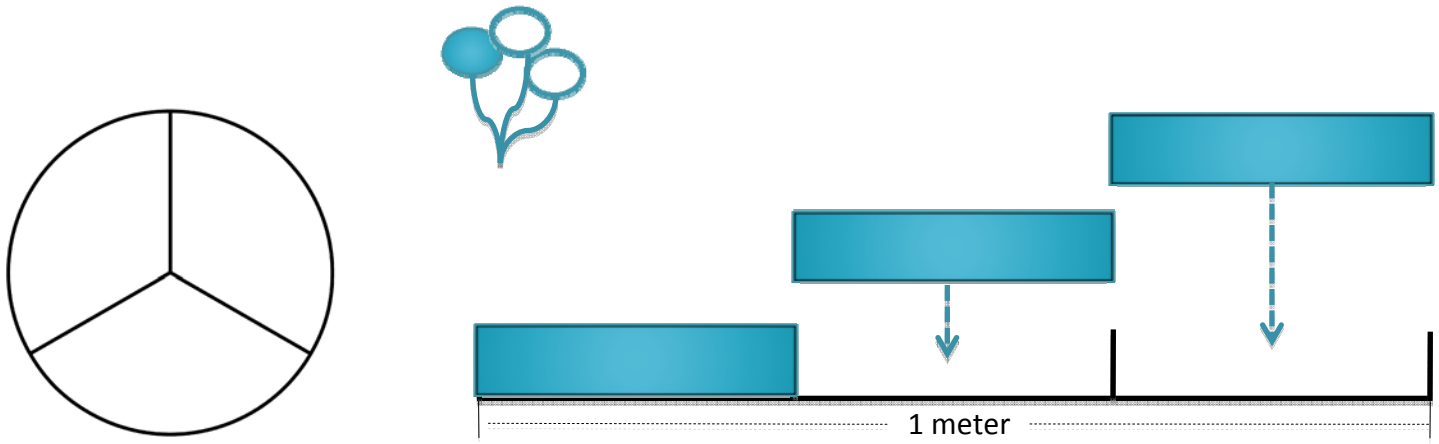
Understanding Meaning of Denominator

Only 1 dimension (length) varies, making it easier to see that ½ is bigger than ¼



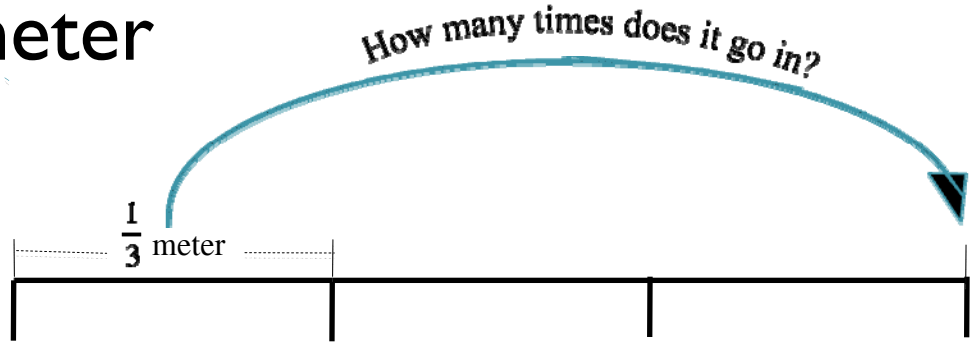
Understanding the Whole

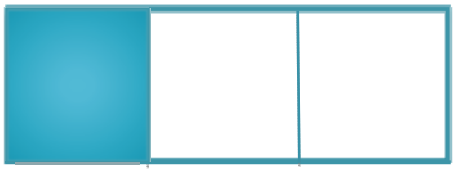
Standard measurement unit gives clear, stable image of the "whole"

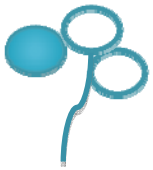


Understanding 4/3 as 4 1/3's

Students may use length to develop the image that 3 times 1/3 meter is 1 meter and x times 1/n meter is x/n meter





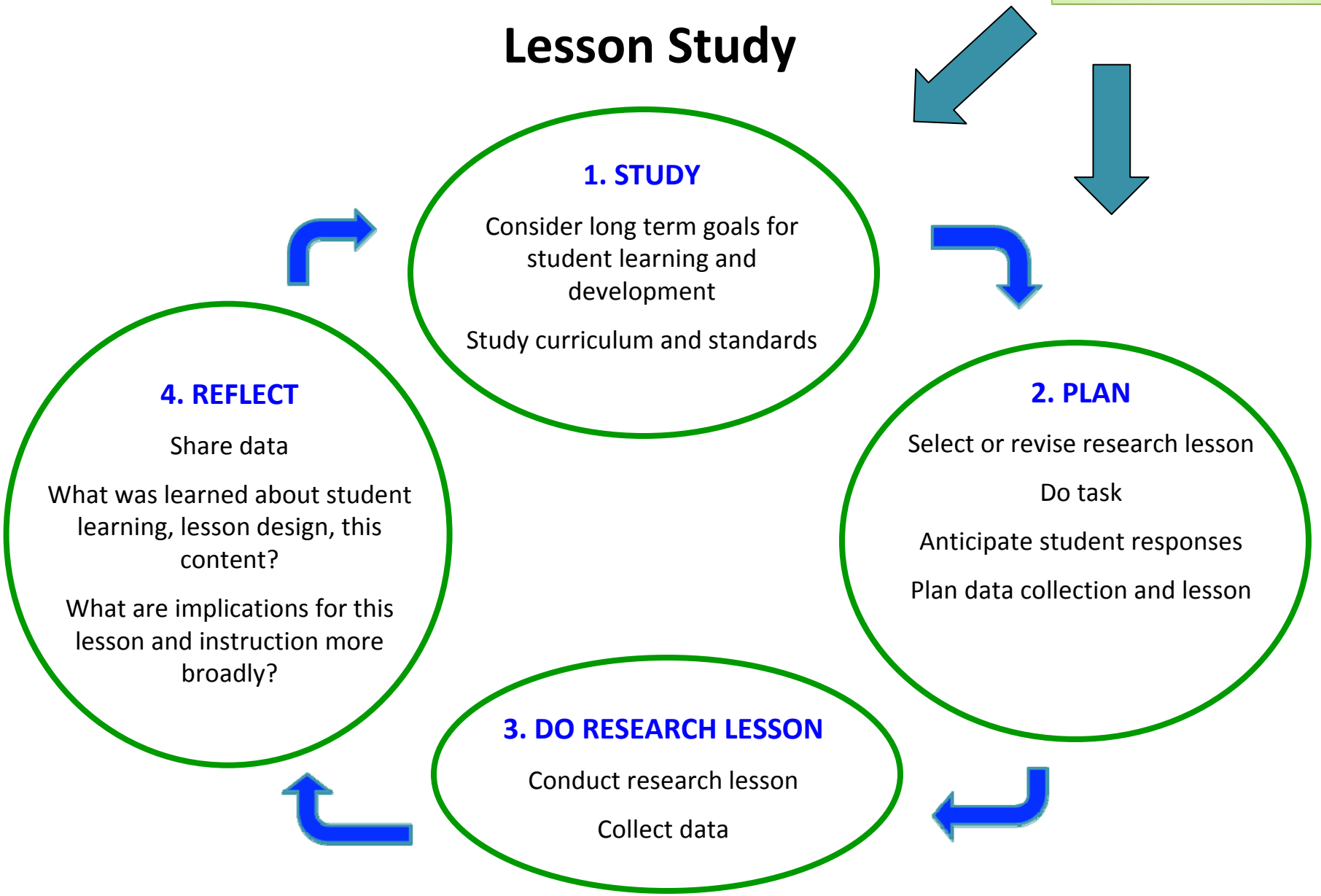


Lesson Study Resource Kit

1. Mathematics tasks to solve and discuss (& related student work to analyze)
2. Curriculum inquiry: Japanese textbook, lesson video, teachers' materials
3. Lesson study materials (template for lesson plan, protocol for discussion, etc.)
4. Suggested process to explore and use resource kit

Lesson Study

Materials



Teachers try a problem: Find the length of the mystery strip

Conduct Lesson Study Cycle

Perceived Quality of Professional Learning

- Teachers in *both* lesson study conditions rated their professional learning significantly more positively than the locally-chosen professional learning condition on professional learning quality indicators

Professional Learning Quality

- Built on my existing knowledge of teaching and learning
- Helped me consider how to apply what I learned…
- Gave me ideas I would like to share with colleagues
- Was intellectually engaging and important
- Helped me see how content ideas are connected…
- Encouraged my active participation
- Valued my opinion, experience, and contributions
- Supported my own professional inquiry and investigation…
- Encouraged me to share ideas and take intellectual risks
- Included intellectual rigor, constructive criticism…
- Encouraged me to become more of an educational leader in my school/ district


Quality of Professional Learning
50.00
45.00
40.00
35.00
30.00
25.00
20.00
15.00
10.00
5.00
0.00
Toolkit
Lesson Study
Prof. Dev.*

HLM Analyses: Lesson Study with Resource Kit (Compared to Other Two Conditions Combined)

Lesson Study with Resource Kit Had Significant Impact on Teachers' and Students' Fraction Knowledge

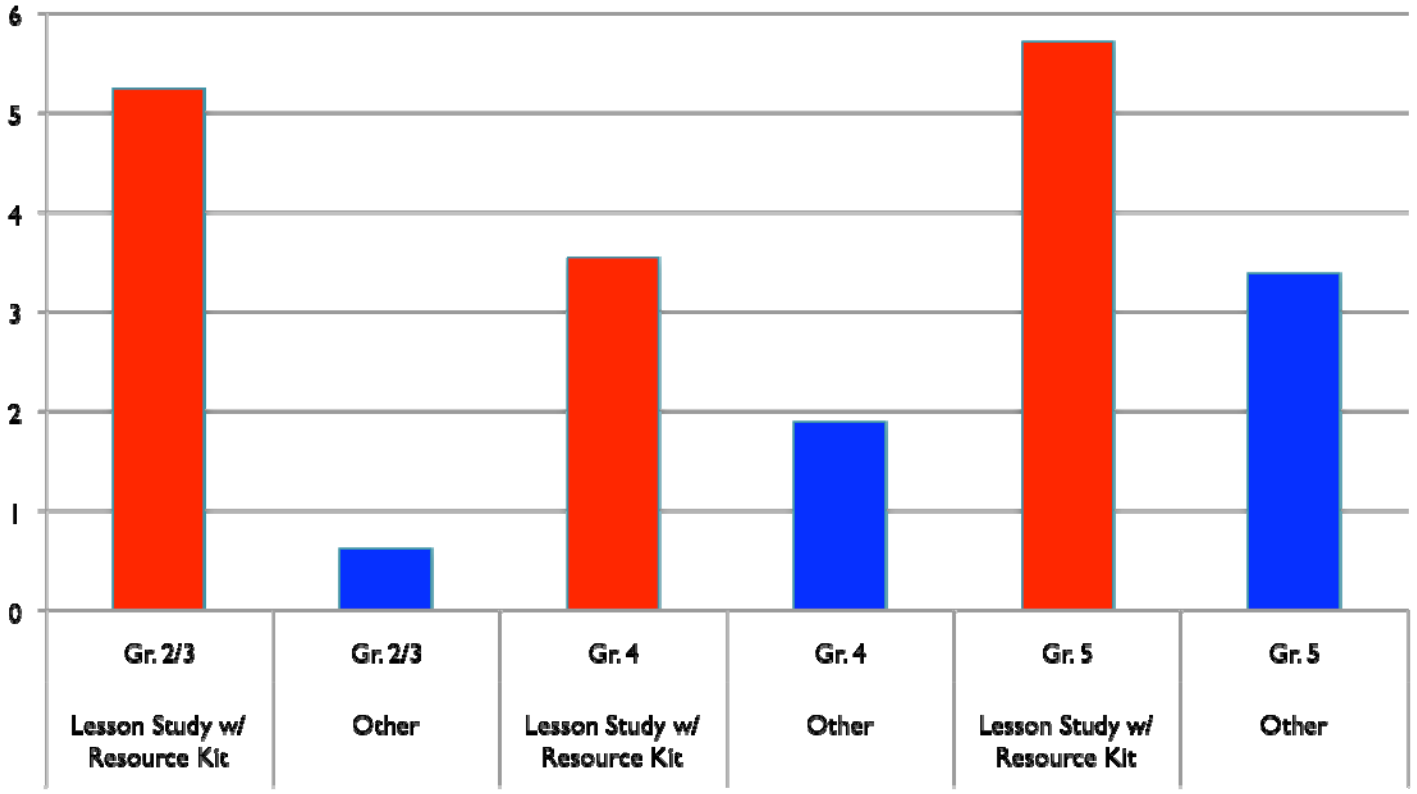
Effect sizes for teacher knowledge:

.08 for LMT-based measure

.25 for open-ended measure of understanding of whole

.38 for self-ratings of fraction knowledge

Change in Students' Fraction Knowledge (N=1059) Effect Size: .49



HLM Analyses of Teachers' Beliefs

Lesson Study with Resource Kit Showed Significant Positive Impact on:

- *Perceived Effectiveness of Collegial Learning*
- *Expectations for Student Achievement*
- *Research Relevance for Practice*
- *Using and Promoting Student Thinking*

But not on:

- *Interest in Mathematics*
- *Professional Community (why different from collegial learning, above?)*

Perceived Effectiveness of Collegial Learning in Mathematics

I have learned a lot about student thinking by working with colleagues

Working on mathematics tasks with colleagues is often unpleasant (rev)

I have good opportunities to learn about the mathematics taught at different grade levels

I have learned a great deal about mathematics teaching from colleagues

I find it useful to solve mathematics problems with colleagues

Vs. Professional Community Scale e.g.

Mathematics teachers in this school regularly observe each other teaching classes….

Survey Item Examples

Expectations for Student Achievement

No matter how hard I try, some students will not be able to learn aspects of mathematics [reversed item]

Research Relevance for Practice

Educational research often provides useful insights for teaching

Using and Promoting Student Thinking

I have some good strategies for making students' mathematical thinking visible

Quotes from Participants

"The information my lesson study colleagues gathered while observing the lesson was very eye-opening. I would never have realized how many misconceptions my students had about fractions by listening to them. They could say with ease the sign represented one fourth of a mile, but they could not explain what that meant. Having additional eyes and ears in the classroom during a lesson is extremely valuable to me as a teacher. …The collaboration that occurs before, during, and after a lesson is extremely valuable to me." *[Teacher #557]*

Quotes from Participants

The lesson study has taught me: We must never assume that all students understand. It was observed several times that even our "good" students did not have full understanding….Lesson study is staff development in its purest form. Rich discussion occurs. Team members are allowed to be creative, curious, self-motivated participants. The team building was incredible."

[Teacher #562]

Conclusions

Using strong research method, randomized trial, demonstrated that "low touch" lesson study supported by mathematical resources:

- Increased teachers' and students' content learning
- Increased reported effectiveness of collegial learning

- Lesson study was viewed more positively than locally-chosen professional development

- Groups of teachers worked independently in remote sites, suggesting the potential of locally-led learning.

Growing a Mathematics Teaching Community that Brings CCSS to Life in Classrooms

So, we have "existence proofs" that US K-12 & university-based educators can create vibrant mathematics teaching communities that engage in steady improvement from within the profession, motivated by the satisfactions of shared inquiry and improvement

But some big challenges remain….

Challenges to growing a lesson study community focused on CCSS

Few chances to observe and systematically analyze actual instruction. This is essential, as the example of "To Open a Cube" reveals.

Perhaps we have few venues because many believe that teaching can be captured, distilled & disseminated (using test scores, lesson plans, "best practice" descriptions etc.) without actually providing opportunities to observe and discuss it.

Challenges to Building a Mathematics Teaching Community (cont'd)

•Disparate curricula hamper accumulation and sharing of knowledge about teaching-learning

•Commercial, political & historical commitments to existing curricula. CCSS may be "addressed" through checklists, rather significant curriculum and instructional change. Why is it so hard to adopt curricula that have been proven in other countries?

Challenges (cont'd)

Lack of well-developed clinical methods for careful, close observation of student learning, perhaps because of root ideas about teaching as "fashion show" (everyone's got a unique style) or dust-bowl empiricism (whatever correlates today)

Challenges (cont'd)

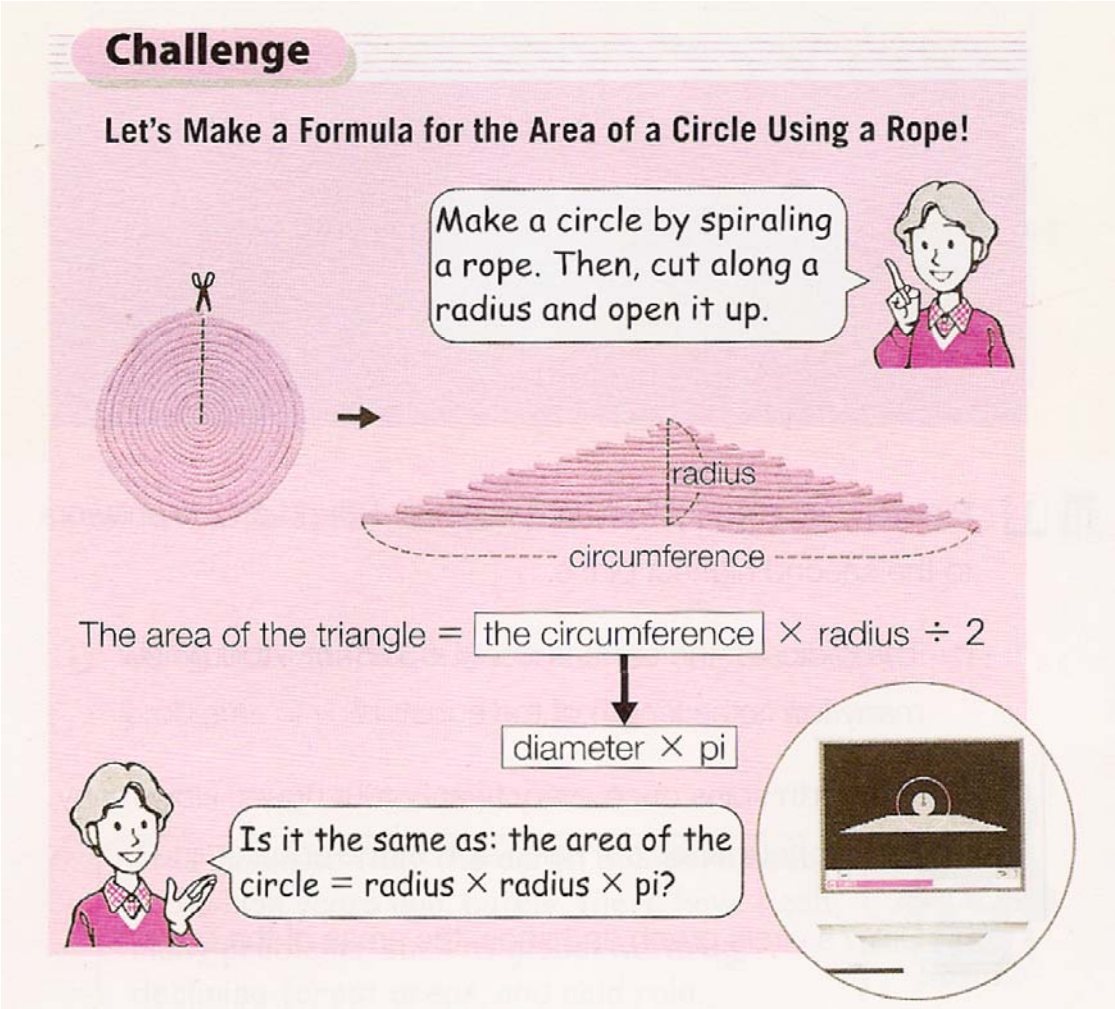
Need for a learning stance by all participants (including university-based participants).

•Japanese mathematics professors say they learn mathematics (as well as mathematics teaching-learning) through lesson study. Lesson study is not a "charity" activity, but one in which all members expect to learn and develop.

Tad Watanabe (Department of Mathematics, Kennesaw State University, Georgia)

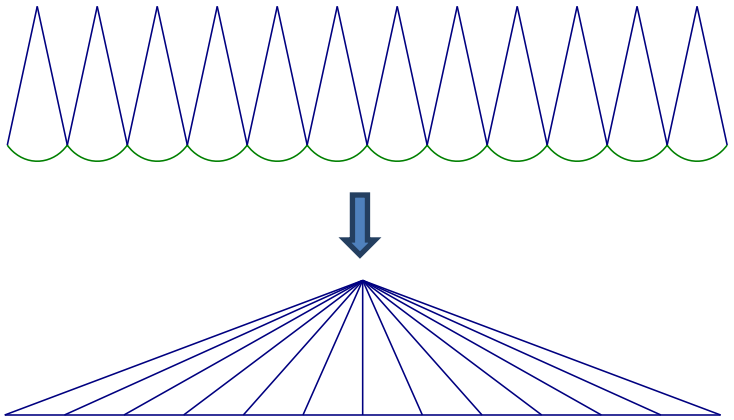
"10 years ago, I probably knew only one way of deriving the area formula for circles…."

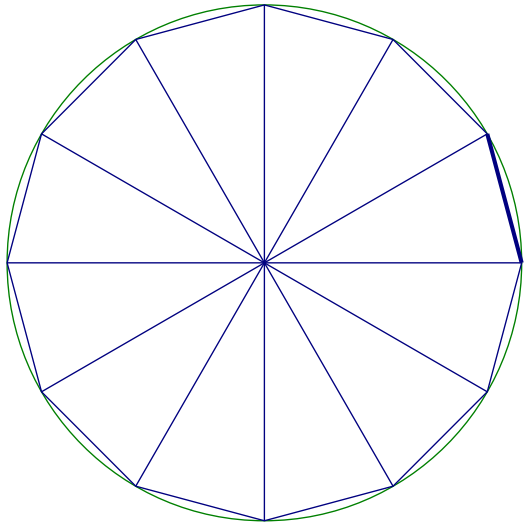
Other ways learned from lesson study activities…

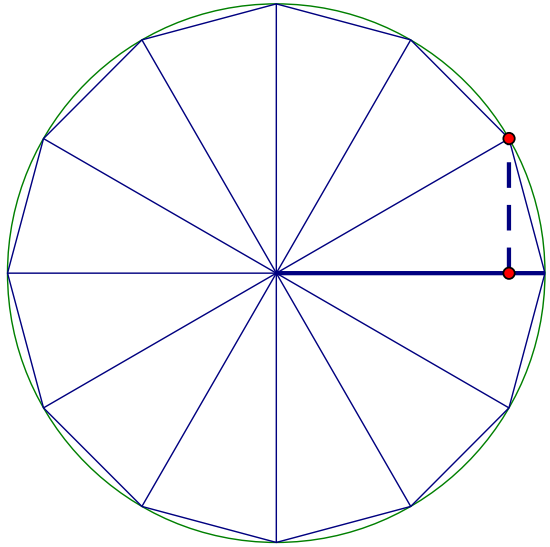


From Hironaka et al., 5B, p.91

Other ways….







Imagine if….

The next MSRI workshop included public research lessons that bring to life community members' visions of the CCSS, and enable us to share and discuss them…

As a final product of grants, foundations asked for public research lessons….

Superintendents and policymakers automatically thought of lesson study when faced with the task of implementing CCSS

Lesson Study Panels, May 13

10:30-12:00

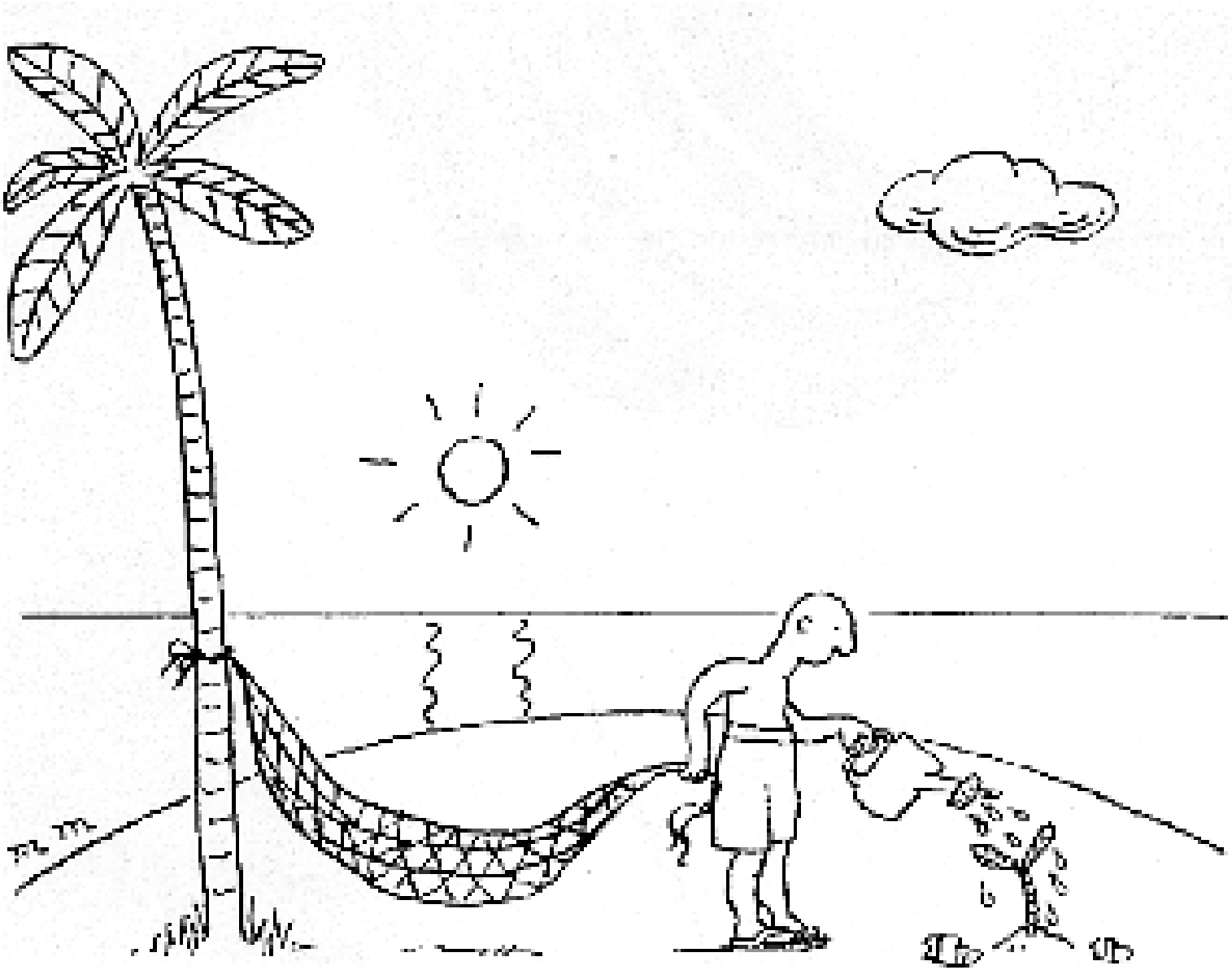
Lesson study models in the U.S.

Founders and participants of lesson study models including: Preservice; School-wide; District-based; and Regional Coaching Network

1:30-3:00

Advice from experienced lesson study practitioners

Educators from elementary, secondary & university settings, foundations



Thank you!

Catherine Lewis

clewis@mills.edu

Videos, articles, more information at:

www.lessonresearch.net