IMPULS

Immersion Program Report 2017

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International Math-teacher Professionalization Using Lesson Study (IMPULS) 2017 Immersion Program

Final Report

Contents

1. Introduction

> *"The best part about a lesson study is that it is not a blaming game. The process is very reflective and evolves due to the ability to discuss and gain internal and external input, and so in this sense no lesson plan can fail. The participants all focus on the lessons to be learned by all. The teacher reflects on what to improve, colleagues share ideas, authors of the textbooks are told what works and what doesn't on each task, and the feedback is actively sought, and warmly received….The journey to getting better seems to be an evolutionary cycle where everyone is involved."*
>
> *Excerpt from Belle Cottingham's blog LSIP participant 2017*

Global interest in Japanese mathematics classroom instruction was sparked from the Third International Mathematics and Science Study TIMSS, Video Study 1999 (Hiebert, Gallimore, Garnier, et al., 2003). Subsequent TIMSS data from the 2015 Global Study saw Japanese 4th grade elementary mathematics students ranked fifth among students in 49 countries and Japanese 8th grade mathematics students ranked fifth out of 39 countries (Mullis, Martin, Foy, & Hooper, 2016). Japan's position among the top five countries in the world for mathematics education further encouraged teachers, researchers and policymakers to find out more about what goes on inside Japanese classrooms. When asked, Japanese teachers reveal that it is through the process of lesson study that they learn to teach (Lewis & Tsuchida, 1997). Stigler & Hiebert in The Teaching Gap (1999) hypothesize *'that if our educational system can find a way to use lesson study for building professional knowledge of teaching, teaching and learning will improve"(p.131).*

Lesson study occurs in more than 95% of Japanese schools (National Education Policy Institute, 2011). A unique feature of Japanese lesson study is the way it enables teachers to improve continuously through collaboration with their colleagues. In addition, lesson study is embedded into the Japanese education system connecting policy to classroom practice and classroom practice to policy. As noticed by Belle Cottingham (excerpted from her blog cited above), research lessons are often attended by textbook publishers and what transpires during a post-lesson discussion provides important information about student thinking with respect to tasks presented in the textbook.

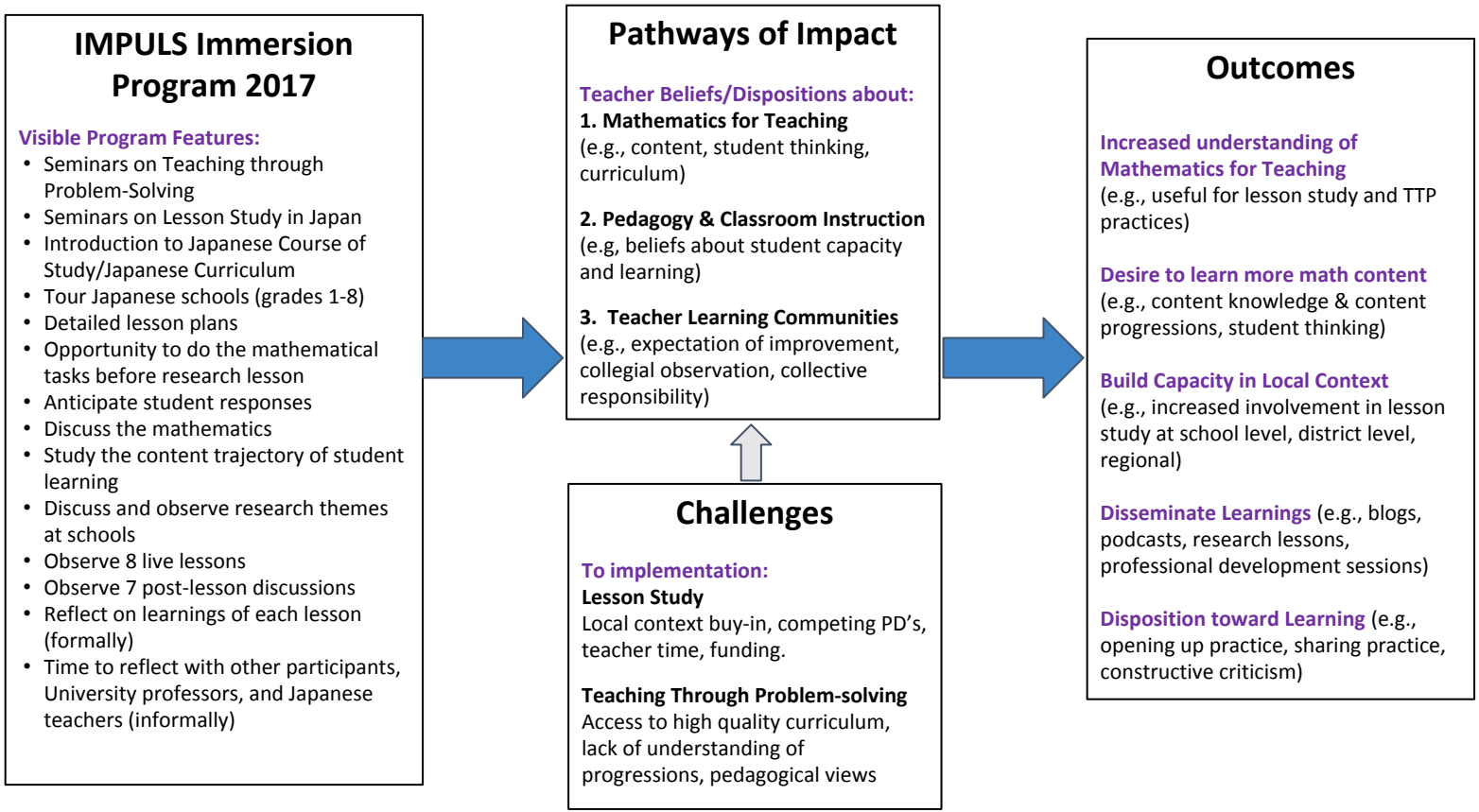
The **I**nternational **M**ath-teacher **P**rofessionalization **U**sing **L**esson **S**tudy (IMPULS) project began in 2011 to support professionals from throughout the world learn about Japanese lesson study. Funding for this project came from the Ministry of Education, Culture, Sports, Science &

Technology of Japan and Tokyo Gakugei University (April 2011-March 2017). The total cost amounted to ¥151,887,378 (approximately $1.4m or £1m) over 6 years allowing 196 participating international educators to go through the immersion program from 11 different countries including U.S.A. (107), U.K. (40), Netherlands (17), Australia (12), Singapore (9), Malaysia (3), Ireland (2), Portugal (2), Canada (2), Qatar (1) and Switzerland (1). This generous investment to support teachers, researchers and policymakers from other countries improve teaching and learning for their students through the practice of lesson study, aligns with the spirit of sharing and openness that greets you as you enter into the Japanese education system. Japan's sponsorship of this international program shows their commitment to continuously improve mathematics education worldwide. The IMPULS project remains housed in the Mathematics Education Department of Tokyo Gakugei University in Tokyo, The immersion program now continues to be funded through organizations and individuals outside of Japan.

Participants in the 2017 IMPULS immersion program used a combination of self-funding and funding obtained from institutions, including the Gates Foundation. A total of 27 participants attended the program; 21 from the U.S. and 6 from the U.K. The 10-day immersion program focuses on in-school observations and discussion, along with follow up meetings with IMPULS faculty. Participants experience different kinds of lesson study (school-based, district-based, and University-based), observe *teaching through problem solving (TTP)* approaches to mathematics learning, and have the opportunity to see how the Japanese Course of Study and textbooks are brought to life in Japanese classroom.

This report provides information about the visible program features of the 2017 program and profiles the participants that attended. It summarizes the key pathways of impact on participants' beliefs and dispositions as derived from their written reflections, written lesson reports and responses to survey questions. The report also reveals participants' perceived challenges to implementing lesson study when back in their local context. Implementation outcomes between the end of the program in June 2017 and February 2018 are also shared. Figure 1 provides a conceptual framework describing this report's findings.

Figure 1:


IMPULS Immersion Program 2017
Visible Program Features:
• Seminars on Teaching through Problem-Solving
• Seminars on Lesson Study in Japan
• Introduction to Japanese Course of Study/Japanese Curriculum
• Tour Japanese schools (grades 1-8)
• Detailed lesson plans
• Opportunity to do the mathematical tasks before research lesson
• Anticipate student responses
• Discuss the mathematics
• Study the content trajectory of student learning
• Discuss and observe research themes at schools
• Observe 8 live lessons
• Observe 7 post-lesson discussions
• Reflect on learnings of each lesson (formally)
• Time to reflect with other participants, University professors, and Japanese teachers (informally)
Pathways of Impact
Teacher Beliefs/Dispositions about:
1. Mathematics for Teaching (e.g., content, student thinking, curriculum)
2. Pedagogy & Classroom Instruction (e.g, beliefs about student capacity and learning)
3. Teacher Learning Communities (e.g., expectation of improvement, collegial observation, collective responsibility)
Challenges
To implementation:
Lesson Study
Local context buy-in, competing PD's, teacher time, funding.
Teaching Through Problem-solving
Access to high quality curriculum, lack of understanding of progressions, pedagogical views
Outcomes
Increased understanding of Mathematics for Teaching (e.g., useful for lesson study and TTP practices)
Desire to learn more math content (e.g., content knowledge & content progressions, student thinking)
Build Capacity in Local Context (e.g., increased involvement in lesson study at school level, district level, regional)
Disseminate Learnings (e.g., blogs, podcasts, research lessons, professional development sessions)
Disposition toward Learning (e.g., opening up practice, sharing practice, constructive criticism)

A detailed appendix including participant and faculty information, program readings, program schedules, orientations and presentation can be found at the end of this report. School research reports, research lesson plans and participants completed lesson reports are also included. Evaluation tools and blind participant raw reflection data are also available for further examination in the appendix.

2. Participants

Geographic/occupational identities

27 participants attended the program; 19 teachers, 2 University-based professionals, and 6 professionals working in roles that support teachers (1 math coach, 2 administrators and 3 mathematics professional development providers). Of the 19 teachers attending 1 was Kindergarten, 2 were first grade, 5 were second grade, 2 were third grade, 5 were either fourth grade, fifth grade, or combined fourth/fifth, 2 teachers taught 7th grade math, and 2 taught SPED in the elementary school. Of the 27 total, 6 participants were from the U.K. and 21 were from the U.S. Three U.S. school districts were represented: San Francisco Unified School District (SFUSD), Oakland Unified School District (OUSD), and Chicago Public Schools (CPS). One U.K. school borough was represented: Southwark, London. In total, teachers from 11 different schools attended the program.

Prior experience with lesson study

Participants had different levels of experience with lesson study: 6 participants had no prior experience with lesson study, 6 had less than a year of experience, 11 had between one and three years of experience, and 7 had over three years of experience.

Out of the 24 participants who had prior experience with lesson study, 23 had used it in Mathematics, 2 had used it in both Mathematics and Language Arts, 1 had used it in Language Arts only. The remaining 2 participants were administrators who had experienced lesson study in these and additional subjects (including an assistant principal who had attended a Science research lesson and a district administrator who had supported groups doing lesson study in almost all subjects). All of the 24 participants with prior experience had been on at least one planning team, 19 had taught a research lesson, and 1 had experience giving final comments.

3. Overview of Program Activities

Day 1: Opening Session (June 20th, 2017)

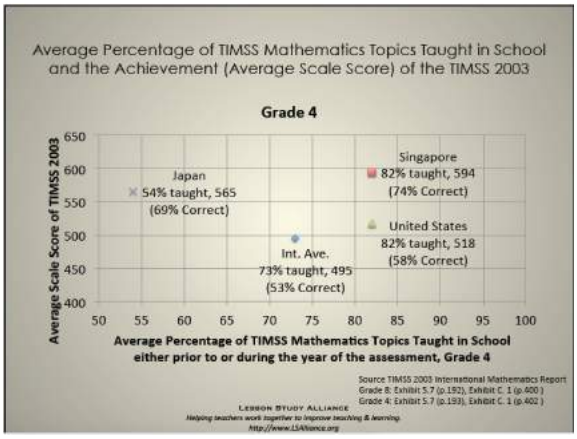
Welcome

The 2017 Immersion Program was opened by Dr. Takahashi, Professor from DePaul University and the Director of IMPULS, Professor Fujii from Tokyo Gakugei University. Faculty members and graduate students from Tokyo Gakugei University (see Section 2 of the Appendix) introduced themselves to the 2017 participants. Professor Watanabe from Kennesaw State University and Professor Yoshida from William Paterson University acted as content specialists and translators for this session, and continued throughout the program to provide these services. All participants introduced themselves (see Section 1 of the Appendix). Dr. Friedkin from Mills College Lesson Study Group joined the program as the evaluator.

Lesson Study in Japan

Dr. Takahashi introduced participants to the value of lesson study, a 3-level framework used by Japanese educators to discuss their practice, and the different kinds of lesson study in Japan. His presentation slides are in Section 5 of the appendix and highlights from his lecture follow.

Lesson study is intentional research in teaching and learning. Results from TIMSS 2003 data show Japanese students (grade 4) score higher than would be expected, given the number of topics studied prior to the TIMSS test. This may be attributable to teaching through problem-solving (TTP), which enables students to tackle problems not previously studied.



Japanese educators use a framework during lesson study that lays out 3-levels of teaching. At level 1: the teacher can *tell* students the important basic ideas of mathematics such as facts,

concepts and procedure, at level 2: the teacher can explain the meaning and reasons of the important basic ideas of mathematics in order for students to understand them, and at level 3: the teacher can provide students with opportunities to understand these basic ideas, and support their learning so that the students become independent learners (Sugiyama, 2008). In Japan teachers strive to be level 3 teachers and lesson study supports them to do this. Lesson study is not an end in itself but a process for accomplishing specific learning goals for students.

There are three main types of lesson study in Japan; they are school-based, district-wide, and cross-district. School-based lesson study is where the school develops a theme and works to understand how to implement it through doing cycles of lesson study. The entire school faculty including the principal and assistant principal, teachers, support staff, school nurse, everyone attends. The main purpose is to develop a common vision of education at the school. Through continuous cycles of lesson study the school develops systematic and consistent instructional and learning experiences for students. District-wide lesson study is where a district releases teachers one afternoon a month to attend a research lesson of their choice. Cross-school teams focused on different subject areas e.g., PE, Language Arts, Mathematics , Music, etc. present research lessons open to other educators in the district. The main purpose of district wide lesson study is to develop communication among schools within the district and to exchange ideas between schools about how to improve instruction and learning in the district as a whole. Facilitation of district wide post lesson discussion differs from school wide lesson study. Cross district lesson study can be sponsored by university-attached laboratory schools, professional organizations (such as an association of mathematics teachers) or designated research schools that have received grants to conduct special research to address new curriculum topics or goals, or to try out innovations, etc. Often these research lessons attract hundreds of participants. As an example, Dr. Takahashi introduced the use of pattern blocks through a cross-district lesson study event and now pattern blocks are used in most Japanese classrooms.

The learnings from all three types of lesson study are always written up. Teams include the lesson plans and findings and publish a report. In addition, books written by teachers often include reports of their lesson study work and can be purchased in local books stores. Both schools and districts write comprehensive reports on their findings. Additionally, special reports are written for parents so they too can understand the improvement taking place at their school. Schools in Japan also have a Research Steering Committee and the role of this committee is to

support the logistics of lesson study and take responsibility for sharing learnings about school's research theme and publish these findings.

In March 2017 a new Japanese Course of Study was published. Implementation, however, is not expected until 2020, allowing a 3-year transition. District and cross district lesson study have already begun to explore the new changes in the Course of Study so that teachers can understand how to adopt the changes. Textbook companies will also be closely observing this type of lesson study in order to inform the new textbooks and teacher's editions.

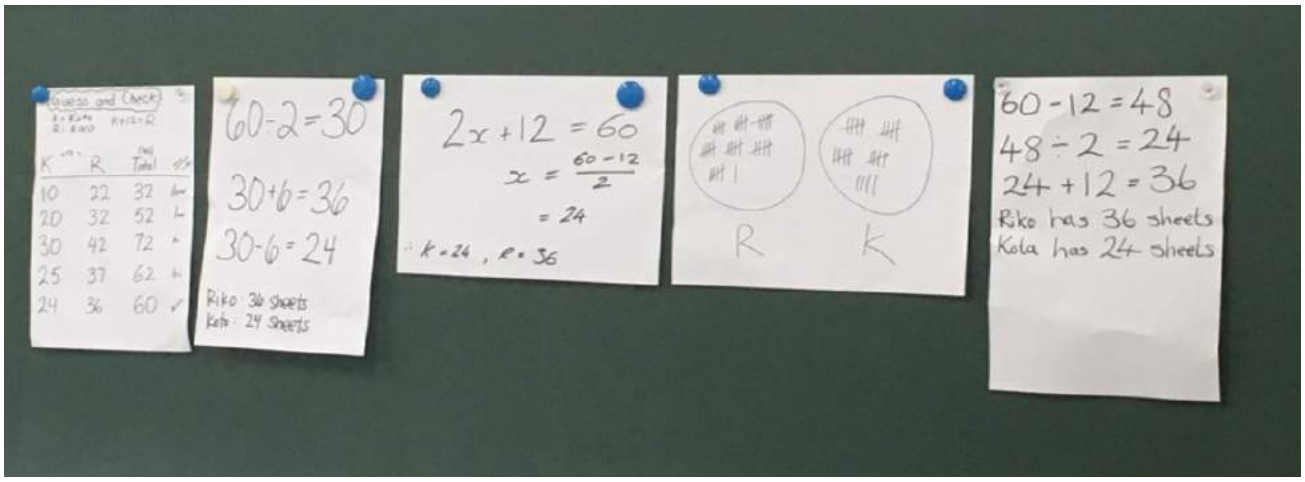
Anticipating Student Responses

Dr. Yoshida provided an interactive learning session to support participants understand what is involved when anticipating student responses. During this session Dr. Yoshida modeled teaching through problem solving practices and connected them to the 5 Practices for Orchestrating Productive Mathematics Discussion (Smith, 2011): Anticipating, Monitoring, Selecting, Sequencing and Connecting. Highlights from this session follow.

The task posed to participants:

> Riko and Kota split 60 sheets of origami paper to are paper cranes. Riko has to have 12 more sheets than Kota. How many sheets of origami paper will they each have?

Participants solved the problem and five solution strategies were posted on the board (see below):



Participants, with solutions posted on the board, shared how they solved the problem. The following strategies were discussed:

1. Guess and check using a table - systematic way
2. Split 60 into two and then added 6 to 30, and subtracted 6 from 30..
3. X + (X+12) = 60
4. Put 12 into Riko's pile and then did one and one until they were all used up.
5. Subtract the difference of 12 from 60, then divide by 2, add the difference back to Riko's share

Through whole group discussion participants identified the main difficulty for students when doing this problem is deciding what to do with the 12. The Grade 3 Research Lesson # 3: Pay attention to commonalities (thinking with diagrams) that participants will be observing on Friday poses this same problem to students, asking them to think about how they can show clearly the difference of 12. Participants were encouraged to review the lesson plan.

Teaching Geometry - a Japanese Approach

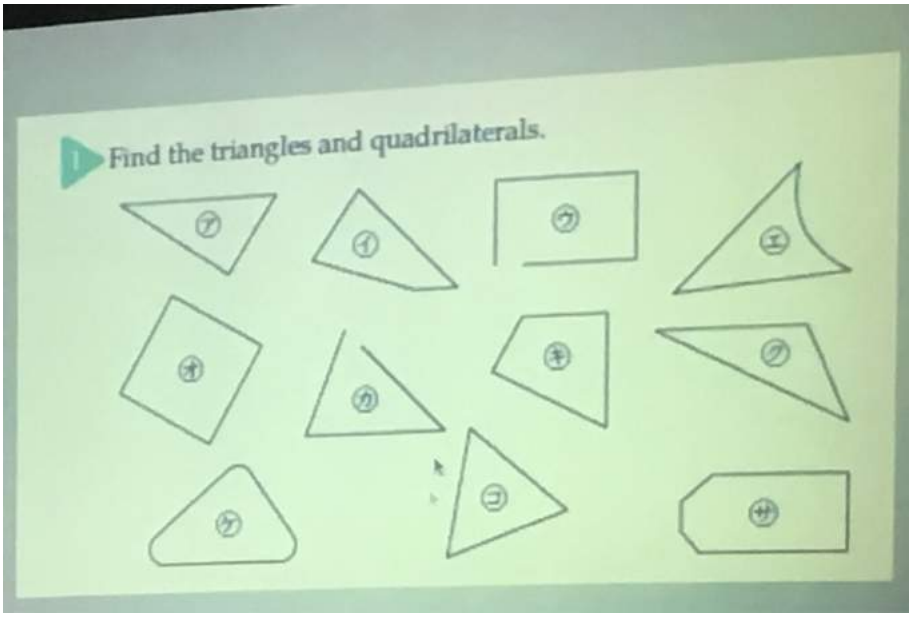
Dr. Takahashi provided a lecture on the progression of geometry found in Japanese textbook. Highlights of his presentation are summarized next.

The introduction to geometry starts with 3D shapes as in real life things are 3D, not 2D. Students start by playing with boxes, grouping and sorting them. It is important to ask students what they are paying attention to - is it round?, is it square? The answer to this depends on the students viewpoint. This difference of viewpoint allows the student discussion to start. In grade 1 students focus on the characteristics of the 3D objects and pay careful attention to what they are observing. Then, they begin to trace the shapes and this begins the introduction to 2D shapes. At this point, names of the shapes are not provided. Students see composite figures and start to understand the concept of shape.

In grade 2 students define fundamental geometric figures: triangle, quadrilateral, rectangle, square, right triangle and shape of a box. DEFINE means that students explore the components of shapes: lines, right angle, sides, vertex, face. Then, they EXAMINE the geometric figures from different viewpoints; focusing on the components of the shapes and the equality of sides or a right angle.

Before introducing a new mathematical term to students, they must be able to define it. Students can only truly know a straight line if they draw it, this is the CONSTRUCT phase. Students

investigate a shape by looking at its components and sort it by the number of sides or how many lines it has. The use of mathematical terms should be specific. For example, how do students define a line? It is either curved or straight. Below is a lesson from the Japanese textbooks to illustrate this point.



To be able to create viable arguments students have to go back to definition. Triangles and quadrilaterals have straight lines, they are not curved, and they are enclosed. We can then see how different shapes fit into this definition. The name of shapes should always be connected to a concept. The principle behind teaching geometry in Japan: **Define, Examine, Construct.**

In Grade 3 students define fundamental geometric figures: isosceles triangle, equilateral triangle, circle and sphere. They also explore the components of shapes: angle, radius, diameter, center. They are analyzing geometric figures from the viewpoint of the equality of angles.

Closing

Throughout the program there are seven research lessons and in groups participants will write a detailed lesson report on one lesson. During their assigned lesson participants can move up close to students to take pictures and see the student learning. Groups emerged based on grade level interest.

Day 2: Research Lesson 1: Heisei Elementary School, Tokyo (June 21st, 2017)

Type of lesson study: school-based lesson study

School Research Theme: Nurturing students who can identify and solve mathematical questions and express their ideas on their own -- through problem solving in mathematics --

Let's think about division of decimal number. Grade 5, Ms. Konohara *(see Appendix p. 62 for full lesson plan)*

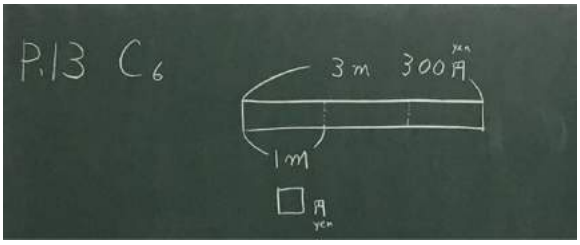
Review of lesson plan and content by Dr. Watanabe

Goal of the lesson: Students can think about the meaning of dividing by decimal numbers by making connections to their prior learning of calculation and numbers lines, and they can explain their ideas logically.

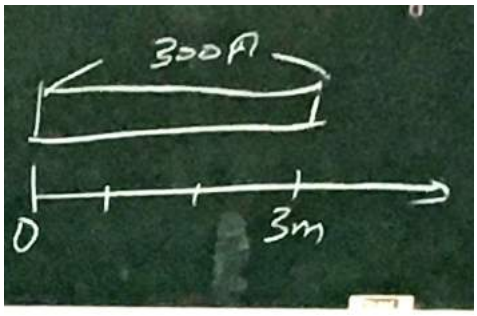
Problem: A 2.5m of ribbon costs 300 yen. How much will 1m of the same ribbon costs?

In the Japanese curriculum students learn to divide by decimals in grade 4. A challenge inherent in dividing decimals is that it is difficult for students to see and use equal groups strategies. This lesson is a fair sharing group situation, but now with decimals. In the Japanese curriculum the division of fractions and multiplication of fractions comes after decimals.

Based on the school theme, the task has been adapted so that the students have to figure out the operation and justify it. The teacher will pose the problem using ribbon and together (students and teacher) will come up with the following diagram as a way find out what 1m of ribbon costs.



Students will then create the mathematical question on their own, for example: What calculation do I need? Will it be division? This problem is not pushing for divide by 5 and multiply by 2 to get to the unit rate, it is gradually moving students toward the double number line (see below).



Participants Lesson Report Reflection Highlight (see Appendix p.78 for full report)

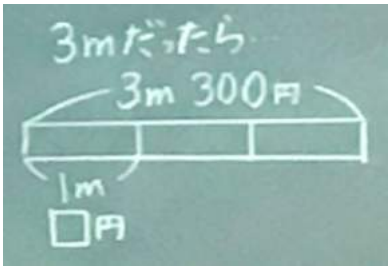
> *"Different problems and contexts lend themselves to the various types of division. The context for today's lesson would not lend itself to partitive or quotitive division, but rather to unit quantity and proportional reasoning. Typically, teachers choose to introduce division in a partitive context because it is a more concrete visualization of division. However, through the IMPULS participant post-lesson discussion, we discussed the advantages of teaching quotative division first, because this foundational understanding would allow for stronger understanding of unit quantity."*
>
> *Prepared by Alexandra Johansen, Amber Richard, Leilia Christensen, Karen Cortez-Ramirez, and Lisa Gaglioti.*

Post Lesson Reflections with IMPULS (held on June 22nd, 2017)

To open the session, participants were asked whether they viewed the teacher of the lesson at a level 1, 2 or level 3, based on the prior day's lecture about the levels of teaching. Participants discussed between themselves. Professor Fujii and Dr. Takahashi then shared their reflections on the research lesson.

Dr. Takahashi's comments:

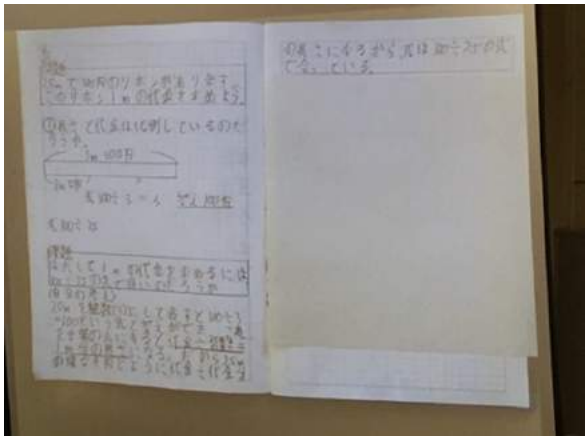
The teacher is at a level 2 because the use of the first diagram was too leading. It was not a summary of students prior learning, instead it led the students thinking?



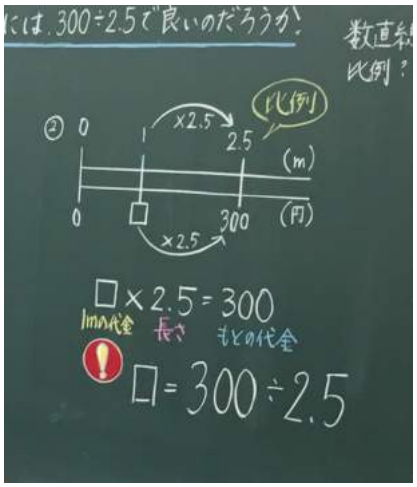
In addition, many students used the hint cards and this is an indication that students do not have the prior knowledge needed for the lesson.

Professor Fujii's comments:

The teacher mostly at a level 2. She was at a level 3 to the point where the students said '3m and 25m'. Up to this point, the teacher had listened very carefully and had picked up important things the students said. After that, the teacher picked up only what she wanted to hear and was very focused on why we can write 300 ÷ 2.5. When the teacher shared one student's note on the overhead projector she covered up part of it because she wanted the students to only see the expression with words. She ignored the second part of the student note that showed divide by 5.



In addition, the descriptors on the double number line shown in middle strategy shared on the board were the wrong way round. The board work showed price divided by length, whereas it should the length (m) on the bottom?



In Japan there are many arguments, especially during lesson study, about whether it is better to have the independent variable on bottom and dependent variable on top, or other way around. This lesson was designed to help students have an image of division, but the teacher shared '1m' in the introduction, therefore it had to be division. The image of division is 'seeing' the divisor as one thing, not being led to it. In Japan, students have a good image of addition, subtraction and multiplication, but they do not have a good image of division. In conclusion, the teacher was at level 2 because she just wanted to teach through her lesson plan.

Day 3: Research Lesson 2: TGU Koganei Junior High School (June 22nd, 2017)

Type of lesson study: specially appointed lesson study for University-Attached School teachers

Research Theme: Design lessons to raise the quality of student understanding of mathematical processes

This school is attached to Tokyo Gakugei University and the teachers at the school work closely with professors to develop and test ideas to improve teaching. They are developing curriculum, and provide professional development for new teachers. It is a very popular school as it is cutting edge. The fee for students to attend is low and the application level is fifty times more than spaces available. The students at this school are specially selected to represent the average student and may travel from a long distances to attend. The research lesson upcoming is a cross-school lesson study created by 4 middle school teachers and 2 high school teachers.

Letters in algebraic expressions, Grade 8, Mr. Shibata *(see Appendix p. 90 for full lesson plan)*

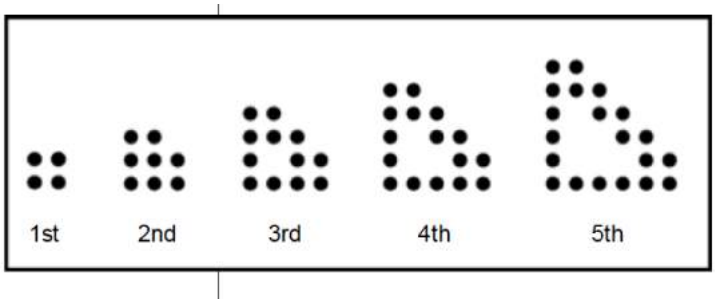
Goals of the lesson: Students are able to express the quantities, relationships among quantities, and rule of patterns in a phenomena using algebraic expressions with letters. In addition, they are also able to interpret algebraic expressions with letters and understand the quantities and quantitative relationships of the phenomena. Students understand the importance of comparing and discussing quantities and letters in algebraic expressions, and making connections between/among the transformation of algebraic expressions and phenomena. These actions help students conduct high quality mathematical processes.

Review of lesson plan and content by Dr. Yoshida

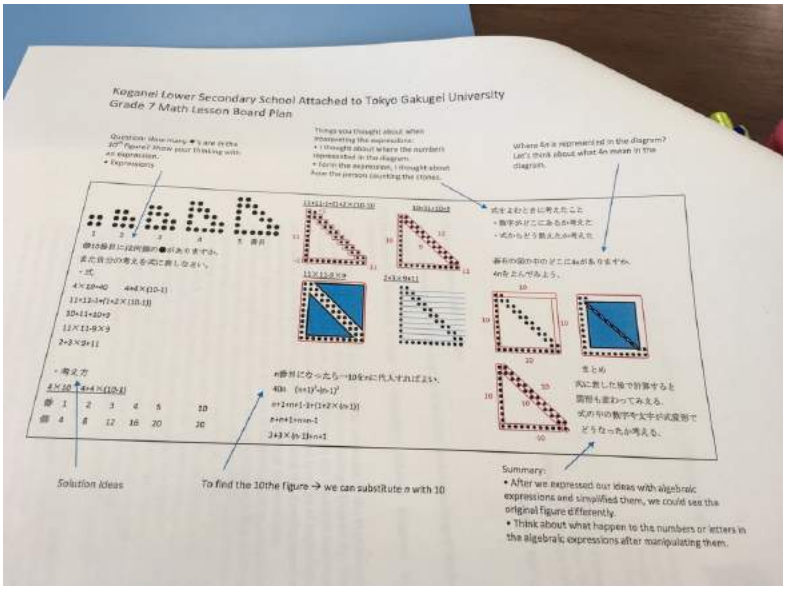
Dr. Yoshida focused the participants on the mathematical processes in the lesson plan. A summary of his comments follow.

In lower secondary school students learned that letters such as *a* and *x* may be used in place of □ and Δ (symbols used in elementary school, 5 +□= 8 or 3 x Δ = 24). This is the foundation for the study of algebraic expressions with letter symbols. Students also learned how to express direct and inverse proportional relationships using algebraic expressions. Students also have experienced using quasi variables, for example, thinking about way to express relationship patterns in numbers.

Problem: How many stones are in the 10th figure? Show how you can find the number of stones using an expression.



Students formally learned about variables in grade 7. During this lesson students will be looking at the pattern and writing the equation and also looking at the equation and drawing the pattern. Once they use the variable n to rewrite this, it becomes 4n. Student will think about what 4n mean. First they need to manipulate the equation, second they think about where the 4 and n are represented in the original pattern, and lastly they think - can we create a new shape using the same algebraic equation? Participants reviewed and discussed the board plan (below) found in the lesson plan.



Final Comments for this lesson were provided by Professor Nishimura from Tokyo Gagukei University *(see Appendix p.110 for complete slide presentation).*

Participants Lesson Report Reflection Highlight (see Appendix p.134 for full report)

> *"From this lesson we developed a more nuanced understanding of pile patterns as a mathematical task. If a pile pattern is growing by four every subsequent figure, we are used to thinking of "n groups of four," where a pattern adds 4 more stones in a clear and predictable way. In this particular lesson's pile pattern though, identifying where the four stones were added was not as clear, even though students were able to identify +4 pattern in their individual thinking. This pattern is better conceptualized as "4 groups of n", where the number of groups stays constant, but the number of stones in each group changes. We thus recognize the limitations of thinking about pile patterns as n groups of 4, and recognize the opportunities for further exploration when there are "4 groups of n".*
>
> *Prepared by Edward Southall, Stephanie Hironaka and David Correa*

Day 4: School visit and Research Lesson 3: Showa City Oshihara Elementary School, Yamanashi (June 23rd, 2017). Type of lesson study: school-based lesson study

Research Theme: Developing students' communication skills through English Language lessons and activities developed under the school-based research theme "Fostering Students' Ability to Thrive in a Global Society".

School visit

Participants freely toured Oshihara Elementary School during the morning, visiting classrooms and grade levels of interest to them to observe instruction. Each participant was assigned to a

classroom for lunch, where students (even in 1st grade) served food to the visitors and the rest of the students. In the afternoon participants experienced a grade 4 research lesson.

Research lesson

Pay attention to commonalities (thinking with diagrams), Grade 4, Mr. Ohma *(see Appendix p. 145 for full lesson plan)*

Goals of the lesson: Students recognize the merits of using diagrams that help them visualize the relationship between quantities clearly and easily in the context of word problems. Students are able to solve word problems by paying attention to the difference between two quantities, a difference that results in splitting one quantity into two parts or moving one of the two parts to the other part.

Review of lesson plan and content by Dr. Yoshida

> Problem: Riko and Kota split 60 sheets of origami paper to make paper cranes. Riko has to have 12 more sheets than Kota. How many sheets of origami paper will they each have?

Participants were reminded about the work they did on the first day of the program to solve this problem. The complexity of this problem for students is how to represent the difference of 12. In the research lesson students will be using different diagrams to help them visualize the relationship between the quantities.

Focus questions for the post lesson discussion

As part of the lesson plan information, participants were provided an observation and discussion handout that included space to write reflections about the following three questions after the research lesson. The questions were 1). Were students trying to solve the problem by paying attention to the difference between two quantities, difference that results from splitting one quantity into two parts or moving one of the two parts to the other part?, 2). Do the students recognize the merits of using diagrams that help them visualize the relationship between quantities clearly and easily?, 3). Was the lesson appropriate for supporting the students to develop their communication skills? These questions also provide the discussion points for the post lesson discussion.

Post lesson reflection with IMPULS (held on Monday June 26)

Participants were given the opportunity to share their thoughts about this lesson, and to reflect on any questions that still remained. Comments and questions from participants included: *It was very teacher-led. Enjoyed the post lesson discussion. Learning is messy. Students did not understand the diagram. At the point of the lesson when the 12 and 12 did not work, there was a lot of interest by the kids (climax) and this would have been a good time for collaborative work. About 30 minutes in I noticed that the students got lost or their interest changed. What is the pedagogy that may have supported this? There was an unwillingness from the teacher to deviate from the plan. The bar model maps nicely onto the difference of 12. Not necessary to use the diagram to solve the problem.*

Participants were asked if they could propose an alternative approach to the lesson based on the evidence they had collected or from what they had heard during the post lesson discussion.

Importance of evidence

Dr. Takahashi discussed with participants the importance of evidence from live lessons and shared his data from Lesson Note. A summary of this session follows.

If we watched a video of yesterday's research lesson, we might think it is a great lesson, but by being there we were able to see that students struggled. Therefore, we cannot use video for lesson study, we have to see the live lesson. On the surface view it is was a beautiful lesson, but the gap between student learning in the classroom and goals of the lesson were apparent and we know this because we were there. The data we collected and the post lesson discussion helped us think about how we can improve.

From reviewing the Lesson Note data it is apparent that students did not know how to use a diagram and therefore were unable to see the relationship between table and tape diagram. There was a lack of formative assessment by the teacher around the students' experience with diagrams. There were two different ways to think about the use of the table in this lesson and the teacher needed to be ready for both uses to come up during the lesson. The teacher must forget the lesson plan once in the classroom and the lesson starts, and must keep seeing the students. Strong lesson plans have width to them, not a single pathway.

Participants Lesson Report Reflection Highlight (see Appendix p.154 for full report)

> *The final commentator also noted that it was important for the teacher to be able to make use of students incorrect answers and to value their thinking. For example, many students did 60-12=48 and 30-2=18. This was another opportunity for the teacher to take the incorrect answers and go back to the table/diagram to help students figure out whether or not they were correct and what they might do next. Here, the commentator stated, was an opportunity for students to think about how to overcome challenges.*
>
> *Prepared by Marty Garrett, Nicole May, Kim Towsley, Stephanie Moore*

Day 5: Research Lesson 4: University of Yamanashi Attached Elementary School, Yamanashi (June 24th, 2017). Type of lesson study: cross-district lesson study

On Saturday June 24th, IMPULS participants joined two cross-district lesson study research lessons (3rd grade and 6th grade) and educators from local schools across several district joined. Over 150 educators attended on a Saturday (not unusual in Japan) and a special viewing room with a TV screen was prepared for the overspill.

Research Theme: In mathematics, we believe the engine for learning is "questions". In the process of learning, when one problem is solved, a new "question" arises. "Questions" are continuously generated. What supports this learning process is students' disposition to tackle problem solving autonomously.

Division with Remainders, Grade 3, Ms. Nomura *(see Appendix p.172 for full lesson plan)*

Goals of the lesson: Students will deepen their understanding of remainders, and they can obtain answers to problems by rounding up the remainder, if necessary.

> Problem: We are all going on the boat ride. Each boat carry 4 people. How many boats do we need?

Post lesson reflection with IMPULS (held on Monday June 26)

Participants were given the opportunity to share what they thought about this lesson and reflected on any questions that still remained. Comments and questions from participants included: One child understood it from the beginning. If that was my child, I would not be happy that they sit every lesson waiting for the others. I saw a teacher making a very detailed map of what students understood and their responses. What are teachers doing to assess the students during the lesson. The teacher missed the part on the plan that was the most important: students need the opportunity to

create their own images to seal their understanding. Did anyone get data to show if students that did not get it correct at the beginning, got it by the end of the lesson? Writing the table on the board again and again, the students were bored, I could see as they were fidgeting, for example, one student was tapping his feet. 90% of the teacher talk was questioning. There were a lot of questions but the level/depth of the questions seems low. I want to dive into the pros and cons of whole class instruction to make sense of the different kinds of pedagogy. The diagram was a point of clarity and students got the manipulatives out on their own. I think the students lost the learning when the table was introduced. There was no need for the kids to see the pattern at this time in the lesson and this is why they lost interest.

Dr. Takahashi shared his views on the lesson. A summary of his comments follow.

The teacher planned very carefully and she has ten years of experience, yet we still see many students not learning and unhappy faces. It is important to observe students' face and body language very carefully and develop a good eye for students, even while you are teaching. In order to develop a good eye, you need to observe many students. Often those new to lesson study look at the teacher, but it is the students that let you know what is really happening. The teacher of the lesson may have seen that the students were bored but did not have an alternative plan. In lesson study and during the post-lesson discussion, we should reflect on the moment when the direction of the students' interest started changing?

At the outset of the lesson, only 1 student had written 6 boats as the answer. From this data (shown through Lesson Note) it is not necessary to use the counters, rather the teacher should have brought a small boat and put in 4, 4, 4, 4, 4 and then the students would have seen 3 cannot fill the boat, and therefore they need to add another boat. What is interesting about this problem is that the answer of the calculation and answer of the problem are different, and this is the first time they have seen this kind of problem. Even very experienced teachers always learn something from lesson study, therefore when teaching a research lesson, it is important to open it up to others so they can learn too.

Participants Lesson Report Reflection Highlight (see Appendix p.185 for full report)

Mathematical Modeling Process (Miwa,1983)

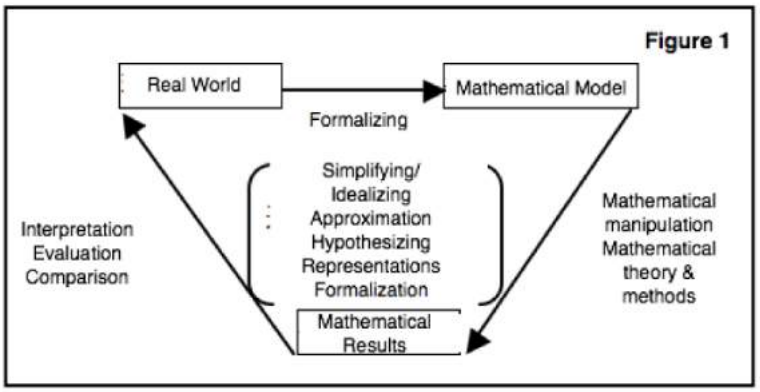


Diagram excerpted from lesson plan by report team

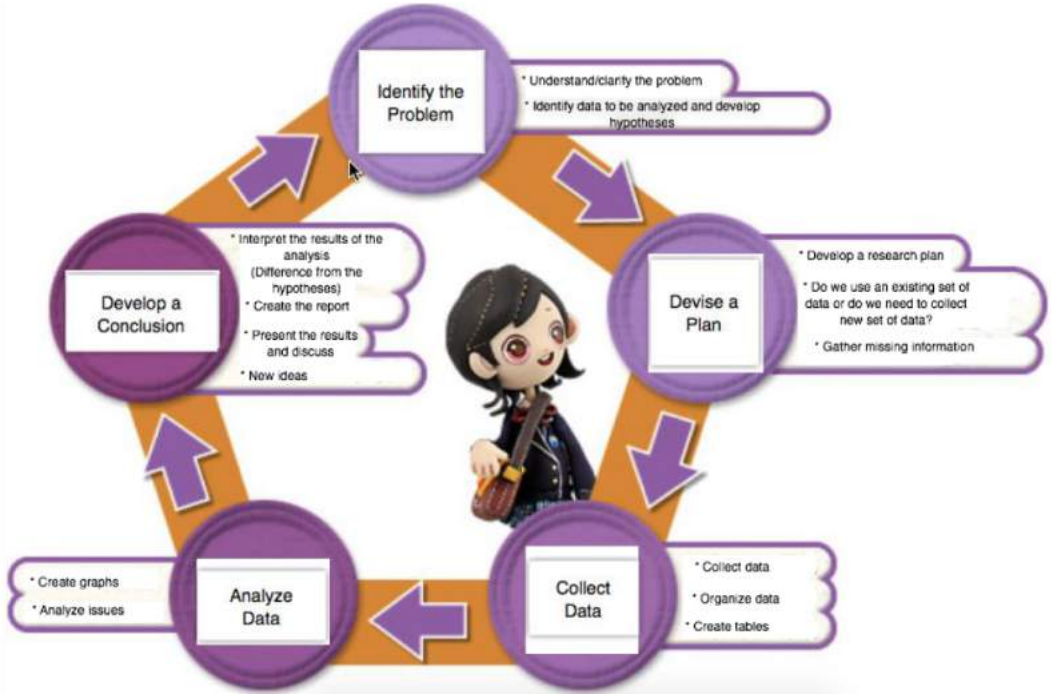
"We learned a great amount from this lesson in terms of our mathematical understanding as well as high impact practices. One key takeaway we had was the level of questioning from the teacher. In the lesson almost all teaching talk was done through questioning which forced the children to think for themselves and did not allow them to simply accept information because it the teacher had told them."

Prepared by Meghan Smith, Nakachi Kasimu, Sarah Horwitz, Rory Dearlove and David Allyn

Day 5, Research Lesson 5: University of Yamanashi Attached Elementary School, Yamanashi (June 24th, 2017). Type of lesson study: cross-district lesson study

The new Japanese Course of Study was released on March 31, 2017 and there is a new domain "D. Use of Data" added to elementary mathematics. Terms such as mean, median, mode and ranks have been shifted from Grade 7 (lower secondary school) to Grade 6 (elementary school). This is an example of a mathematics working group focusing on one of changes in the new Course of Study described by Dr. Takahashi on Day 1.

Research Theme: Help students purposefully collect data, organize them in appropriate tables and graphs, and then identify trends in the data set by observing the representative values. Students will engage in various learning activities generally sequenced as shown below in the PPDAC cycle:



Organizing Data, Grade 6, Mr. Yamaguchi *(see Appendix p. 199 for full lesson plan)*

Goals of the lesson: Students can organize data to solve problems and explain their reasoning.

> Problem: This is the second lesson of a 2-lesson sequence. Question: In order to meet as many people as possible, from what time to what time should we be standing at the school entrance. Students have already collected on what time people tend to come to school, and they have determined representative values and summarized the data in a frequency distribution table and a histogram. Today students will share their conclusions for discussion.

Post lesson reflection with IMPULS (held on Monday June 26)

Due to limited time, and the need to set out for the afternoon research lesson, Dr. Takahashi briefly shared his reflections on this research lesson. A summary of his comments follow.

There is always a risk to using everyday data, as this lesson did, because students may not be able to tell what is important from the data set, as the data may show something else. When planning a lesson it is essential to be clear on what students need to learn. Using the '5 practices for orchestrating productive mathematics discussions' (Smith & Stein, 2011) can support planning and make it safer to dive into the unpredictability of teaching for student learning. These 5 practices were identified by Smith & Stein after reading Japanese mathematics lessons, they are:

1. ***Anticipating*** *• Do the problem yourself • What are students likely to produce? • Which problems will most likely be the most useful in addressing the mathematics?*
2. ***Monitoring*** *• Listen, observe, identify key strategies • Keep track of approaches • Ask questions of students to get them back on track or to think more deeply*
3. ***Selecting*** *• what do you want to highlight? • Purposefully select those that will advance mathematical ideas*
4. ***Sequencing*** *• In what order do you want to present the student work samples? • Do you want the most common? Present misconceptions first? • How will students share their work? Draw on board/use document camera?*
5. ***Connecting*** *• Craft questions to make the mathematics visible. • Compare and contrast 2 or 3 students' work – what are the mathematical relationships? • What do parts of student's work represent in the original problem? The solution? Work done in the past?*

Smith & Stein, NCTM & Corwin Press, 2011 www.nctm.org

Participants Lesson Report Reflection Highlight (see Appendix p.211 for full report)

"It is critical to have a strong rationale for the choice of the math lesson that illuminates the need to use math in an authentic context.

- *What was the point of this lesson? This lesson did not provide a rationale for using statistics - thus students did not learn the value of math for problem-solving.*
    - *There was not a strong purpose for presenting the information on walkers vs riders as the questions was not "when is the best time to meet/greet" but rather "in order to greet as many people as possible, what time should we be standing". As a result, there was not a mathematical purpose for investigating the additional histograms, as the goal was not to consider how to be representative of walkers and riders, but simply to determine a time frame for when the most people will arrive at school.*
    - *Further, the time-based arrival data from one day was not necessarily consistent beyond that day, thus the data may not have even been useful for solving the problem generally - this may have reinforced mathematical misconceptions about the use of data."*

Prepared by Laura Schmidt-Nojima, Lauren Goss and Nora Houseman

Day 6: School visit and Lesson 6: Kiyose Daiyon Junior High School, Tokyo (June 26th, 2017). Type of lesson study: school-based lesson study

Research Theme: At this school, we aim to develop students who can think for themselves and express their ideas effectively.

On arrival at Kiyose Daiyon Junior High School, participants attended a musical concert performed by students playing koto instruments and followed by a show from the drama

students. After the entertainment, participants joined a regular 9th grade lesson. This was not a research lesson, rather a lesson presented by a very experienced Japanese teacher.

Square Roots, Grade 9, Mr. Ginnan (see Appendix p. 226 for full lesson plan)

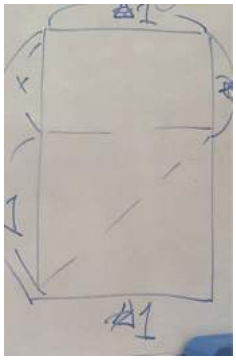
Goals of the lesson: [Interest] Students will be interested in comparing the ratios of the lengths of the short and long sides of the standard paper, and they are trying to apply what they have learned about square roots. [Ways of Thinking] Students can explain what the length of the long side is $\sqrt{2}$ if the short side is considered as 1 by using diagrams. [Skills] Students can determine the ratio of the lengths of the short and the long sides of the rectangle obtained by folding a B5 paper in half is $1:\sqrt{2}$. [Knowledge] Students understand the characteristics of the standard sizes of papers.

Review of lesson plan and content by Dr. Watanabe

> Problem: Students are shown several books and try to sort them based on their shapes. By doing so, students pay attention to ratios of the short and the long side of the books.

A summary of Dr. Watanabe's comments follow.

Students will use B4 paper to discover that if the short side is one, the long side is the square root of 2. He draws the following model to explain 1:(1+x)=x:1:



The underlying concept of the lesson is for students to see that irrational numbers are part of everyday life, and perhaps to be impressed by the wisdom of people who devised these sizes of paper.

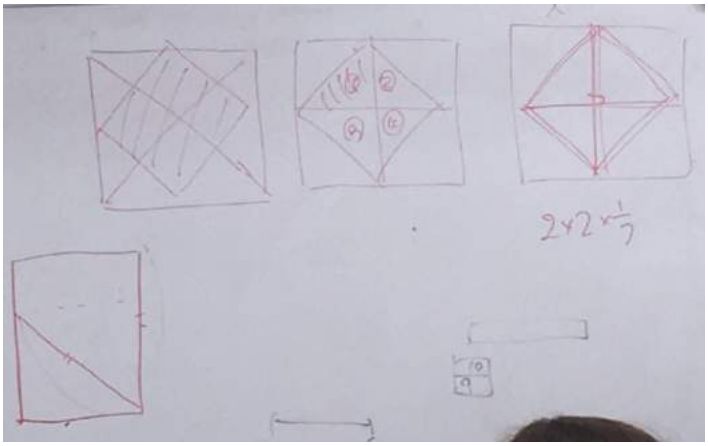
Post lesson reflection with IMPULS (held on Tuesday June 27)

Participants were given the opportunity to share what they thought about the lesson and to reflect on any questions that still remained. Comments and questions from participants included: Waiting at the beginning was too long. I really liked the structure of the lesson, especially the group work part of the lesson. The problem created the need for everyone to come together to solve

the problem. The activity required all members of the group to get the answer. It took 22 minutes to get students to see ratio. Students were trying to figure out what the teacher wanted. I saw the wait time by the teacher around the introduction as a kind of persistence. It was a messy lesson and he changed the flow based on the student learning.

There was some debate among participants as to whether the teacher waited too long (as noted above) and whether the struggle was productive or unproductive. Dr. Takahashi shared his comments. A summary of them follows.

If a teacher changes the plan while teaching, as the teacher did in this lesson, and where the change allowed students 22 minutes to struggle during the introduction, then the teachers needs to have a good rationale for doing this. Group work for this lesson was authentic because it was essential to the mathematics and to solving the problem. The mathematics was modelled on the board.



As shown in the diagram above, if 4 copies of the right isosceles triangle are put together, a square with the area of 2 can be made. Therefore, the length of the side must be √ 2.

Day 7: Research Lesson 7: Sarugaku Elementary School, Tokyo (June 27th, 2017).
Type of lesson study: school-based lesson study

Research Theme: Students can feel, think and extend through mathematical discussion.

Let's Investigate Quadrilaterals, Grade 4, Mr. Kimijima *(see Appendix p. 233 for full lesson plan)*

Goals of the lesson: Students can think about ways to construct parallelograms. Students try to discuss with their friends how they solved the problems based on their prior learning.
Assessment standards: Students think about and explain ways to construct parallelograms using the definition and properties of parallelograms. Student can construct parallelograms.

Review of lesson plan and content by Dr. Watanabe

Problem: Let's think about ways to construct parallelograms

Dr. Watanabe's comments are summarized below.

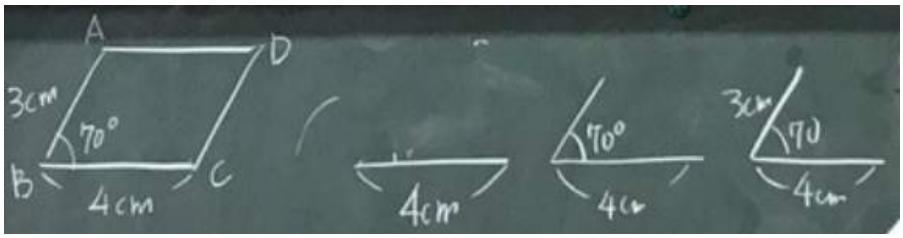
During this lesson the teacher will draw a parallelogram on the board, but it is not a parallelogram and the students will notice this and get excited and motivated to do it correctly. The students will then have the task of constructing a parallelogram. Students will need to think about which properties and tools they will use to construct it. In Grade 3 students studied the use of the compass and in 4th grade they learned how to use a set square to draw parallel and perpendicular lines. Using a set square to find a parallel lines is often not taught in U.S. or U.K. classrooms. Students have already defined the properties and characteristics of both trapezoids and parallelograms. The lesson is lessons 9/10 of a 16 lesson unit plan, and the teacher has adapted the task from the textbook. The students will work in groups of 4. In Japanese, these groups are called *Han* which means 'family' and so everyone has to take care of each other.

Sarugaku Elementary School recently completed their research report. The school focused on how students can feel, think, and extend through mathematical discussions for 3 years. The report included a compilation of their research lesson plans and research findings from the school's work together.

Post lesson reflection with IMPULS (held on June 28th)

Dr. Takahashi made a few comments about this lesson. They are summarized below.

The teacher adapted the lesson from a problem in the textbook. The textbook had more information, including angles and side lengths (see below).



By keeping the measurements in the task, it encourages students to use more tools (protractor, set square, compass, etc.). This then makes for a good student discussion and debate. The textbook is much better than the teacher's design and therefore if you revise the curriculum, you need a strong rationale to do so. Students needed more practice with the compass and it is through lesson study we saw this. It is important to encourage students to use a compass in many activities, not just mathematics, as students need lots of practice with these kinds of tools.

Participants Lesson Report Reflection Highlight (see Appendix p.248 for full report)

> *"In this particular lesson, the teacher engaged the students in critiquing his mistakes when drawing a parallelogram incorrectly. He asked them questions like, "Is that true?" and "How can we be sure?" These are essential questions in order to put the cognitive load on the students and foster a culture of justifying their thinking with mathematical proof as well as fostering mathematicians who are willing to tackle problem without the guidance of their teacher. However he quickly answered his own question by saying "let's take a look at these set squares. If we want to see the two sides are parallel, how should I use them? Show with your hands." The more teachers answer their own questions and tell students what to think and the less we listen to students, the less opportunities they are given to construct their learning and grow as problem solvers. These are all important practices in order to get a real picture of the students' conceptions of the math."*
>
> *Prepared by Karen Wilding, Shelby Halela and Evanne Ushman*

Day 8: Research Lesson 8: Ohta Ward Kojiya Elementary School, Tokyo (June 28th, 2017). Type of lesson study: district-wide lesson study

Research Theme: The instruction and assessment that activate mathematical view and reasoning and deepen learning.

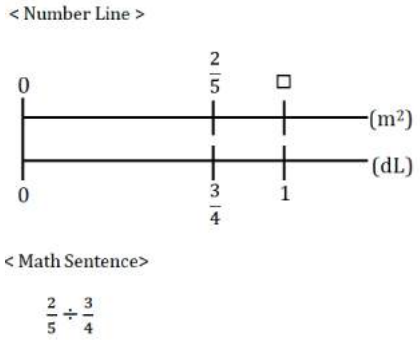
Let's Think about How to Divide by Fractions (Division of Fractions) Grade 6, Mr. Shibata (see Appendix p. 265 for the full lesson plan).

Goals of the lesson: Students explain and discuss the ideas of the calculations of fraction divided by fraction and generalize the ideas to establish the generalizable formula.

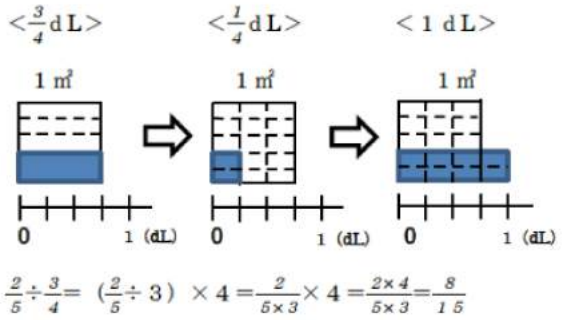
Review of lesson plan and content by Dr. Takahashi

Problem: Let's think about and explain how to do the calculation fraction ÷ fraction.

This is lesson 2 of 6 lessons focused on the division of fractions where students explore how to calculate a fraction by a fraction. Students have previously learned division with whole numbers and the properties of division, and they understand the idea that if you multiply the dividend and divisor, the quotient does not change. For this problem students apply their knowledge of whole number to fractions. Earlier in 6th grade students multiply by a fraction and now they divide by a fraction. Page 6 of the lesson plan (p. 274 in the appendix) provides the previous lesson and shows the double number line. The calculation is 2/5 ÷ 3/4.



The area model with number line underneath solves the story problem, whereas the double number lines models the calculation.



Post lesson reflection with IMPULS (held on June 29th)

Participants were given the opportunity to share what they thought about the lesson from the prior day and to reflect on any questions that still remained. Comments and questions from participants included: Strong self-evaluation by the teacher and he seemed disappointed that he had to adapt his lesson according to how the students responded, although we thought this was a strength. Final commentator pushed the teacher's knowledge by having the teacher's be accountable for his choices. The final commentator made teachers solve the problem without an equation and pushed on their conceptual understanding, and the Japanese teachers found it hard to do. This was a message to the teachers that must be clear about what and why they are teaching a certain problem. The teacher wanted to get the students to do 1 and yet this was not the way the content naturally unfolds for students. Need deep content knowledge to teach this lesson. If you are bound to

the curriculum, the students will not be flexible in their thinking. Need to step back and think about the why so students cannot think more critically about the problem. Learned a lot about the comparing the 3 approaches and how to unpack this for student learning. Process is more important than the product. Teacher had sequenced but he had to focus on commonalities and intermediary steps. In planning you have to think carefully so you can be flexible. This was one of the few lessons where we saw time allowed for students to reflect on the summary. Spreading out a TTP lesson over 2 days may not work as students can change their thinking.

Participants Lesson Report Reflection Highlight (see Appendix p.303 for full report)

> *The importance of understanding, as a teacher, why you are teaching a topic, what understanding it is built on, from previous grades, and how it fits with future learning. This then leads to a greater understanding of the mathematics in the topic and allows you to consider contexts that will be useful and appropriate and numbers that will give rise to the need for the new understanding. Sometimes contexts can be problematic; for the mathematics in this lesson it is difficult to find a convincing 'real life' context; most often calculations with measures will involve decimals rather than fractions. The fractions used in the lesson had to be ones where converting them to decimals to calculate was not obviously easier and so prompted the need to be able to divide a fraction by a fraction.*
>
> *Prepared by Belle Cottingham, Sara Liebert, Camilla Pratt and Ruth Trundley*

Day 9: Program Reflections and Action Steps

The last day of the program was designed to allow participants to address the faculty with any remaining questions. Participants had time to reflect on their learning journey throughout the program, and to create implementation plans and timelines for when they returned to their local context.

Q&A session

Participants individually wrote down their questions. Collectively 38 questions were submitted by participants (see p. 49 of this report to view the questions on lesson study and p. 65 to view the questions on mathematics teaching). The questions were sorted into two main categories 'teaching mathematics and pedagogy' and 'lesson study and Japanese education', and sorted again into sub-categories as follows:

- Teaching Mathematics and Pedagogy (26 questions)
- Lesson study and Japanese education (12 questions)
- Teacher professional development and teacher training(3)
- Research lessons (3) and reluctant teachers (1)
- Knowledgeable others (2)
- Steering Committee (3)

Dr. Takahashi clustered the questions and a summary of his responses follow.

Teaching Mathematics and Pedagogy

Japanese Curriculum and textbooks

The Japanese curriculum is designed to build conceptual understanding and fluency. The flow is Try, Discuss, Summarize. There are 6 different textbooks companies in the elementary and lower secondary. These books are approved by the Education Ministry. Districts adopt the textbooks and the government subsidizes the cost. Each student gets one to keep. The cost per textbook is around $7 per book, so $15 for both volumes. If a student loses the book, they have to purchase again themselves. The book is theirs to keep at the end of the year. Additional books are sometimes needed such as a workbook and parents purchase these. Teachers have access to 4 supporting books per grade level and these are: 1. Teacher's edition, 2. Research volume (includes findings from lesson study), 3. Practice problems, and 4. Assessments. These costs for one grade around $200, and there is usually one per school.

The textbook is very thin and two volumes cover one year (one volume is shown below). They are designed to cover around 120/130 math periods, with an optional 60 math period to use as needed.

The textbooks build on prior knowledge, what you learned the lesson before therefore you start from page 1 and go to the end, you do not skip the sequential order. When teaching, teachers rarely ask the students to open the textbook, although they do use the problems from the textbook. The teacher presents the problem and lets students work on it by themselves. The textbook is for everyone and each student has one. Students are not encouraged to go faster, rather they are encouraged to go deeper. In the U.S. and U.K. the textbook is like a buffet - if

you try to do everything you will get sick. The Japanese textbook is minimal, if you are hungry then you can add to it.

Instructional Strategies

In 1st and 2nd grade students use manipulatives and parents purchase a manipulative kit for their child and they use it for 2 years. In later grades parents will also equip their students with set squares, compass, etc.

Computers and software are not that popular in Japanese classrooms. The High School entrance test does not allow students to use calculators.

The notebook is very important in Japan, if a students has to explain their thinking they need to have recorded it. The teacher will collect notebooks every day and make a comment.

Teachers do give homework, but often students' homework is to review for understanding what was learned in class that day. Parents are not encouraged to help students, rather they should encourage the students to try. Juku is designed for students to be ready for the private schools, and lower secondary schools. Juku is very popular in the City and can start as early as grade 3 or 4. Typically in Juku they teach the facts and this can make it harder for these students to work with TTP concepts.

Group work

Tokyo prefecture encourages students to turn and talk a lot, but teachers are not sure if it helps. Currently there is a lot of lesson study taking place to try to figure out how and when turn and talks work. The purpose of group work is very important and there should be a good rationale for using it with an activity, as we saw in the 9th grade lesson on square roots.

There are lots of opportunities for students to talk and share throughout the day in Japanese schools. For example, students lead many discussions in the class every day and each student has this responsibility to start the class two or three times a month. At the end of the day there is also time allowed for students to talk to each other about how they felt about the day, and whether they feel happy or not? Lunch time is also a social time. Catherine Lewis' book 'Educating Hearts and Minds' provides many examples of how students interact with one

another during the school day. In mathematics, however, it is important that the learning and discussion is for the whole class, this way students do not get left behind.

Differentiation and inclusion

Typically, differentiation is not used as a variety of student thinking is needed to support a good discussion and to allow students to value everyone's ideas (although, the Tokyo prefecture is currently exploring the use of differentiation). Over the course of a good discussion it is important that everyone comes to the same goal. There is a huge gap in understanding when students come to elementary schools and therefore they are brought up together. In Japan 1st grade teachers do not presume students have any prior knowledge, although many students already know numbers. American public schools are more homogenous, wealthy versus poor, but in Japan there is a mix of all kinds of students at a school.

Lesson study and Japanese education

Professional development and teacher training

We assume that most of the students who want to be a teacher have the level 1 knowledge and they have to take a mathematics test to prove this, so there is basic math knowledge. Teachers attend a University program designed to give them the knowledge needed for teaching. Student teachers have to learn how to do Kyouzai Kenkyuu (study of research and instructional materials), and they have to do it for every single lesson. In the University elementary teachers take two methods courses, each course is 15 weeks per semester of 1.5 hours twice a week. They have two sets of teaching practices, the first in an attached school and is for three weeks each year, and the second one is at public school when they are in their 3rd and 4th year.

Research lessons & reluctant teachers

Teachers typically attend six or seven lesson research lessons a year. The plan is that every teacher in the school will teach a research lesson every 3 years year and will be part of a planning team at least once a year. The more experienced teachers are expected to teach more research lessons. There are a few teachers that do not want to join lesson study and they tend to stay very quiet and when it is there turn to teach, they often move schools.

Who to observe during a research lesson? Dr. Takahashi knows within the first 3 to 4 minutes which students he wants to watch closely. These are key students that can inform him about the

impact of the lesson. The more research lessons you attend, the sooner you will develop the eye to make these decisions. Sometimes planning teams assign observers to particular students or student groups, for example struggling students or quiet students to see how the lesson supports their learning. Following one or two students is best practice, rather than jumping from one student to the next, this way you can see the complete learning journey from the student perspective.

Research Steering Committee

The steering committee summarizes the findings of lesson study after a research lesson and gives it to the next team so they can use it. This includes the summary of the final comments and findings around content and the research theme. The steering committee will push teachers to write up what they discovered.

Knowledgeable others

It is important that knowledgeable others don't tell teachers how to teach, but rather let teachers come up with their own practice and then give them feedback through the lesson study process. This way teachers have the ownership going forward.

Individual learning journeys and next steps

Participants were given time to write reflections on the key learning from the program. They were then grouped into either site-based groups (where teachers/administrators from the same site were present), or grade band groups (for example, middle school teachers), or other professional groups (university-based or professional development providers). A group formed for teachers who were starting at new schools or developing lesson study for the first time at their school. Each group discussed ideas, created implementation plans and timelines, and publicly shared their key ideas. In summary, the following ideas and plans were shared.

Site based groups shared how they planned to access and use K-5 grade translated Japan curriculum materials and teacher's guides. Some sites also wanted to revisit their school's research theme with their colleagues and make it more concrete and exciting. 4 schools planned to go from a few groups doing lesson study to school-wide lesson study. All groups discussed building content knowledge and two groups mentioned the importance of thinking about mathematics tools and models (eg., set square or number lines) across the grades. Two schools were planning all staff trainings the week before school started where they would share

with their colleagues the importance of lesson study and problem solving and set up schedules for others to do it. Another schools wanted to share lesson study with the PTA and parents through an informational evening. Two schools said the first thing they needed to do was to create a Steering Committee to organize the work and share/publish their findings.

Grade-band group shared wanted to use their district summer institute to plan research lesson with their colleagues. They also wanted to expand lesson study to the ELA department. One participant also felt it was important to revisit their research and get more focused about the data they collect during research lessons.

Other professional groups shared the desire to bring this work into their regional math teams. They also wanted to think about how to inform Principals about the work. Two participants wanted to focus on undergraduate training of teachers and find a way to help them to do more collaborative planning and set up lesson study cycles. Another wanted to create school-wide lesson study.

Changing schools or starting lesson study group shared they planned to start small and organically as their primary focus would be learning about their new schools. Another felt the first priority was finding knowledgeable others to support the lesson study work.

The session and program closed with much enthusiasm for next steps. IMPULS hosted a farewell dinner for participants.

4. Participants Use of Lesson Study and Learning Outcomes: Survey Responses

In this section, the organizational contexts in which participants experienced lesson study prior to the program is summarized, along with the strengths and challenges they attached to using lesson study in that context. Participants' expectations of what they hoped to learn by attending the program are compared with what they reported they learned by the end of the program. Finally, the program elements are examined in relation to participants views of what would be professionally useful to them going forward.

Participants local organizational context for using lesson study

In addition to the overview of participants' experience with lesson study prior to attending the program in section 2, how lesson study is being used in participants local organizational contexts is described.

U.S. participants

In total, 10 U.S. school sites and 1 district administrator were represented at the IMPULS program. Participants from 2 of the 10 U.S. school sites attending the program were already doing school wide lesson study; 1 site had been doing it for 7 years and the other site had just completed their first year. Participants from 3 of the 10 U.S. school sites attending the program intended to move from a few voluntary groups of lesson study to school wide lesson study during the school year following the program. The remaining 5 of the 10 U.S. schools sites had a few voluntary groups of lesson study at their school site. One U.S. participant provided a district level perspective, supporting 6 of the 10 U.S. school sites in their lesson study work.

U.K. participants

In total 6 U.K. organizations were represented at the IMPULS program. This consisted of 1 school site where voluntary groups of lesson study had been taking place. 2 of the 6 U.K. organizations were represented by universities where faculty attending this program had been part of lesson study or had recently been introduced to lesson study, both universities had interest in understanding lesson study's use in mathematics learning and pre-service education. 2 of the 6 organizations were education consulting agencies providing teacher professional development: 1 agency was new to lesson study and the other had several years of experience developing regional lesson study groups. 1 of the 6 U.K. organizations focused on writing curriculum. They were new to lesson study and held a specific interest in using problem solving to teach mathematics.

Benefits and challenges of participants' use of lesson study within local organizational contexts

Participants were asked to describe the benefits and challenges of using lesson study within their organizational context in a pre-program survey. (For detailed responses see p. 346-351 of the appendix.) Of the many benefits reported, the affordances of the collaborative aspect of lesson study came up most often. Many of the participants wrote that lesson study allowed for vertical alignment of content and/or teaching practices. More specifically, the U.S. participants mentioned the importance of using lesson study to establish teaching through problem solving

problem solving at their school. Participants also noted the teacher-led affordances of lesson study as very important as this provided agency and leadership opportunities to teachers. A few participants mentioned the improvements in student achievement and deeper understanding of how to implement the U.S. mathematical practices for students (for example, construct viable arguments and the reasoning of others) as a benefit of lesson study.

Participants reported challenges to using lesson study

Of the challenges to using lesson study in their organizational context, participants reported that finding the time to do lesson study was the most challenging. Other challenges raised included; not having access to good curriculum, funding to support lesson study work and ensuring effective facilitation of lesson study groups. Mentioned less often, but still a trend in the responses, was getting buy-in from colleagues to do lesson study, figuring out how lesson study impacts daily practice, and creating a culture in which teachers feel comfortable opening up their classrooms for observation.

Learning expectations versus learning outcomes of the program

Participants were asked to rank how much they expected to learn about each item from a given list of program elements (see elements in table below a through u) both before the program started and then again after the program. They used a 5 point scale (“not at all”, “a little”, “some”, “quite a bit”, and “a lot”) to rank their responses. To compare the participants’ learning expectations to learning outcomes, each of the five response options were given a weight (with “not at all” = 0, “a bit” = 1, “some” = 2, “quite a bit” = 3, and “a lot” = 4). The average and standard deviation of participant responses for each program element is reported in the table below.

Program learning opportunities (elements)	Pre-survey		Post-survey	
	average	standard deviation	average	standard deviation
(a) Important features of lesson study	3.63	0.56	3.52	0.70
(b) How lesson study is conducted in different educational contexts (e.g., schools, districts, etc.)	3.19	0.79	3.52	0.64
(c) Supporting participants to have powerful and effective lesson study experiences	3.33	0.73	3.07	0.87
(d) Writing a good lesson plan	2.89	1.09	2.70	0.95

(e) Evaluating the quality of a lesson plan	3.11	0.89	2.63	0.88
(f) How to observe research lessons	3.44	0.70	3.19	0.62
(g) Organizing a successful post-lesson discussion	3.26	0.86	3.04	0.81
(h) The role of the knowledgeable other	3.04	0.90	3.41	0.80
(i) How to support student problem-solving	3.44	0.70	2.89	0.89
(j) How to build students' mathematical habits of mind and practices	3.44	0.85	2.70	0.82
(k) How to organize the board	3.33	1.04	2.93	0.62
(l) Teacher questioning techniques	3.44	0.75	2.33	0.68
(m) How to summarize a lesson	3.48	0.64	2.04	0.94
(n) Anticipating student responses	3.33	0.68	2.56	0.97
(o) How teachers support whole class discussion (neriage)	3.48	0.70	2.48	0.75
(p) Strategies for making students' thinking visible	3.37	0.63	2.70	0.72
(q) Student note-taking	3.19	0.79	2.37	0.88
(r) Knowledge about the Japanese educational system in general	2.89	0.85	3.07	0.87
(s) Mathematics content	2.74	0.86	3.00	0.85
(t) Knowledge about Japanese curriculum materials	2.85	0.99	2.59	0.93
(u) How to develop a mathematics unit/curriculum	2.59	1.01	2.07	0.92

In general, the averages were quite high (the range being from 2.59 to 3.63 in the pre-program survey and 2.04 to 3.52 in the post-program survey) and the standard deviations were quite small (the range being from 0.56 to 1.09 in the pre-program survey and 0.62 to 0.97 in the post-program survey). This reflects that participants often marked that they expected to and did learn “quite a bit” or “a lot” about many of the program elements. However, all elements except five had higher averages for learning expectations than learning outcomes, suggesting that participants generally expected to learn more about the program elements than they did. The participants’ high expectations for learning going into the program may have been due to general enthusiasm without much specific knowledge of what the program entailed, so not meeting the expectations is not necessarily a reflection of the program, but rather the participants’ limited awareness of the programs’ areas of focus.

The five elements that had higher averages for learning outcomes than for learning expectations are listed below:

(b) How lesson study is conducted in different educational contexts (e.g., schools, districts, etc.)
(h) The role of the knowledgeable other
(r) Knowledge about the Japanese educational system in general
(s) Mathematics content

If, as a whole, participants did not expect to learn as much as they did about these elements, it is reasonable to assume that they did not realize the importance that these elements play in Japanese lesson study before attending the trip, and likely would not have realized the importance if they were not given opportunity to attend an immersion program. Perhaps some of these elements reflect missing pieces to lesson study work in the U. S. and U.K. -- participants often wrote about the challenge of not having enough time or opportunity within their organizations for lesson study. These are affordances that Japan's institutionalization of lesson study allow for, reflected in items (b) and (r). Another area participants brought up as a challenge for using lesson study was access to a good curriculum. Lack of good curriculum, along with unfavorable personal experiences in learning mathematics that many participants reported, might explain why participants learned more mathematics content that expected.

To get an overall sense of what participants most expected to learn about and what they reported to have learned from the program, the top three averaged learning expectations and learning outcomes were subsetted, as shown in the table below.

Top 3 Learning Expectations	Average	Top 3 Learning Outcomes	Average
(a) Important features of lesson study	3.63	(a) Important features of lesson study	3.52
(m) How to summarize a lesson	3.48	(b) How lesson study is conducted in different educational contexts (e.g. schools, districts, etc.)	3.52
(o) How teachers support whole class discussion (neriage)	3.48	(h) The role of the knowledgeable other	3.41

The table reveals that the top learning expectation -- item (a) -- was also the top learning outcome. Given how general item (a) is, this is not surprising. The other top expectations were both focused on pedagogy, while the other top outcomes deviated from this pattern.

Interestingly, items (b) and (h) were also within the group of items with higher averaged learning outcomes than learning expectations. So, not only did participants in general learn more about how lesson study is conducted in different educational contexts and the role of the knowledgeable other than they expected, but participants learned the most about these items, along with item (a), out of all the items.

Participants were also given the choice to add their own learning expectations and outcomes in both the pre-program survey and post-program survey. 13 of the 27 participants listed additional learning experiences they hoped to have before attending the program. Of the responses, several categories emerged. One category of responses centered around participants wanting opportunities to see how lesson study or instruction played out in their particular grade level or teaching context (e.g. how is lesson study used in a lower grade classroom?). Another type of response focused on learning more specifics of how Japanese educators conduct lesson study. As an example of this response type, one participant wrote, *"...in the planning, I am curious the types of evaluation questions we will see and how/why the teams decided on those specific evaluation points"* (LSIP YT17c). The last category that emerged centered around participants wanting to learn more about the Japanese curriculum, for example, *"what learning progressions [the Japanese] use to inform their curriculum"* (LSIP YT1d).

10 of the 27 participants added at least one additional learning outcome. Many of the additional learning outcomes were related to the influence of Japanese culture in school settings. For example, one participant wrote, *"[One additional thing I learned about was] the independence Japanese children are entrusted with and how they are expected to contribute to the running and care of their school"* (LSIP BA24a). Other participants emphasized their learning about the importance of collaboration with colleagues around content knowledge and/or pedagogy. Relatively fewer responses were focused on the status and training of teachers in Japan and math instruction in Japanese classrooms.

Changes in participants views of the professional usefulness of the program elements

To uncover how learning from the program may have altered participants' views of the usefulness of lesson study in their professional capacities going forward, participants ranked the top five items from the list of program elements that would be most professionally useful to them both before and after the program. A weighted count was used to compare participants' views of

professionally useful elements before and after the program. For each element, the number of participants who marked it as the most professionally useful was multiplied by 5, the number of participants who marked it as the second most professionally useful was multiplied by 4, and so on until the number of participants who marked it as the fifth most professionally useful element was multiplied by 1. For each learning opportunity, these weighted counts were summed to represent a "score". Scores among elements were compared to look at the overall rank of elements in regards to how useful participants anticipated them to be in the next year. The highest possible score any element could have is 105. The top 5 overall ranked items from before and after the program and their scores are reported in the table below.

Pre-program: Overall top 5 ranked professionally useful learning opportunities	Score	Post-program: Overall top 5 ranked professionally useful learning opportunities	Score
(i) How to support student problem-solving	61	(i) How to support student problem-solving	51
(o) How teachers support whole class discussion (neriage) ^	58	(n) Anticipating student responses *	42
(j) How to build students' mathematical habits of mind and practices	42	(a) Important features of lesson Study *	32
(c) Supporting participants to have powerful and effective lesson study experiences ^	37	(s) Mathematics content *	31
(l) Teacher questioning techniques ^	32	(j) How to build students' mathematical habits of mind and practices	30

The items (o), (c) and (l) marked with ^ are elements not ranked in the top 5 after the program. And, the items (n), (a) and (s) marked with * are elements not ranked in the top 5 before the program.

Two of the top 5 overall ranked items from before the program, (i) How to support student problem solving and (j) How to build students' mathematical habits of mind and practices, remained in the top 5 overall ranks after the program. These results suggest that the learning opportunities in the program affirmed participants' beliefs that these elements were worthy of focus in their lesson study work during the following year.

Both of the items that remained within the top 5 overall ranks are focused on the qualities teachers want their students to have as math learners. Looking at the items that changed, one pattern is a shift from the focus being on teacher instructional techniques, items (o) and (l), to the focus being more on the mathematical content and viewing content through student eyes, items (s) and (n). These changes could be interpreted as the ways participants planned to achieve the qualities they wanted to have in their students. So, the goals of fostering student problem solving and mathematical practices remained the same, but participants' views of how to achieve these goals may have changed as they learned more about lesson study in the program.

5. Participants Understanding of Lesson Study

Participants' views on essential features of lesson study prior to the program

Participants were asked on the survey administered before the program what they viewed as the essential features of lesson study. Many participants noted collaboration as an essential feature of lesson study, especially in the studying and planning phase.

> *"I think the very thoughtful and careful design of a lesson with peers is one of the most valuable aspects of lesson study. Mapping out every piece of the lesson from the standards to expected student responses leads to important learning for every teacher involved."* (LSIP YT9c)

Another theme that came up with participants was the 'research' aspect of lesson study and the opportunity lesson study provided to 'test' out a lesson plan with students. Some participants noted that this lesson plan was intended to address a specific academic, socio-emotional, or curricular need at their schools. Other participants saw lesson study as a way to test out instructional strategies and as a way to create a shared instructional vision with colleagues:

> *"I see lesson study as an inquiry cycle around one lesson, where the lesson is a rich task that tests an aspect of teaching. Lesson study is a way to develop a shared vision within a math department."* (LSIP YT8c)

Additional essential features of lesson study included viewing content through the eyes of students and reflecting after the lesson. Features such as the continuous improvement aspect of lesson study, making time for lesson study and observing others' instruction were mentioned, but less frequently.

Daily reflections about Lesson Study

At the end of each day participants were asked to reflect on any new 'aha's' they had about lesson study based on the day's program (refer to program activities by day). Their reflection responses are summarized and recorded in the tables below. Several clusters of similar responses appeared. The total number of participants for each type of reflection are provided in the far right column of the table, along with a break-down of participants number of years of experience with lesson study. These results reveal that there may be kinds of learning reflections associated with different levels of lesson study experience.

Day 1 (see program activities for this day)

Participant Learning Reflections about Lesson Study	Participant lesson study experience (by years)				Total # of participants
	0	<1	1-3	3+	
District wide lesson study is needed to improve our practice.		1	5	1	7
School wide lesson study seems more effective, greater impact for school & alignment across grade levels.	1		3	2	6
The Steering Committee plays important role from logistics to sharing the findings from research lessons.			4	1	5
There are three kinds of lesson study (school, district, university).		2	1		3
Important to summarize learning at the end of a cycle.		1		1	2
Lesson study in Japan brings together all levels of educators and University faculty.				2	2
Lesson study is part of a large and consistent system in Japan.		1	1		2
I did not realize how much work was involved in planning and conducting a lesson study cycle.	1				1
I want parents involved in our lesson study process.			1		1
Our lesson study should include cross grade level teams.				1	1
Lesson study can be used to implement curriculum change				1	1
We need to publish learnings from lesson study eg. newsletter, research reports, websites, etc.			1		1

Day 2 (see program activities for this day)

Participant Learning Reflections about Lesson Study	Participant lesson study experience (by years)				Total # of participants
	0	<1	1-3	3+	
Whole-school lesson study should include all teachers including support staff.		2	1	1	4
The students did not mind so many observers watching them.	1	1			2
Seeing how lesson study allows teachers to learn and develop and critique each other so honestly.	1		1		2
Good to have teacher speak again at the end of post lesson discussion.		1			1
Early release day for lesson study - students dismissed except lesson study class		1			1
Do mathematics with teaches as part of final commentary to highlight a point.				1	1
Attention to detail that goes into lesson study and the importance of the lesson plan. Detailed and every element discussed and analyzed including anticipated student responses.		1			1
The final commentator prepares before the lesson, just like the planning team do.				1	1
Post lesson discussion are much longer than ours.		1			1

Day 3 (see program activities for this day)

Participant Learning Reflections about Lesson Study	Participant lesson study experience (by years)				Total # of participants
	0	<1	1-3	3+	
Teachers speak very honestly to each other saying what went well and what did not. Critique is welcomed.		1		3	4
Having focused clarifying questions for the post lesson discussion (rather than having team members share what they noticed) helped me gain a clear understanding about the research.		2		1	3
Very detailed articulate lesson plan.		2		1	3
I'm finding it hard to stage engaged during post-lesson discussion. Is there a way to make it more engaging?			2		2
Lessons are never perfect, they need a continued process of improvement.		1		1	2
I used lesson note and it helped better track the lesson.		2			2

School-wide lesson study benefits all staff at the school.	1			1	2
You can teach a public lesson in a gym or auditorium without any trouble and students can be just as focused as in the classroom.			1		1
The knowledgeable other stays quiet until the end.				1	1
Important to connect lesson study cycles to each other to build on learning.			1		1

Day 4 (see program activities for this day)

Participant Learning Reflections about Lesson Study	Participant lesson study experience (by years)				Total # of participants
	0	<1	1-3	3+	
It is good that discussions can be had in a professional environment and that the lesson study community feel comfortable with sharing honest reflections.	2	3	3	2	10
We must always make our lessons student focused, even if it moves away from our lesson plan.		2	4		6
Guiding questions related to the research theme to facilitate the post lesson discussion.		2	1	2	5
Having an organizer for observation and assigned observation roles.	1			1	2
We need to have a clear purpose for our lesson study work and we need to hold each other accountable to our goals in lesson study.			1		1
It is okay to plan and try new methods during lesson study.		1			1
Having State support present at a research lesson is how it should be – there is so much buy in.			1		1

Day 5 (see program activities for this day)

Participant Learning Reflections about Lesson Study	Participant lesson study experience (by years)				Total # of participants
	0	<1	1-3	3+	
There is much less interaction with the teacher (or planning team) and the final commentators during the district-wide post lesson discussion. Felt not as rich conversation.	1	3	3	2	9
Each post-lesson discussion seems to have a different structure to it and different ways to provide reflection. Is there any research on this?	2			1	3
District-wide lesson study, very interesting. How do teachers discuss this back at their school.			1		1

Final commentators can add significantly to the learning of others at the lesson study.				1	1
I think it is beneficial how the lesson plans and discussions often link the learning to how its relevant later on in education (today's 3rd grade lesson was linked to grade 9 National Assessment on algebraic expressions).		1			1
We need to develop an eye for observation, especially seeing students and seeing the impact of the lesson on their learning.		1			1
Lesson study is definitely needed when developing new curriculum or making changes to existing curriculum.		1			1
Impressive how many teachers turned up for the cross-district lesson study, especially on a Saturday.				1	1
Watch the students during lesson observation, not just the teacher.			1		1

Day 6 (see program activities for this day)

Participant Learning Reflections about Lesson Study	Participant lesson study experience (by years)				Total # of participants
	0	<1	1-3	3+	
When you prepare for one lesson you study ten but when teaching you give up nine and teach one.	1	1	1	2	5
Live lessons allow real discussion to happen, not the same as watching video.			4		4
Seeing students faces and work is the truest way to assess the impact and benefit of the lesson.		1	1	1	3
Lesson study is about learning to observe student learning	1	1		1	3
Lesson is a way to see things through the eyes of children.			1	2	3
Looking at student work is important.			2		2
Once the lesson starts, we should forget the lesson plan and listen to the students very carefully.	1		1		2
Using lesson study to implement curriculum changes.		2			2
It is important open up your teaching to others to let us all grow as teachers.		1	1		2
Engaging in lesson study makes teachers more thoughtful and considered in their everyday practice.		1			1
For deeper conversation in the post lesson discussion examine where was the breaking point in the lesson? Where in the lesson did the students become disengaged. What was the climax of the lesson?				1	1

Student need to be prepared for crowds of onlookers.			1		1

Day 7 (see program activities for this day)

Participant Learning Reflections about Lesson Study	Participant lesson study experience (by years)				Total # of participants
	0	<1	1-3	3+	
As observers we should be 'like air', we cannot help or probe (from Prof. Fujii)	2		2	3	7
Observers can use post it notes to share their thinking. One color for what they liked and another color for questions, comments or critiques.			3	1	4
Final commentators are always well informed and have a high level of subject knowledge.		2			2
Plan the observation ahead of time and assign roles and create data collection tools, this makes for a good post lesson discussion.			1	1	2
School's research report was impressive and so informative		1	1		2
Principals are instructional leaders involved in student learning.				1	1
Lesson study can be done across disciplines with a common school theme (not just math).			1		1

Day 8 (see program activities for this day)

Participant Learning Reflections about Lesson Study	Participant lesson study experience (by years)				Total # of participants
	0	<1	1-3	3+	
District wide lesson study is impactful.	2	1	2	1	6
The final commentator gave a direct challenge the teacher to justify his approach.		1	2	2	5
Having small breakouts discussion groups during the post lesson discussion was engaging.		1	2	1	4
In lesson study even when the lesson is great, there is still room for improvement.		1	1	1	3
Every school is very clear about its research theme and goals relating to it.	1		1		2
Do the math of the task before you attend a research lesson	1				1

Summary of learnings reported on the daily reflections about lesson study

The daily reflections by participants provided details of the kinds of learnings that took place for participants each day. They can be looked at in relation to each day's activity (see overview of program activities by day). Or, they can be looked at collectively. The first noticing is that collectively the program activated a wide variety of learning reflections about lesson study: a total of 51 different learning reflections. These reflections focused on several key areas including the disposition needed for lesson study, the organization/logistics involved in school wide or district wide lesson study, the role of observation, the role of the final commentator, the structure of post lesson discussions, the importance of the research theme, and dissemination of the lesson study findings.

Remaining questions on final day about lesson study

On the last of the program, a session was dedicated to answering any remaining questions from participants. The following questions arose in the category of lesson study and Japanese education: (see p. 30 of this report for the responses to these questions)

1. What training is required to become an elementary school teacher in Japan? (A specific level of mathematics/university degree etc.?)
2. Can we speak more specifically about math teacher training in Japan? What sorts of certification course work is involved in teacher preparation?
3. What is the role of novice teachers in the lesson study process?
4. What qualifications do teachers, final commentators and curriculum writers have to have in order to attain their positions in education?
5. Do Japanese teachers study lesson study in teacher prep courses? What math courses are the required to take for becoming a teacher? Are they using textbook to prepare for teaching math?
6. How does the Japanese education system make sure teachers at the elementary level have good subject knowledge in mathematics?
7. What systems are in place to support teacher acquisition of content knowledge?
8. What is the number one or two factor(s) that get Japanese teachers to know content up and down the grades?
9. What supports/trainings besides lesson study are provided in Japan for teachers to deepen their content knowledge?
10. What trainings/ongoing supports do teachers receive to deepen their mathematical content knowledge across grade levels?
11. Through TTP or otherwise, how often are Japanese teachers receive lesson observations and feedback from a coach/principal etc.?

These questions reflected a remaining curiosity from the participants about how Japanese pre-service and in-service teachers acquire their content knowledge for teaching.

Changes in views about lesson study

On two instances after the program participants were asked to reflect on the biggest change to their views about lesson study. The first point of reflection was on the final evening of the program in their daily reflections. Participants were asked - How did your views of lesson study change from your participation in the IMPULS program? The second point of reflection was given two weeks after the program, in the post program survey. Participants were asked - How did your views about the essential features of lesson study change as a result of this trip?

Responses to this question on the last day of the program, revealed that the biggest changes in understanding were around lesson study was part of a coherent educational system for the improvement of student learning, one participant reflects; *I am blown away by the structured systems in Japan through which lesson study is used as a vehicle for school growth, district learning, and curriculum development. (LSIP YA21c).* The second most remarked about change was focused around how the school and theme research theme guide the work and collective responsibility of teachers to guide students learning*; "I have learnt that research themes are carefully chosen based on areas of perceived weakness or difficulty - it isn't about a "show lesson" (LSIP BU27b)*, and *"This approach is about team and school-wide responsibility and understanding that real change takes time and sustained focus". (LSIP BA24))* Additionally, several participants mentioned that they had learned a lot about content and needed to make this a primary focus in their lesson study work, *"We need to have a growth mindset with regard to content knowledge. It is a gradual process." (LSIP YT18b).*

Responses to the survey questions two weeks after the program revealed a slightly different pattern of responses. Over half the respondents (total 27) commented on the importance of the post lesson discussion: *"After participating in this program I now see that we need to make our post lesson discussions more reflective as opposed to just observational."* (LSIP YT1c) , *"I have a greater appreciation for the post-lesson discussion and the participation of the whole school in the observation and post-lesson discussion."* (LSIP YT18b), and *"I now see the importance of discussion protocols in the post lesson discussion that allow everyone to focus on just a couple key questions."* (LSIP YT2c)

Another feature of lesson study highlighted by participants, not mentioned before and also not appearing in the program elements (outlined on p. 37 of this report), was a dispositional shift towards a more critical lens during lesson study: *"The more "buy in," the better, and you can never really have too many critical eyes observing a lesson",* (LSIP YT5c), *"Prior to the trip I didn't understand what lesson study involved...the criticism, the feedback and all the views were given in such a constructive, respectful way -*

something that I had never seen before." (LSIP Y9c), and *"Teachers who teach the research lesson are in the spotlight for better or worse, but even if there's considerable flaws in a lesson the criticism in a post-lesson discussion is all in service of everyone's learning."* (LSIP YT8c)

The change between the final day's reflections and reflections two weeks after the program may be due to the program activities on the last two days where participants attended both a cross-district and district-wide lesson study that exhibited all the important structures and support of lesson study coming together.

Participant's before the program views on the essential features of lesson study can be found on p. 42 of this report. To summarize; participants highlighted the essential features of lesson study as collaboration, research or the opportunity to test out a lesson plan or instructional approaches, viewing content through the eyes or students, and reflecting after the lesson. When asked the same questions again two weeks after the program participants mentioned the importance of the post-lesson discussion, the need for a critical lens, both detailed above. In addition participants commented on the importance of school-wide lesson study and the need to publish and disseminate findings from the research lessons.

How administration can support lesson study implementation

As part of each lesson report prepared by groups of participants during the program, a reflection question in the report focused on how administrators can support lesson study. Broad categories emerged in response to this question, and they are summarized below:

(1) Scheduling opportunities for all teachers to be involved
(2) Showing that they value lesson study as a PD model by participating in the process (as part of the planning team, if possible)
(3) Facilitating discussions before and after research lessons to leverage the learning as a school towards their research theme
(4) Ensuring access to high quality resources is available to support lesson study team's inquiry into the school's research theme,
(5) Connecting teams to knowledgeable others
(6) Creating a school culture that values reflective practices and discourages judgement.

One group comprised of an administrator, math coach and teacher leader reflected on how they planned to support lesson study implementation. They shared:

Supporting with coordinating and implementing a Research Steering Committee:

- Organizing a process to nominate/elect teachers to committee from each lesson study team
- Coordinating meeting schedules/timelines for all teams - including meeting times and research lesson dates for each lesson study team
- Facilitating or coordinating process of choosing and writing a research theme for school
- Facilitating or coordinating process of reflecting on learnings from lesson study and writing research report

Supporting with identifying relevant input in relation to the research theme (books, articles, videos, collaborators, etc.):

- Importance of bringing in new knowledge & new strategies to the LS process (to build knowledge base and tool-kit of participating educators)
- Importance of building from research-based practices

Supporting with identifying and inviting knowledgeable others/expert commentators (from local universities, from district departments, from other school sites, from external/grant partners):

- Importance of an outsider perspective
- Importance of bringing in new knowledge/perspective to the LS process

Supporting teacher to be reflective and open to feedback in the post-lesson discussion (as opposed to summarizing the lesson or defending his/her own teacher moves):

- Importance of building a culture of self-reflection and vulnerability
- Supporting all teachers to build comfort giving critical feedback
- Importance of building an adult culture of peer-to-peer critique and open classroom practice

LSIP YA21c, YT20b, and YT18b

6. Participants Views of Teaching and Learning Mathematics

Daily reflections about mathematics teaching

At the end of each day participants were asked to reflect on any new 'aha's' they had about mathematics teaching based on the day's program (refer to overview of program activities for day to day details). Their reflection responses are summarized and recorded in the tables below. Several clusters of similar responses appeared. The total number of participants for each type of reflection are provided in the far right column of the table, along with a break-down of participants number of years of experience with lesson study. These results reveal that there may be kinds of learning reflections associated with different levels of lesson study experience.

Day 1 (see program activities for this day)

Participant Learning Reflections about Mathematics Teaching	Participant lesson study experience (by years)				Total # of participants
	0	<1	1-3	3 +	
Learning about the progression of geometry – starting with 3D shapes makes sense.		3	2	1	6
Teachers must always do the problem before giving to students.	1		1	1	3
Folding paper any way twice makes a right angle and defining parallel lines through the definition of perpendicular.	1	1			2
Teaching with the textbook versus teaching from the textbook.	1		1		2
Quality curriculum is important.			1		1
Importance of knowing - What is the new math learning from students' today				1	1
Saying that multiplication is the opposite of division so division works may be insufficient if we really want an understanding of division to deepen and stick.			1		1
Japanese teachers place emphasis on deep content knowledge.			1		1
Showing the structure of mathematics on double number line (division of fraction by fraction)		1			1
Problems should be set in real life contexts		1			1

Day 2 *(see program activities for this day)*

Participant Learning Reflections about Mathematics Teaching	Participant lesson study experience (by years)				Total # of participants
	0	<1	1-3	3+	
The focus on a mathematical questions surfaced from the students, (for example, why do we use division, is division the correction operation to use?) allows the students work on developing proofs.	1	6	6	1	14
Color coded board work (visual, diagrammatic, symbols) has the capacity to reveal so many connections for students. I need to be more thoughtful about how I lay my board out.		3	4	3	10
The way the context was introduced in order give to the children a real purpose to engage in mathematics, going from concrete (the ribbon) to writing a formula.	2		1	1	4

Double number lines support the conception of multiplication in terms of proportional relationships and ratios.		1	2		3
Students were looking back in their notebook to relate their thinking to previous learning.		2			2
Why don't we teach proportional reasoning in elementary school?			1	1	2
When teaching division, it's important to take into account the fact that each problem and context lends itself to a specific type of division.				1	1
Independent student work time occuring as key part of the teaching sequence not 'after the teacher input'.	1				1
The importance of asking students what operation will solve this problem.				1	1
Careful board work supports students in their notebook writing.			1		1
Asking the students to write down the problem allowed them to consider the problem deeply.				1	1
Students were allowed to create their own summaries.			1		1

Day 3 *(see program activities for this day)*

Participant Learning Reflections about Mathematics Teaching	Participant lesson study experience (by years)				Total # of participants
	0	<1	1-3	3+	
Seeing how the dot patterns progress across the grade levels, from early grades right through to upper secondary and calculus (from final comments).	1	3	2	2	8
Importance of connecting visual to mathematical expressions for deep understanding of each variable and component of the expression.	1	2	4		7
Still thinking about how many student strategies can be shared on the board – today seemed too many?		1	2		3
Using the 3 levels of teaching to analyze/critique teaching is a valuable tool		1	1		2
Planning the board to support students with mathematical connections.		1		1	2
I want to learn more about 'the new learning for the lesson' or 'most important point of the lesson'		1		1	2
So impressed with the content knowledge of teaching.			1	1	2
Liked that the whole lesson looked at just one problem deeply.		1			1
Excellent idea to get students to express to the 10^{th} term.		1			1

Fascinating to hear about the Japanese textbook structure for division and the arguments that occur.				1	1
Very rarely do I think about what my students will be learning in mathematics years down the line.				1	1
Allow students to discuss in depth other students ideas	1				1
How you pose the task greatly affects how students try to solve it.			1		1
Returning to a simpler representation from students prior learning is okay.			1		1
Not reaching the summary of the lesson suggests a gap between lesson goals and students' prior knowledge			1		1
4n can mean "n groups of 4 (quotative) or "4 groups of n" (partitive) depending on the what the pattern looks like. 4 groups of n is a richer task.				1	1

Day 4 *(see program activities for this day)*

Participant Learning Reflections about Mathematics Teaching	Participant lesson study experience (by years)				Total # of participants
	0	<1	1-3	3+	
Today's commentators reinforced the idea that if a teacher's goal is to have students make use of diagram, then they have to be given opportunities to create authentic diagrams (diagrams that they find useful and generate)	1	2	6	1	10
The final commentator shared there is value in messiness and lessons can be messy.		2	3	1	6
The importance of understanding the scope and sequence of how the math progresses throughout the grades.			1	2	3
The concept of difference was paramount in today's lesson, but was not the focus of the teaching.	2				2
I really need to think about how I am structuring problems as I could make slight tweak and change the trajectory of student learning.			2		2
Final commentator made some really useful comments on the maths: this included the suggested use of the questions 'why have you subtracted 12? Can you show why?'				1	1
These are challenging topics teachers are taking on. The goals of the lesson are around abstract ideas, like – why is this a division problem?				1	1
You can strategically include or take out information in the problem structure in order to best activate prior knowledge and develop the schema around the learning target.			1		1

Actual strips of paper are a more concrete model of quantity, both part-part whole and comparison situations that can then lead to effective use of tape diagrams.			1		1
Important for students to have a shared visualization of the problem context.			1		1
We have to teach students to understand the reasonableness of their answers.			1		1
The importance of building to a mathematical climate in the lesson where students realize a critical misunderstanding or aha.			1		1
Teacher knowledge in Japan is far greater than that of many western teachers.	1				1
Doing the problem with Dr. Yoshida as a group before the lesson helped me access the content more readily.			1		1
When creating lessons, we need to keep in mind the accessibility of the numbers we choose. The numbers we use have to be intentional.			1		1

Day 5 *(see program activities for this day)*

Participant Learning Reflections about Mathematics Teaching	Participant lesson study experience (by years)				Total # of participants
	0	<1	1-3	3+	
We need to stay with the students when teaching, not the lesson plan.			2	1	3
Both tasks today were based on real life situations and this gives students a chance to see what they learned in the mathematics classroom relates to the real world.	1	1		1	3
Teachers need to have a deep understanding of content progression	1			1	2
Sorting out histograms in the computer during the second lesson seemed time consuming and unnecessary.	1			1	2
We need to be careful about the numbers we choose for our problem (eg. today the remainder was 3: an intentional choice so students would be left with a dilemma to solve).			2		2
Students having the opportunity to explore and talk about data in depth and then deciding whether mean, mode, etc. makes the most sense to use.	1	1			2
Lesson started with a student misconception.		1	1		2
We need to help students understand that they need to pay attention to remainders and grasp the relationship between the quotient and remainder.			1	1	2

Glad to see an image used today, but wished students could have had the chance to manipulate it themselves.				2	2
Teacher questioning – I went back through my notes and almost every single thing the teacher said was a question – How do you know? Do you understand this? Can you find out the answer? Can someone please explain what he meant? Does anyone have a similar idea? What do we need to do?... and so on.			1		1
Students (6th grade lesson on histograms) needed to articulate pro and cons of their recommendations.			1		1
The wording 'I got it' rather than ' I did it' (part of research theme) is really helpful and useful to reflect on.				1	1
Students need time to reflect on their misconceptions.			1		1
The use of language is very consistently used, for example; 'expression' and 'equation' with full understanding by the teachers and pupils.	1				1
The board provided a consistent record of the lesson that students could refer back to as needed.	1				1
Intrigued by the division lesson and how students have to think about why the remainder is never larger than the dividend.			1		1

Day 6 *(see program Activities for this day)*

Participant Learning Reflections about Mathematics Teaching	Participant lesson study experience (by years)				Total # of participants
	0	<1	1-3	3+	
Students had to collaborate in their group in order to solve the problem.	1	5	3	3	12
Struck by the teacher knowledge putting irrational numbers into real world context through studying the sides of paper and ratios.	2	2	2	1	7
Even with complex problems the teacher pushes students to prove their strategy. They can do it better than the teacher.		1		2	3
The visual was needed to see where the square root of 2 was coming from.		1		1	2
You don't always need a notebook to record your ideas – sometimes manipulatives alone are enough.		1	1		2
The teacher asked students to visualize 1.5 times as long. This was meaningful to students and a simple way to get students to think about multiplication in a tangible way as opposed to something as abstract as unitless numbers.				1	1
It is important to provide that "hook" when introducing the lesson.			1		1

Day 7 *(see program Activities for this day)*

Participant Learning Reflections about Mathematics Teaching	Participant lesson study experience (by years)				Total # of participants
	0	<1	1-3	3+	
Students need to spend time constructing polygons using tools.	1		3	3	7
Students need a lot of practice with mathematical tools (protractors, set squares, compass), or they will not use them to solve problems.		3	3		6
Constructing a parallelogram by splitting off the right angle triangle and using the point of symmetry was new to me.		2	2	1	5
Students need to see math as create, rather than a set of procedures.		2	3		5
If we revise a textbook task, we need a strong rationale for it.		2	2		4
Using a student survey to find out what they are thinking /feeling about math is important data.		1		2	3
Teachers need to understand the content across grade levels.	1	1			2
Having a poster in the classroom showing how to use a set square gave students confidence.		1		1	2
I want to explore more how to use a set square.			1	1	2
Compass is not a tool to help students' visualize constructing a parallelogram.				1	1
Importance that the teacher solve the problem ahead of time and anticipate student solutions.				1	1
I saw the flow of Define, Examine, Construct today that Dr. T spoke about.		1			1
Teacher should constantly model the use of mathematical tools.		1			1

Day 8 *(see program Activities for this day)*

Participant Learning Reflections about Mathematics Teaching	Participant lesson study experience (by years)				Total # of participants
	0	<1	1-3	3+	
It is important to record the student's interim steps in this case it allowed the students to see the commonalities between solutions.		4	5	4	13
There are so many different ways to think about to how divide fractions.	1		4	1	6
The summary of the math lesson should be a hypothesis that gets tested on subsequent days.	1	2	2	1	6

Teacher made a choice not to move forward with the area model toward, this was a strong read on his students.	1		2	1	4
Double number lines are effective when there is more than one unit or dimension of measurement spoken about in the problem.		1	1	2	4
Double number lines can support students in transferring their understanding of multiplication and division of whole numbers to fraction or decimal quantities.			2	2	4
I'm thinking about when visual models are helpful/unhelpful.			1	3	4
The emphasis put on the properties of division in previous grades as children secure with these properties can then apply them to fraction problems, and will underpin much of the algebraic work they will encounter later on.		1	1		2
The knowledge of division of fraction by a fraction combines knowledge of all 6 prior years of elementary school.	1	1			2
The challenge of identifying a meaningful context for the problem.			1	1	2
Need to carefully choose the numbers in the task to work toward the goal of the lesson.			1		1

Summary of learnings reported on the daily reflections about mathematics teaching

The daily reflections by participants provided details of the kinds of learnings around mathematics teaching that took place for participants each day. They can be looked at in relation to each day's activity (see overview of program activities by day). Or, they can be looked at collectively. The first noticing is that collectively the program activated a wide variety of learning reflections about mathematics teaching: a total of 101 different learning reflections were provided by participants, this is almost double the amount of reflections participants provided on lesson study (51). This suggests a lot of learning associated with mathematics teaching was happening for participants.

It is interesting to note the clusters of similar learning experiences by participants. Below are examples where 10 or more participants on any given day of the program (# of participants) shared the same learning experience. There were 5 cluster of learning:

Day 2:

1) The focus on a mathematical questions surfaced from the students, (for example, why do we use division, is division the correction operation to use?) allows the students work on developing proofs.(14)
2) Color coded board work (visual, diagrammatic, symbols) has the capacity to reveal so many connections for students. I need to be more thoughtful about how I lay my board out. (10)

Day 4:
3) Today's commentators reinforced the idea that if a teacher's goal is to have students make use of diagram, then they have to be given opportunities to create authentic diagrams (diagrams that they find useful and generate) (10)

Day 6:
4) Students had to collaborate in their group in order to solve the problem (12)

Day 8:
5) It is important to record the student's interim steps in this case it allowed the students to see the commonalities between solutions (13)

Reviewing the participants reflections on mathematics teaching across the 8 days, there are several broad learning categories that emerged:

1. content knowledge and the progression of content knowledge across grade levels,
2. mathematical knowledge for teaching including anticipating, selecting, discussing, comparing and summarizing students responses
3. mathematical practices, for example using evidence, persevering
4. use of visuals and tools to support mathematical understanding
5. task choice including setting up the context, number choice, and connection to goals of the lesson
6. teacher use of board work, precise use vocabulary and thoughtful questioning, and
7. listening and observing students carefully

Daily reflections about pedagogy

Participants were also asked to reflect on any new 'aha's' they had about pedagogy and instruction based on the day's program (see overview of program activities for day to day details). Their reflection responses are summarized and recorded in the tables below. Several clusters of similar responses appeared. The total number of participants for each type of reflection are provided in the far right column of the table, along with a break-down of participants number of years of experience with lesson study. These results reveal that there may be kinds of learning reflections associated with different levels of lesson study experience.

Day 1 (see program activities for this day)

Participant Learning Reflections about Pedagogy	Participant lesson study experience (by years)				Total # of participants
	0	<1	1-3	3+	
Geometry sequence - start with more hands-on experiences before giving formal definitions for shapes, students become hungry for the definition.	1		3	3	7
Student need to Define, Examine, Construct (Japanese approach to geometry)	1		3	2	6
Three levels of teaching, we focus on level 1 teacher centered, rather than level 3 where students construct their own ideas.			2	1	3

We need to find commonalities between student solutions (for example, like the Riko and Kota problem).				2	2
Students themselves access prior knowledge, it is not given by teacher.			2		2
In Japan less content is taught but test scores are higher due to students confidence and competence from TTP.		1	1		2
I need to be more thoughtful about shaping 'student discovery'			1		1
Japanese teachers do not tell students what to think about.				1	1
Use of models and images supports student understanding.				1	1
It is possible to start with a problem that students do not know the answer to when you choose the right level challenge.		1			1
Homework in Japan is allowing students to study as they see fit so they are prepared for the next day.			1		1
Differentiation of entry point into the lesson as opposed to differentiating the lesson.				1	1
Importance of anticipating student responses.	1				1
It is okay to let students struggle.			1		1
Must do careful board planning although important to know that you might need to change the plan based on students' actual thinking.			1		1

Day 2 (see program activities for this day)

Participant Reflections about Pedagogy and Instruction	Participant lesson study experience (by years)				Total # of participants
	0	<1	1-3	3+	
I can carry one lesson over multiple days, with different objective, to emphasize process as well as accuracy/efficiency.	1	2	2		5
Liked the hint card.		2	2		4
I will take away the impact of joyful learning that I saw today.		2		1	3
The students did not have to raise their hands, instead there was respectful discussion.	1	1			2
The teacher gave no visual cues with her face, she listened careful and recorded what the students said on the board.	1		1		2
Teacher observes, listens, captures and problem.	1		1		2
I am questioning what authentic engagement looks like – must it always be			1		1

equal talk time?					
Would love to understand more about the class being split? Seems like differentiation is going on?		1			1
I still want to see more student to student interaction.			1		1
I want to create a resource area with prompt and tools for student to use when they need to.			1		1
A good teacher talks less and listens more.	1				1
A teacher should never say something a student can say.			1		1

Day 3 (see program activities for this day)

Participant Reflections about Pedagogy and Instruction	Participant lesson study experience (by years)				Total # of participants
	0	<1	1-3	3+	
All students knew exactly how to begin to solve the problem.	1	2	1	1	5
Teachers need to meet students where they are in their learning, not just keep going regardless.		2	2		4
Concerns with pedagogy and lack of genuine conversation, collaboration and engagement between students (both student to student, student to teaching)			2		2
Students need the opportunity to go back and revise their work.		1	1		2
Students use mathematical vocabulary with far greater ease than our students do.	1				1
Teachers needs to listen to student voices in order to understand their needs.				1	1
I like the ice breaker the teacher did with students before the research lesson started.		1			1
Students need time to do applied practice after learning a new strategy.			1		1

Day 4 (see program activities for this day)

Participant Reflections about Pedagogy and Instruction	Participant lesson study experience (by years)				Total # of participants
	0	<1	1-3	3+	
There has been little evidence of children being expected to engage in talk with each other.	1	1	1	2	5

The teacher must listen to children to be able to respond effectively and genuinely hear what they are saying to be able to help them construct new thinking and connections.		1	4		5
I am wondering about the absence of manipulatives to support students' understanding		1		2	3
Students need time to tackle problems independently.		1	1		2
When the teacher talks too much (even asks too many questions), students cannot think.			1		1
Communication between students is done through the board work and class discussion, rather than student to student collaboration.			1		1
I need to trust my student's thinking more.			1		1
Student leaders starting the lessons and ending lessons is effective and creates shared leadership.		1			1

Day 5 (see program activities for this day)

Participant Reflections about Pedagogy and Instruction	Participant lesson study experience (by years)				Total # of participants
	0	<1	1-3	3+	
I am wondering if students have enough partner, small group time to really learn from each other (only seen one time during histogram lesson).		1	4	1	6
Learning is messy and our lessons needs to reflect this.			2	1	3
Teachers want to control the students' journey (too much?)			1	1	2
I need to watch more carefully for when students are engaged or disengaging from the lesson.			2		2
Students were respected for giving answers that matched their existing knowledge.	1				1
Learning is most effective when done through thoughtful questioning.		1			1
I am seeing students erase their work to keep their notebooks meticulous, but we spend time making sure students do not erase (?)				1	1
Using color coding to emphasis aspects of the board work.				1	1
Writing student's names with their ideas on the board.				1	1

Day 6 (see program activities for this day)

Participant Reflections about Pedagogy and Instruction	Participant lesson study experience (by years)				Total # of participants
	0	<1	1-3	3+	
The long wait time by the teacher at the beginning of the lesson was required to keep the agency with the students.	2		2	3	7
A good lesson is when the teacher works hard to learn what the children are doing/thinking/understanding. Not a good lesson if the children have to work hard to know what the teacher wants them to do.	1	2	1	2	6
The intro of set up for the lesson seemed too long.		1	3		4
Good rapport, humor and engagement are extremely effective pedagogy.		1	1	1	3
Group work needs to be intentional.		1	1		2
Anticipating student responses is the key.		1		1	2
When Dr. T reflected with our group discussion he didn't offer opinions regarding our contributions. I will use this more in my own work with adults.	1				1

Day 7 (see program activities for this day)

Participant Reflections about Pedagogy and Instruction	Participant lesson study experience (by years)				Total # of participants
	0	<1	1-3	3+	
There needs to be good reasons for groups to work together.	1	2	7	4	14
Today the teacher asked children to come forward for further instruction if they were unsure on what to do.	1	2	1		4
We need ways to access what is going on in group work, accountability structures.			3		3
I realized it is worthwhile to try to find (even small) ways to minimize teacher talk time, e.g. holding up fingers rather than telling 'it's time to end'.			1	1	2
Students were able to quickly and quietly reorganize themselves and the room for group work.		1			1
Activating students' prior knowledge is important to make connections to new learnings.	1				1
Appreciated how the teacher asked the students 'do not shout out, speak to yourself and to your heart'.				1	1
A good lesson is when the teacher works hard to learn what the children are			1		1

doing/thinking/understanding. Not a good lesson if the children have to work hard to know what the teacher wants them to do.					

Day 8 (see program activities for this day)

Participant Reflections about Pedagogy and Instruction	Participant lesson study experience (by years)				Total # of participants
	0	<1	1-3	3+	
Turn and talks allows students to share ideas, but we need to listen carefully to what students say to each other.	1	3	2		6
You have to listen carefully to students.			1	2	3
The job of the teacher is to select carefully students strategies to share out, this is not random.		1		1	2
Elementary school is not about answers, but all about creating processes to solve problems.		1			1
Groupings and turn and talks need to be purposeful.			1		1
I like the approach of "we will fix it together" when a student made mistake on the board or explanation.			1		1
I have never thought about students coming up with their own definitions.			1		1
Learning is messy but must also be productive.			1		1
I need to be more mindful about calling on the students I know have the right answers.			1		1
The students wrote down their ideas on a whiteboard and the teacher worked off these.	1				1

Summary of learnings reported on the daily reflections about pedagogy and instruction

The daily reflections by participants provided details of the kinds of learnings around pedagogy and instruction that took place for participants each day. They can be looked at in relation to each day's activity (see overview of program activities by day). Or, they can be looked at collectively. The first noticing is that collectively the program activated a wide variety of reflections about pedagogy and instruction: a total of 76 different learning reflections, compared to 51 on lesson study and 101 in mathematics teaching. Interestingly, 8 of the reflections were not learnings, rather they expressed concerns around pedagogical practices noticed in Japanese classrooms. Participants were particularly concerned about the lack of students to student engagement and opportunities for students to talk to each other, lack of group work, too

much control of student thinking by the teacher through the use of whole class discussion, unequal balance of between boys (over speaking) and girls (under speaking), little use of manipulatives (in the lessons they experienced), and differentiation.

Participants also noted many new learnings about pedagogy and instruction, for example, learning is messy and teachers must meet students where they are regardless, the need to let students struggle and discover by themselves, the importance of anticipating student responses and the need to activate students' prior knowledge, teachers must listen and observe well during instruction to really understand student thinking, use of teacher questioning to keep agency with the students, and the use of the board to support communication and help students make meaningful connections around the mathematics.

Questions remaining on the final day about teaching mathematics and pedagogy

On the last of the program, a session was dedicated to answering any remaining questions from participants. The following questions arose in the category of teaching mathematics and pedagogy: (see p. 30 of this report for the responses to these questions)

Instruction

1. What does the full menu of Japanese math instruction look like (TTP + practice + small group intervention + homework? + Kumon tutoring?
2. How does PACING align with student-driven instruction? I am noticing a lot of classes using the student thinking of the fastest or most comfortable student to pace and drive the discussion? How do teachers ensure pacing and selection of student work isn't driven by the most "accelerated" students?
3. Many of the lessons ended with the teacher saying, "we will talk more about this topic tomorrow" – what does this lesson look like and how might it impact the length of the unit?
4. In most of the lessons we observed the summary was either left out or very rushed. What role does the summary and reflection play in everyday math lessons in Japan?
5. The summaries and student reflections did not seem to have much weight in the lessons we observed. Is this a common practice in everyday lessons, or is it because they happen to run of our time for the public lessons? What is the common practice surrounding summaries and student reflections?
6. What opportunities do students have to reinforce or practice a skill or concept? For example, in the remainders lesson, will students have additional practice subsequently?
7. How do upper grades research lessons transfer to primary (k/1) lessons? What is the main differences (if any) in terms of flow? What does board work, class discussion, and summary look and sound like?
8. What are the differences (if any) in how the primary (k/1) research lessons flow? What are the communication expectations (written or oral)?
9. What feedback do teachers give to students in math journals? What does feedback look like in Japanese mathematics classrooms?
10. What does feedback in notebooks look like?

11. How are students who appear to be understanding more easily extending their learning and those struggling being supported while maintaining a focus upon the goals and key learning?
12. How are teachers utilizing notebooks for assessment when it seems there is a lot of copying from the board or others thinking? Is the focus just on the students individual reflection at the end (although this did not occur each lesson)?
13. What manipulatives are used in Japanese schools?
14. Are students encouraged to use manipulatives to show their thinking? This was not observed very often?

Curriculum

1. Can we see the course of study for grade 1?
2. Does every child have a textbook and/or workbook they use at home. (If they want to practice more similar questions to the ones taught in the lesson)?
3. To what extent do math teachers plan using multiple resources? How are these resources/curricula integrated with the Japanese textbook?
4. What do Japanese children typically do out of school for mathematics?
5. Do all curriculum designers use the same mathematics learning progressions? What do they use? Is it translated into English?

Group work

1. The US loves group work. In the classrooms that used group work, the final commentators said it was unnecessary. When is it necessary or recommended?
2. Group work – beyond being intentional to support content mastery, is there a value placed on 1. fostering cooperation (negotiating a task, sharing air time, actively listening, etc.) OR – 2. deepening understanding by articulating orally (by putting ideas into words, explaining and defending to others, you deepen your understanding)?
3. How is partner work/ group work thought about in Japanese teaching? How do you construct problems where group work is needed?

Differentiation

1. It is mentioned that schools in Japan are moving towards inclusion. In most of the lesson we observed, students were separated based on their levels – can you explain this?
2. How do teachers support students with different levels of need within a teaching through problem-solving task – Ideas for differentiation structures to increase all students access? I know that some schools have infrastructures to divide the class into skill levels, but what about classrooms where the varying levels of need are in one classroom with one teacher?
3. What strategies are Japanese teachers using to increase student voice, Conversation, expression and are they aware/mindful of student voice based on gender?
4. How/when are procedures for positive group interactions taught/reinforced?

Concerns around group work and differentiation were highlighted, along with great curiosity to know more about the Japanese curriculum and different aspects of teaching through problem-solving, for example; the use notebooks, or getting to the summary of the lesson.

Changes in views about teaching and learning Mathematics

Two instances after the program participants were asked to reflect on changes to their views about teaching and learning mathematics. The first point of reflection was on the final evening of the program where participants were asked - How do you view teaching and learning mathematics now? The second point of reflection was given two weeks after the program, in a post program survey, where participants were asked - how did your views of the teaching and learning of mathematics change as a result of this trip, if at all?

Below are examples of reflections from the final day's question - How do you view teaching and learning mathematics now? There are several noticings; the first being a focus on content knowledge and the role it plays in teaching mathematics. For example: *"My big takeaway was that in order to be a better math teacher I need to learn more math content and be more thoughtful around numbers, tasks, and discussions."* (LSIP YT9c) and, *"I also now see the critical importance of having deep content knowledge in order to plan the best ways to plan constructivist lessons that draw the mathematics out of the students rather than giving it to them. The teacher and student are both life-long learners and should approach their work as such."* (LSIP YT2c)

Similar to the last participant (LSIP YT15d), many participants saw mathematics teaching and learning as a continuous process of improvement: *"No matter how well a lesson may go there will always be an opportunity for improvement."* (LSIP YT5c), *"Learning should not be a tick box exercise, and discussions around learning should not obsess over self-interest or ego or be a blaming game. It should be a place from where improvement can happen."* (LSIP BA23a), and acknowledged of the risk inherent in the improvement process, *"We cannot develop our practice and learn new things without taking risks and testing strategies and practices in our own classrooms"*. (LSIP YT3c)

A shift in perspective around pedagogical choices for mathematics instruction also appeared: *"I am thinking a lot about independent time in the classrooms at our school, giving students quiet time to grapple. I am also wondering about group work. I think we see it in SF as a mark of good teaching and I am thinking about how we can track to what extent that it is effective."* (LSIP YT20b), and *"This experience has shifted my thinking about the positive roll that whole-class discussion can play in holding high expectations and setting clear modelling for all students, if correctly facilitated."* (LSIP YT12d).

The final noticing was around participants embracing a student perspective on learning: *"The best question, which sums up what I think was at the heart of what we observed, was 'Are you teaching for your students of for yourself?' I shall be using that!"* (LSIP BA22d), and *"After IMPULS, I view the role of the teacher as*

to identify the understandings of key students to help further the lesson by allowing those understandings to influence the discussion and understandings of other students in the class." (LSIP YT13b)

Responses to the survey questions two weeks after the program revealed a similar pattern of responses to final day's reflections. Content knowledge and content progressions remained a consistent change in the majority of participants, for example,: *"I found that in order to be a better math teacher I need to take a deeper look at my own math content knowledge in order to support my students from where they are coming from and take them on a progression to where they need to be."* (LSIP YT1c), *"I need to deepen my content knowledge above and below my grade level. This is necessary for many reasons, but a new reason is so that I am able to better listen to my students during a lesson."*, and *"Not only did it [the program] give me an important means of assessing my own level of content knowledge, but it deepened my commitment to working in community with peers and "knowledgeable others" to deepen my knowledge as I develop that depth in my students."* (LSIP YT7d). Participants also referred often to the importance of student mathematical thinking, for example;: *"The aim of all my work since participating in the IMPULS project is the development of students' mathematical thinking."* (LSIP YT9c), and *"I was particularly drawn to the emphasis on processes over answers, which is something that has definitely affected the way in which I teach."* (LSIP BU26a). Added to this was the foundational need to understand the structure and properties of the mathematics for teaching : *" I also think it [the program] consolidated that idea that looking at the structure and properties of the mathematics is essential and that everything needs to be taught with understanding."* (LSIP BU27b)

Several other participants shared about curriculum pacing, task choice and group work, as described below: *"I realized that teachers are willing to dedicate a decent amount of time to open up the problem and let students arrive at the problem themselves. In our curriculum we have more problems to get through so there isn't that time to carefully consider a situation and what questions we might ask."* (LSIP YT8c), *"It has raised many questions for me, including how to introduce problems with giving students enough of an entry point without leading them to a particular strategy, how to construct tasks that are worthy of group work, and how to choose tasks and tools that will best lend themselves to the goal of the lesson.*(LSIP YT6c), and *"The biggest change to my understanding was around the group discussion and group work. I will, in the future, consider carefully when to use group work and when to call on students contributions and do so only to further students understanding - not merely to have students voices heard or because of a vague idea that group work is a good thing."* (LSIP BT25b).

Most participants referred to different aspects of teaching through problem throughout their reflections, for example: *"It [the program] also showed me the importance of knowing the problem inside-out and being able to anticipate both right and wrong solutions that children could come up with and already having a*

clear idea about which direction you would like to take them in." (LSIP BU27b), *"As a result of this trip I now see the importance of questioning."* *(LSIP YT2c)* and, *"Teachers also trust that their students have good ideas worth exploring whether or not they are the most efficient methods or the intended method."* *(LSIP YT8c)*

Summary of participants view of teaching and learning

To recap, the top 3 learning outcomes reported in section 4 (quantitative data), found that participants ranked the following as 'key learnings outcomes' of the program:.

(a) Important features of lesson study
(b) How lesson study is conducted in different educational contexts (e.g. schools, districts, etc.)
(h) The role of the knowledgeable other

And when participants responded with respect to the 'most professionally usefulness' aspects of the program, they ranked as follows:

(i) How to support student problem-solving
(n) Anticipating student responses
(a) Important features of lesson study
(s) Mathematics content
(j) How to build students' mathematical habits of mind and practices

The qualitative data from the participant reflections and open ended survey question shared in this section appear to align more closely with the 'most professionally useful' results (shown directly above). One claim that could be made here is that as a result of the program participants' views on what is most useful in their lesson study work focused on the application of teaching through problem solving.

7. Other Reflections on the Program

IMPULS schedule & timetable

Overall, participants reported favorably on the scheduling and agenda of the program, although many acknowledged how much was done in such a short amount of time. Some participants suggested scheduling more time for reflection, even if it would be at the expense of seeing fewer lessons (two participants noted that seeing two lessons in a day was particularly challenging). Five participants noted that they would have liked more time to try the math before lessons. Four participants mentioned that they would have appreciated hearing more from experts; whether this was in the debrief after lessons, more opportunities for Q&A sessions, or

additional lectures. Three participants stated that hiring professional translators would have helped them to get more out of discussions before and after the lessons. Two participants reflected that they would have liked more information about Japanese culture and the educational system at the beginning of the program (for example, when an appropriate time was to exchange gifts).

Participants Remaining Questions

At the end of the program, participants were asked to list any remaining questions they had. Some participants expressed that they had many, but did not go into detail. The questions asked by participants are stated and categorized in the table below.

Topic	Questions
Desire for networking opportunities	• "I'm wondering if the program can help create regional lesson study networks. It would be really great to receive support from participants of years past and potentially open up our public lessons to one another". (LSIP BA23a) • "I am just wondering if there would be a way moving forward that the participants could connect in kind of an 'exchange' of sorts where we travel to each other's schools for research lessons, etc.". (LSIP YT15d) • "I'd like to be part of a wider group who can help me get things going now we're back in the UK. I believe this will happen and I'm grateful for this opportunity". (LSIP BA24a)
Japanese educational system	• "In England we have 'Ofsted' who come and make judgements on schools. Is there a similar system in Japan? Do Japan do as well in all the other subjects (such as Science, Geography etc.) as they do in Maths"? (LSIP BU27b) • "[I would like] more information on special education in Japan and the "newer" tracking idea that was touched on in a few of the discussions". (LSIP YA16d)
Curriculum & materials	• "I still have questions about the Japanese curriculum. How exactly do the students use their notes? I saw many students with a single sheet of loose leaf paper instead of a notebook. Do they keep this loose leaf in a binder? Do they keep other things in the binder? What about homework? I would love to see all materials that students use during math over the course of a school year". (LSIP YT17c)
Lesson study in primary classrooms	• "I would still like to see lesson study in action in primary classrooms. I'm looking forward to future immersion opportunities that address this". (LSIP YT18b) • "I really wish we could have seen at least one primary public lesson. I still have many questions about what board work looks like, summaries, student

	journals, and the general flow of the lesson". (LSIP YT19b)
How lesson study is conducted	• We discussed a little about the articles we were given ahead of time on the first day. I would have liked to talk through a little more the idea of 're-teaching' as discussed in the Fujii article". (LSIP YA16d) • "I would like to know what they have done in Japan to support teachers in how to observe, how to critique each other and how to design lessons... I am still not clear about whether parents ever attend the public sessions... I am also still not clear on what the professors mean by 'the most important point' in a lesson - what does this mean to them because I think it may mean different things to different people. I also have questions about how the final commentators prepare for the final commentary". (LSIP BA22d)
Structures and tools for sharing lesson study	• "[I would like] structures and tools for how lesson study learnings are shared with the district and ministry of education". (LSIP YA21c)

These remaining questions by participants provide insight into areas that project IMPULS may want to consider incorporating in future immersion programs, for example; more information on special education in Japan, lesson study in other subject areas, research lessons in lower grade classrooms, and a deeper look at students' use of journals. There was also a desire for further networking opportunities.

8. Implementation Outcomes of IMPULS Immersion Program

A test of any program's effectiveness is not just its perceived professional usefulness, but how the 'usefulness' is shared forward for continuous improvement in the field of education, and more specifically to support teacher and student learning. Below is an overview of implementation activities that took place when participants returned to their local context. These activities were either reported by participants or found publicly available. They were shared as being inspired by, or in some part afforded by the learning experiences and knowledge gained from the IMPULS program. The following information does not include data from 6 participants.

Since the end of the program (June, 2017) and submitting this report (February, 2018), the following activities or lesson study events have taken place.

Multimedia

- Podcast: Math Puzzles and Lessons from Japan
  http://www.mrbartonmaths.com/blog/ed-southall-part-2-puzzles-and-lessons-from-japan/

- Blog Series:
  1. Arriving in Tokyo
     https://mathswithbelle.wordpress.com/2017/06/20/arriving-in-tokyo/
  2. A good teacher does not teach the book, but teaches with the book
     https://mathswithbelle.wordpress.com/2017/06/22/a-good-teacher-does-not-teach-the-book-but-teaches-with-the-book/
  3. Learning is messy
     https://mathswithbelle.wordpress.com/2017/06/29/learning-is-messy/
  4. The art of listening
     https://mathswithbelle.wordpress.com/2017/06/25/the-art-of-listening/
  5. The waiting game
  6. https://mathswithbelle.wordpress.com/2017/06/29/learning-is-messy/
  7. A lesson in mathematics lessons - IMPULS project
     https://mathswithbelle.wordpress.com/2017/07/22/a-lesson-in-mathematics-lessons-project-impuls/

- Paper: Lessons from Japan
  http://www.leedstrinity.ac.uk/blogs/camilla-pratt-maths-lessons-from-japan

Research Project

- CLR (collaborative lesson research) Research Project with Jurassic Mathematics Hub started in13 schools: 7 individual schools and 6 clusters of schools

Professional learning opportunities for teachers

- Mathematics Master Class: Learning from Japanese Lesson Study
- 3-day in school training on lesson study and teaching through problem-solving for teachers at the school
- 2-day in school training on lesson study and teaching through problem-solving (TTP) for teachers at the school, including a demonstration lesson on TTP
- Presentations to regional mathematics hubs
- District sponsored event on mathematics deeper dives focused on content progressions

Pre-service teacher trainings

- Lectures about lesson study and teaching through problem-solving to undergraduate and post graduates students
- New course module for 2nd year undergraduate students including a lesson study cycle
- New course module for 1st year undergraduate students including a modified lesson study cycle

Steering Committee in place

- 4 schools

Provided final comments

- 2 participants

School-based lesson study

- Acorn Woodland Elementary School, 2 school-wide mathematics research lessons
- Argonne Elementary School, 4 mathematics research lessons
- Edna Brewer Middle School, 1 mathematics research lesson
- Hillcrest Elementary School, 4 mathematics research lessons
- John Muir Elementary School, 3 mathematics research lessons
- Lawton Elementary School, 1 ELA research lesson
- Prieto Math and Science Academy, 1 math/science research lesson, 4 math research lessons, 1 social emotional learning research lesson, 1 ELA research lesson, 1 ELA/science research lesson, and 1 'resource team' research lesson (total 9)
- San Francisco Community School, 3 mathematics research lessons
- CLR Research Jurassic Math Hubs Project - 13 research lessons

District-wide lesson study

- San Francisco Unified School District, 1 mathematics research lesson attended by 85+ observers. Presented by John Muir Elementary School.

Cross-district lesson study

- Oakland Unified School District/The Silicon Valley Math Initiative, 2 mathematics research lessons attended by 80+ observers. Presented by Acorn Woodland Elementary and Bret Harte Middle School

Total number of research lessons = 43

At the heart of the Japanese education system, the practices of lesson study, and the values held by the IMPULS project is the spirit of generous sharing and opening up ones practice. One participant referred to this as '*professional generosity*' (LSIP BA24a). The implementation results shown here exemplify professional generosity by the participants of the IMPULS 2017 program.

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