IMPULS Lesson Study Immersion Program

2015

Overview Report

March 2016

“IMPULS Lesson Study Immersion Program 2015
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(1) List of participants
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1 Preface

Project IMPLUS is a newly established project funded by the Ministry of Education, Culture, Sports, Science & Technology of Japan since 2011. The Project is housed in the Mathematics Education Department of Tokyo Gakugei University, Tokyo, Japan. The director of the project is Professor Toshiakira FUJII, and the project members include all the faculty members of the mathematics education department—Professors Shinya OHTA, Koichi NAKAMURA, Keiichi NISHIMURA and Tatsuhiko SEINO. Dr. Akihiko TAKAHASHI of DePaul University joined the project as a specially appointed professor. Ms. Naoko MATSUDA also joined the project as a project staff member. The purpose of the project is two-fold. First, as an international center of Lesson Study in mathematics, Tokyo Gakugei University and its network of laboratory schools will help teacher professionals from throughout the region learn about lesson study and will thereby prepare them to create lesson study systems in their own countries for long-term, independent educational improvement in mathematics teaching. Second, the project will conduct several research projects examining the mechanism of Japanese lesson study in order to maximize its impact on the schools in Japan. Under these main purpose, we are working for ;

1) ***Research*** on Japanese Lesson Study to come up with ideas for establishing innovative teacher education systems for long-term, independent educational improvement in teaching mathematics.
2) ***Professional development*** to disseminate ideas for establishing innovative teacher education systems for long-term, independent educational improvement in mathematics teaching. Workshops and institutes would examine how to implement ideas for Lesson Study and innovative ideas for professional development in various schools with different systems and cultural back ground in order to prepare them to create in their own countries' systems for long-term, independent educational improvement in teaching mathematics.
3) Facilitate opportunities for researchers, administrators, and practicing school professionals throughout the region to ***exchange their ideas*** to improve their education systems for teaching mathematics.

The IMPULS lesson study immersion program was designed to give mathematics education researchers and practitioners from outside Japan an opportunity to examine authentic Japanese Lesson Study in mathematics classrooms. The major purpose of this program is for us to receive feedback on the strengths and weaknesses of Japanese Lesson Study and to discuss how to improve mathematics teacher professional development programs. To accomplish this, we invited leaders of mathematics education to immerse themselves in authentic Japanese lesson study, especially school-based lesson study, and to observe mathematics research lessons in elementary and lower secondary grades.

The program started since 2012 and this year's program was held in Tokyo and Yamanashi in Japan from June 22, 2015 to July 2, 2015. In total 25 mathematics educators (11 from U.K, 6 form U.S., 3 from Australia, 2 from Malaysia, 2 form Ireland and 1 from Qatar) including mathematics education professors, principals of school and so on participated in. For this year, IMPULS invited

Dr. Alan H. Schoenfeld, Elizabeth and Edward Conner Professor of Education and Affiliated Professor of Mathematics, University of California at Berkeley, as a Special Guest Participant. Two of IMPULS overseas support committee, Dr. Makoto Yoshida, President of GER and Director of Center for Lesson Study in William Paterson University, and Dr. Tad Watanabe, Professor of Mathematics Education at Kennesaw State University, interpret lessons and post lesson discussions observed. All lesson plans were translated by Dr. Makoto Yoshida and Dr. Tad Watanabe and distributed before observation. And one external evaluator, Dr. Jennifer Lewis, Associate Professor, College of Education, Wayne State University, gave us useful feedback with objective evaluation of program.

We would like to take this opportunity to thank all of our overseas support and evaluation committee, cooperative schools which kindly welcomed our visiting and all concerned professionals for their hard work.

2 Contents of Program

This program is designed for deeper understanding of Japanese lesson study and it consist of these contents below.

1) Basic lecture on Japanese mathematics lesson and lesson study (1 day)
2) Observation of research lesson and post lesson discussion (8 lessons)
3) Discussion among participants, Q/A and review session

Detailed schedule is shown as below.

Date	Time	Contents
June 22	AM	Opening Session, Workshop: Mathematics teaching and learning in Japan,Lesson Study in Japan,Teaching through problem solving and Kyouzai-Kenkyu
	PM	Workshop: Japanese mathematics lessons and lesson study
June 23	AM	Preparation for the research lesson observation
	PM	<Research Lesson &PLD1> TGU attached school, Koganei Junior High School (Specially Appointed LS for Fuzoku teachers)（Grade 8, Mr. Sho Shibata）
June 24	AM	Preparation for the research lesson observation
	PM	<Research Lesson &PLD2> Sugekari Elementary School (Schol-based LS) (Grade5, Ms.Noriko Kudo)
June 25	AM	Preparation for the research lesson observation
	PM	< Research Lesson &PLD3> TGU International Secondary School (Specially Appointed LS for Fuzoku teachers)（Grade 7, Mr. Ren Kobayashi）
June 26	AM	Showa local educational office and courtesy call, Visit Oshihara Elementary School (observe ordinal classroom)
	PM	< Research Lesson &PLD4> Oshihara Elementary School (School based LS) (School-based LS)(Grade3, Mr.Ishikawa)
June 27	AM	< Research Lesson 5> University of Yamanashi Attached Elementary School, Cross-district LS(Grade5, Ms.Kasai)
		< Research Lesson 6>University of Yamanashi Attached Elementary School, Cross-district LS(Grade4, Mr. Yamaguchi)
		Post lesson discussions
June28		Move back to Tokyo
June29		Free
June30	AM	Preparation for the research lesson observation
	PM	< Research Lesson 7> Konagei Elementary School,(Grade4,　Mr. Takeo Takahashi)
July 1	AM	< Research Lesson &PLD8> Sasahara Elementary School (District-wide LS)(Grade5)
	PM	Discussion to wrap up the Lesson Study Immersion Program
July 2	AM	Discussion to wrap up the Lesson Study Immersion Program
	PM	Closing session

June 23: TGU attached school, Koganei Junior High School

Research Lesson Observation Form (Use photos to document each section)
For Group Facilitation and Report
Alan's notes in blue
Tan Phei Ling's note in Green

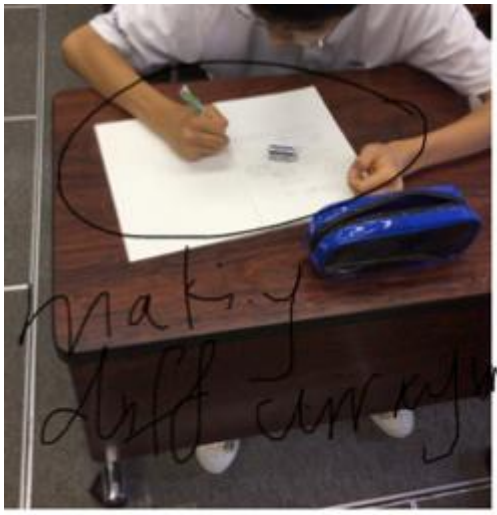
What are the primary lesson goals?

Where is the lesson located within the unit (in relation to previously studied topics and ideas to be studied in the future)?

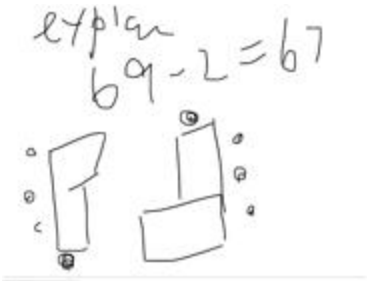
Lesson Phase	Notes
1. Introduction, Posing Task	**-Strategies to build interest or connect to prior knowledge** -Exact posing of problem, including visuals >The teacher presented cases 1, 2, and 3, and made sure the kids knew what the task was. There wasn't much of a problem of connecting to prior knowledge, just making sure the kids "got" the problem. The choice of the number 75 as the desired number of people to seat was interesting, because (a) it was large enough to warrant thinking in patterns and possibly algebra, and (b) the choice of an odd number would cause some extra thinking, since "full" tables always seat an even number of people. >Before starting the lesson, the teacher had a cheer with the students to motivate them for today's lesson. He asked if students were ready for the lesson.   Teacher posed the first diagram of seating plan then the second diagram when two tables were added (please see attachment). He asked students to draw out the possible seating plan for the third diagram. Then teacher prompted the students on how many table do we need to sit 75 people.
2. Independent Problem-Solving	**-Individual, pairs, group, or combination of strategies?** -Experience of diverse learners - Teacher's activities >For someone who does not speak Japanese, the experience of the learners was very hard to get at. The students had 20 minutes of individual seatwork. I saw many different strategies (many of which were later presented at the board). Some students extended the pattern of the diagrams. Many wrote long paragraphs. Some used algebra. There were no conversations, so each student was on his or her own for 20 minutes. They all seemed to make progress – one way or another, they found the number of tables needed. When the teacher asked, they could chorus the answer. But, it's hard to know how productively any of the students were making use of those 20 minutes. Given that there were no teacher interventions, each child was unsupported for 20 minutes.

The teacher was monitoring student activity and choosing which students to have present.

>-Teacher asked the students to try individually. Students started to work on the problem in their note book. This students tried different arrangement.



Student came out with table to help in solving the problem. Student observed the trend and was able to solve using method four discussed by the teacher. Student solved the problem using method three as discussed by the teacher. This student still trying to solve the problem. Student prompting usual way of calculation by stating each of the possibility seating. students prompted the fourth method. This student prompted to solve in the last method, which was another new way of arranging the table.

3.Presentation of Students' Thinking, Class Discussion	**Student Thinking / Visuals / Peer Responses /Teacher Responses** Photos to document chronology (use new box for each new student idea presented) >The teacher called on students to describe their solutions in order, starting with the ones that were simplest conceptually and moving to more complex solutions. He added a solution of his own (the parametric version) for completeness. The students dictated and the teacher took great care to transcribe what they said. He asked for some clarifications – e.g., some students' solutions indicated a numerical breakdown of how they counted, and the teacher went back to the diagram so that the class could see how the numbers represented configurations in the diagrams. *Could someone please put in the chronology with pictures? I've been having major problems with my ipad.* >Teacher asked for presentation of solution. Teacher chosen a student with easiest to be understood solution to iterate his solution to the whole class while teacher jote it down on the board. Teacher wrote on the board after the student explained to the whole class. Teacher started to solve with three methods on the board. Teacher tried to explain what it means by 3 x 2 in the solution. Students proposed four methods.    

4.Summary /Consolidation of Knowledge	Strategies to support consolidation, e.g., blackboard writing, class discussion, math journals. >The blackboard represented a beautiful capturing of the ideas that the students (and teacher) presented. The math journals captured this, so the students had records of both their own work and the record of what had been produced by the class. Unfortunately, there was very little compare-and-contrast of solutions, so that possible connections and deeper understandings of the relationships between the physical configuration, and the various representations were not consolidated. >Teacher compared the solutions with the students. Then he concluded the relationship between two quantities, in this case are number of table and possible seating. The number of people was fixed to be 75. One student argued that actually the arrangement of the table may not be fixed and he proposed another possible setting of the table, which the last one was written on the board. Teacher was concluding on how the three variables: the number of tables, the number of people and the position of the sequence of arrangement affects each other. 

What new insights did you gain about mathematics or pedagogy from the debriefing and group discussion of the lesson?

>The debriefing brought the comments above to light, indicating many of the limitations of the lesson as designed. I was impressed by the forthright nature of the comments.

>I learnt that mathematics problem solving could be done in a way without posing leading questions in advance to the students and let them explore using any methods that they found possible to solve the problem. It would be a more meaningful learning for students as they figured it out by themselves through observing the pattern. The solution may not be restricted to only one method or of using only a single way of solving.
Teacher introduced the different ways of solving it, the rationale of doing it would be to enable students to compare and contrast between the solutions. If the teacher was given more time, he would discuss and compare the solutions to provide an insight to students to scaffold on their own ideas.

What new insights did you gain about how administrators can support teachers to do lesson study?

>The issue is one of climate – how they create a context in which teachers can work together for improvement.

>I realized that the support in terms of arrangement of time table would be helpful as the teacher get to observe the lesson and do the post lesson discussion. The point that every Wednesday, the students were allowed to dismiss earlier so that teachers could stay back in school to observe one lesson was indeed a good act from the school administrators. This would definitely motivate the teachers in doing lesson study and promote collaboration among the teachers for professional development. In a long run, teachers would be able to experience the benefit of lesson study.
The sharing of knowledgeable others as final commentator would be very helpful in providing insight

to the lesson conducted by using evidences. The sharing from final commentator would lead to extending the lesson to a wider area to be discovered by the teachers in the future.
In Malaysia, teachers seem to use 'no time' as an excuse. In fact, with the administrator support, lesson study could be practiced by the teachers. The teachers would be glad to be facilitated by the knowledgeable others in their planning of the lesson. I was quite sure that the teacher would not deny to do lesson study if there were an initiative of dismissing earlier on Wednesday, as practiced by Japan schools. The early dismissal could solve the problem of playing truant and skip classes among Malaysian students.

How does this lesson contribute to our understanding of high-impact practices?

>I think the examination of what went well, but perhaps more importantly, what the lesson failed to achieve, and why, contributed to a greater understanding of what the goals *might be* and how one can think about achieving them.

>This lesson attempted to let pupil try to solve a problem using various way as they had not learnt to solve system of equations using the substitution method. The carefully design task was a very good start to engage students in actively looking for solution. Through this lesson, I observed that the different methods proposed by other students did give some ideas to the students on different ways of solving the problem. The last solution proposed by one of the students led to more thinking among students as the arrangement was different from all other solution proposed. This would definitely aroused students interest to think deeper.

June 24: Sugekari Elementary School

Lesson Observation 2: Report

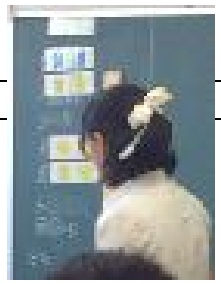
Anne Brosnan, Jun Li and Phillip Noble
Group Observation for 24th June 2015 at Sugekari Elementary School
Congruence of Geometric Figures – Grade 5
Teacher: Kudo, Noriko

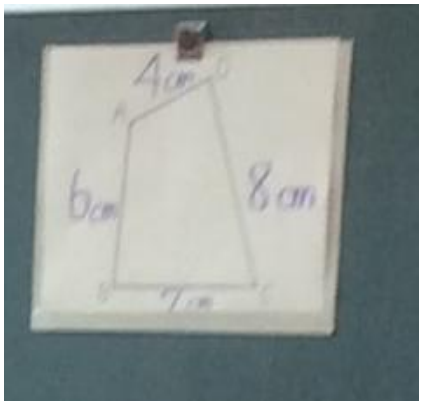
Goal of the Lesson:
Students will:

- Apply the 3 conditions for congruent triangles to find the minimum number of conditions necessary to draw congruent quadrilaterals and can explain why.

Where is the lesson located in the unit?

- The current lesson is number 7 out of 9 lessons in the 5th Grade unit on congruence and angles of geometric figures. In Grade 3, students learned how to draw isosceles and equilateral triangles using the lengths of sides only as they had not learned angle measurements. In Grade 4, they learned how to draw triangles using a side and angles on the ends of the side after they had learned angle measurements. Before this lesson students have learned the meaning of congruence through manipulation. They have investigated the corresponding parts of congruent triangles and understood the term corresponding sides and angles. They have thought about ways to draw congruent triangles and using the SSS, SAS and ASA have drawn congruent triangles. They have explored how to draw congruent figures using as few of information as possible and also realised that congruent triangles cannot always be drawn by using any 3 measurements and worked on practice problems. Prior to this lesson students have learned that geometric figures are made up of vertices, sides and angles. Students have also verified that by cutting a square or rectangle along a diagonal, the two triangles will overlap completely. They also understand that congruent means: the same shape and the same size. In the next two lessons of this unit, students will deepen and solidify their learning.



Introduction: Posing the Task	
Noriko Kudo (the teacher) used yesterday's reflections on the wall, to recap quickly and introduce today's problem . In this way today's work was linked to previous work. All the work from the previous lesson was prominently posted on the wall so these could be referred to and the teacher told the students to keep these in mind for today's problem. The teacher held up a card with the problem hidden on a card under a cover page with a large question mark. Once revealed the students were asked to draw the quadrilateral with 4 side measurements given. The way the problem was presented engaged the students and made them curious. The students were given 2 minutes to draw the quadrilateral. She handed them out the completed quadrilateral and students had to match up what they had drawn with this as a template to see if their quadrilateral was congruent.	 

2. Independent Problem Solving:

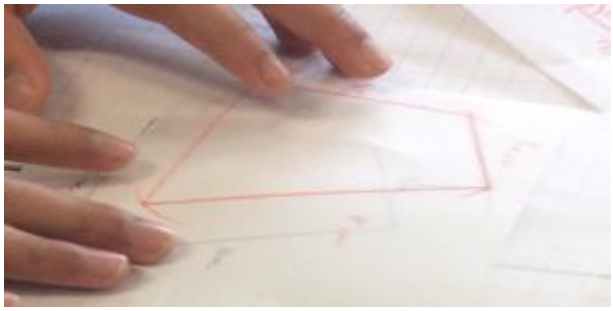
The students were able to check their first attempts with what the teacher handed them out as they drew their attempt on transparent paper which they could see through to check if their quadrilateral was congruent or not. Students began to realise that they could draw BC = 7cm, then BA = 6cm and CD = 8cm but AD posed a problem for the students.
They said it kept moving on them / was not matching up/ and was not accurate. These students however did not give up they persevered. They were convinced they should be able to do it.

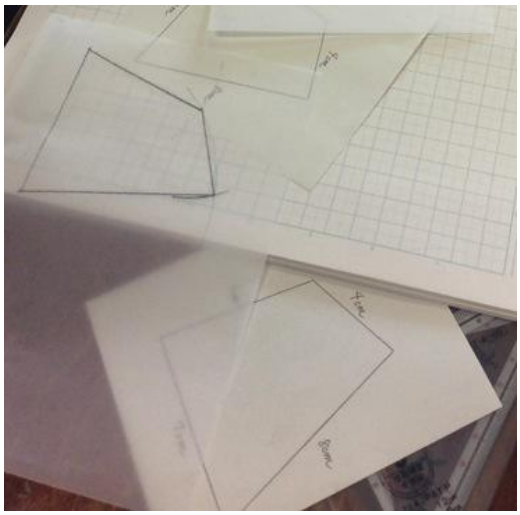
Some students felt they had done it, that is that they were congruent and to these students she asked: Can you do it again for me?
These students realised that whilst they did it first time it was more by luck than anything else and kept rubbing out their work and trying again and again.

From this class discussion it was clear to students that getting the position of vertex A was crucial. Some students also thought that you also needed the position of vertex D as well in order to join A to D.

At this point the teacher posed the question: Can we draw congruent quadrilaterals with just the 4 side measurements?

Students realised from their first attempt this was not possible. The teacher asked what else would “we” need to know in addition to the lengths of four sides to draw congruent quadrilaterals?





3.Presentation of Students’ Thinking, Class Discussion

Some students suggested angles and the teacher now gave them the same quadrilateral but this time included in addition to the lengths of four sides were the two base angles 85 and 70 degrees respectively.

Students now got out their protractors and compasses, without any instruction from the teacher and purposefully set about constructing their new quadrilateral. It was observed that students when they checked their drawing (on the transparency) against the template and realised

they were still not congruent , due to inaccuracies in using their protractors and self-corrected their work.

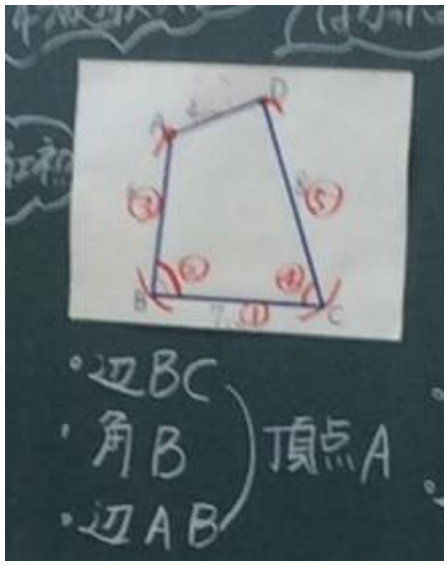
Throughout the teacher kept saying if you didn't get it try again.
The teacher called time up again on this activity.
A student was brought to the board to show how to construct the quadrilateral:
The student drew side BC = 7cm, then angle at B = 85 degrees, side AB= 6 cm, then angle at C= 70 degrees, the side CD = 8cm. The student then explained to the class that knowing the 2 angles and three side measurements A joins to D automatically and accurately.
The teacher summarised that at this stage we need the lengths of 4 sides and 2 angle measurements to draw congruent quadrilaterals.

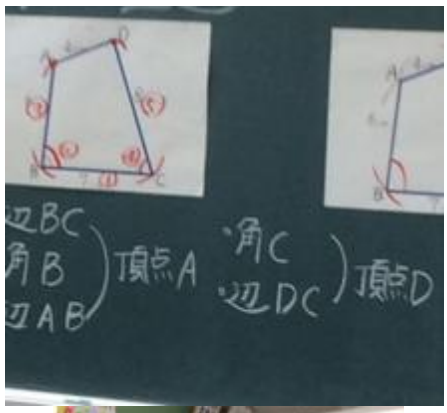
Another student said that they drew angle C first. This student was then brought to the board to construct their quadrilateral. The teacher explained that this was the same as the previous student's work.
The teacher summarised both students' work at this stage and explained how constructing angle B first gives us the position of vertex A, whereas constructing angle C first gives us the position of vertex D.
These explanations were written on the board by the teacher which students took a note of.
The students were now clear that they could draw congruent quadrilaterals if they had known the lengths of 4 sides and 2 angles to.

The teacher then asked that what would we need as a minimum amount of information to draw congruent quadrilaterals?
She called on them to notice that we didn't have to measure all 4 sides, namely AD joined up automatically when we had the 2 angles.

The class became very vocal with enthusiasm at this point. Six students immediately raised their hands. Many students were sitting wondering how could they do this?

One boy said I didn't use angle C at all. He came to the board and explained to the class how he drew BC= 7cm, He measured the angle at B and drew AB= 6am. Then using his compass (centred at A) he drew an arc with the length (radius) = 4cm and an arc centred at C with radius 8cm. The arcs intersected where vertex D should be. He then connected D to A and C.





Another student said I did the same without using angle B at all and used angle C. The teacher got this students to explain this to his class using the previous diagram on the board. She now summarised that we need 4 sides and 1 angle measurement.
At this point she summarised using the board work:
We did it using 3 sides and 2 angles
We did it using 4 sides and 1 angle.
She now posed the question: Can we do it without any angles at all?
She wrote on the board 4 sides and 0 angles.
Who thinks they can do this?

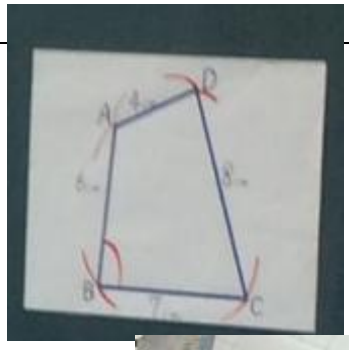
The class again became very animated discussing this possibility with each other.
A student was heard saying “Diagonal”.
The teacher looked at this boy’s work and drew the diagonal on the board saying Mr.X (a student) didn’t use any angles. Check if you can do this with your neighbours?

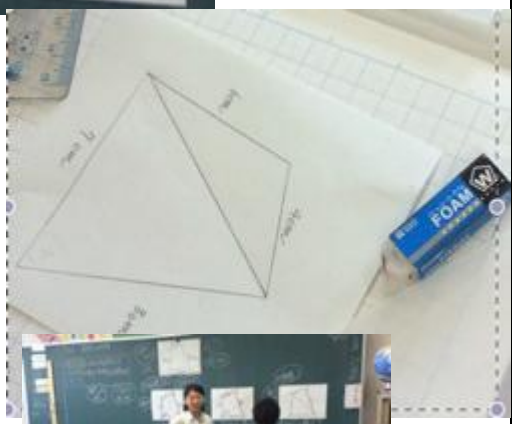
The student who said diagonal initially came to the board and explained how he did it with a diagonal. He drew the diagonal AC. Then using a compass and lengths AB and BC drew arcs to locate vertex B and drew the triangle ABC. Using lengths AD and CD he located vertex D and connected it to A and C.

Another boy said I used a different diagonal. He came and pointed out on the board how he used the diagonal BD.

This required careful explanations by the teacher.
The use of colour by both the students in their copybooks and the teacher on the board was noted.

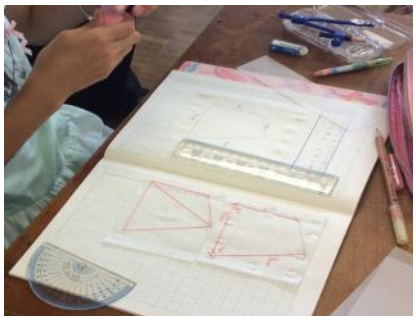
The teacher continuously made regular check ins and offered hints and suggestions when required. The students were encouraged to talk to each other about the work.
Most students appeared to think about the problem themselves and then refer to their partner for checking.





4. Summary/Consolidation of Knowledge

With 4 minutes left the teacher recapped on the lesson using all solutions which had been captured on the board very clearly. Although the solutions were discussed as individual solutions there wasn't much comparison apart from quickly comparing the amount of information used. No depth was given to this discussion.
The students were asked to paste their transparencies into their copybooks and write their reflections on what they had learned. The students are obviously used to this and these are used in the next lesson. Without reading the reflections it would be difficult to judge the consolidation of knowledge at the end of this lesson.
Three students were called upon to read out their reflections.



1.What new insights did you gain about mathematics or pedagogy from the **debriefing and group discussion of the lesson**?

The post lesson discussion was focused on the goal of the lesson and productive as a result. It was interesting how every decision the teacher made was discussed in detail: from forgetting to use the visual tool (Geostrips), using red to highlight measurements, using mathematics vocabulary to using yellow on white paper. There was a long discussion on using the visual tool. Geostrips could visually display that being given four 4 sides of a quadrilateral we cannot construct a unique quadrilateral. So it's natural to ask what other conditions are required in order to draw a unique quadrilateeral. This introduction not only made connections to students' previous knowledge, but also made the task of this lesson clear and open. Observers were able to be honest and really discuss the finer details of the lesson plan whilst still fostering a collaborative environment where they were all trying to learn something new. An interesting comment from the moderator at the debriefing was while it is not possible for a teacher to see what all students are doing it is possible for a teacher to pick up on all their voices.
The Professor made some insightful comments:

1. Good idea to use students' reflections from a previous lesson used at the start of the next lesson
2. Whilst the students responded well to the task set should the teacher always be responsible for setting the task? This was an interesting and new insight. Following on he said how students should/could based on a previous lesson be setting/posing the task for themselves.
3. Referring back to a document written in the 1950s seemed strange at first but so pertinent. This document stated what the essence of good teaching is: "it is to promote students' continuous growth. This should be based on utilising their experiences and continue to use and nurture these experiences".
4. Did the students' reflections match the goal of the lesson (see earlier comment above)?

2.What new insights did you gain about how administrators can support teachers to do lesson study?

Firstly, administrators should be leaders of learning as was evident in this school. Lesson Study is across the continuum at all levels not just one individual or team. Creating or allowing time for planning is vital. Many pre-lesson meetings and mock-ups for this lesson had taken place and this meant that the lesson was the best it could possibly be. Secondly, administrators should identify important research themes to improve the schools' teaching practice significantly. Thirdly, invite knowlegebal others to provide their comments is also very helpful for school teachers. They need voices from outside.

3. How does this lesson contribute to our understanding of high-impact practices?

Teaching mathematics through problem solving seems as a principle in Japan, as almost all the lessons that we observed, including this one, were organised by solving a key mathematics problem. In this class, the main problem was posed by the teacher at the beginning of the lesson. However, she quickly created a friendly, cooperative, inquiry learning environment and attracted her students' attentions by asking a sequence of sub-questions. Students' learning was guided but they still involved in explorations of solving the problem. Allowing students to explore geometry in such ways was really enlightening. The teacher did plenty of check-ins during the lesson; however we would include a caveat here: as observers we were still concerned whether all the students (especially the slower students in the class) were actively engaged in the learning under the high-impact practice. The needs of some students may have been ignored as they kept silent. As observers we would on the one hand commend the high quality use of mathematical vocabulary but on the other hand wonder if all students were adequately mathematically literate to understand all the terms used?

June 25: TGU International Secondary School

Research Lesson Observation Form
'Writing an Equation for a Recurrence Relationship'
25/6/2015
Grade 7

Observation team:
Aoibhinn Ní Shúilleabháin
Jacqui Lomas
Mary O'Connor
Matilde Warden

What are the primary lesson goals?

The goals for the lesson align with the IB curriculum and are detailed below as per the lesson plan:

Criterion B: identify a recurrence relationship in the phenomena and represent it as a general rule using an equation with words that are appropriate for the problem context
Criterion D: Carry out numerical calculations using the equation and interpret the results in the problem context.

Where is the lesson located within the unit (in relation to previously studied topics and ideas to be studied in the future)?

The lesson is in the unit '*how to observe phenomena*' as defined by the school's grade 7 curriculum. This unit is broken into three sections: 1. Tables and graphs, 2. Recurrence relationships, and 3. Equations with letters and linear equations. This research lesson is the first lesson in the 'recurrence relationships' section of this unit.

Students will have had experience solving problems involving functional relationships using tables and graphs and are used to working with whole numbers and integers.
In this lesson, students will likely use the tools they have met in the previous section of this unit and will be encouraged to write relationships in word equations before moving on to more formal algebra in the final section of this unit.

Lesson Phase	Notes
1. Introduction, Posing Task	-Strategies to build interest or connect to prior knowledge -Exact posing of problem, including visuals The teacher presented a problem set in the real life context of taking prescribed medicine. He displayed a photograph of the prescription and medicine and highlighted the doctor's instruction which told him to take the medicine 3 times a day or every 8 hours. He asked students why medicine might be prescribed in this way which prompted student comments suggesting "maybe the medicine is only effective for 8 hours", "maybe there are side effects", and if you didn't take it in these intervals it may not be effective.

	 **Figure 1 Introducing the problem** Without understanding the language used by students it is difficult to know whether the teacher emphasized the particular comment which was related to the lesson (I.e. the effectiveness of the medicine due to the prescribed interval). The teacher then outlined the problem in text to the students on the overhead projector. In building the context of the problem the teacher had prepared a slide about how medicine works in the body, which also links to other areas of the curriculum. The teacher informed students that he wanted them to attempt the problem individually and they would then share their strategies as a class group. He did not relate the problem back to any of their prior learning or to the graphics calculator which they had learned to use the previous week, likely to encourage students to attempt to solve the problem and decide to use specific tools as an independent activity. Without prompt, students asked very relevant questions: "are you talking about the amount of medicine in the blood?" and "what do you mean by the amount decreasing by a half?" A number of students also wanted to clarify the details of the question: "do we add 200 and then 100 or just 200?". The teacher did not seem to have anticipated these questions and did not spend time addressing them explicitly. Unfortunately, he did not use the opportunity to speak about assumptions in mathematical modeling, and references to modelling a mathematical problem were not highlighted in the lesson plan although the problem lent itself to this learning objective.
2. **Independent Problem-Solving**	**-Individual, pairs, group, or combination of strategies?** -Experience of diverse learners - Teacher's activities Students began to individually attempt the problem in a number of different ways: numerically, using diagrams, describing the problem in words, and tabulating results.

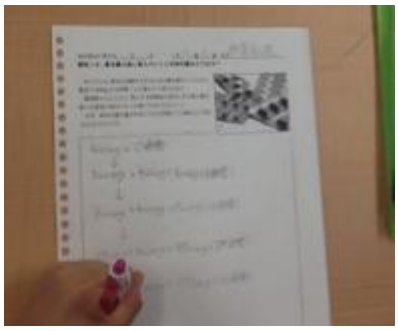


Figure 5

Numerical strategy

Figure 4 Using diagrams

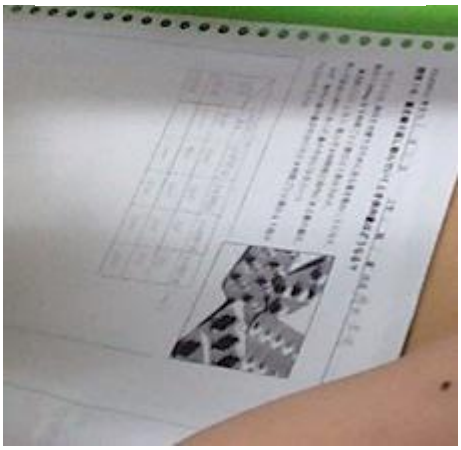


Figure 2 Tabulating

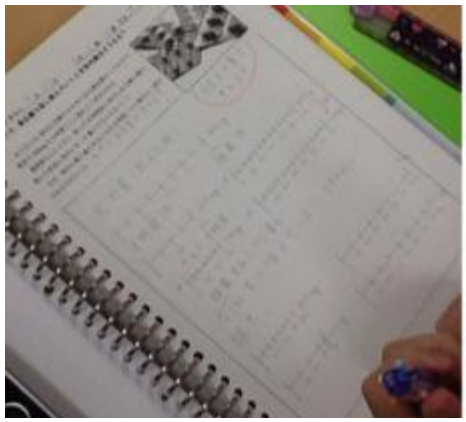


Figure 3 Describing problem in words

Unfortunately, very many students calculated the recursive change for only a small number of iterations which reduced their opportunity to realize the amount limiting over a long period of time.

During this time the teacher went around the room making note of students' strategies but not engaging with any students.
Students had 12 minutes of independent working time before one student was chosen to present her work on the board. While this student wrote her work on the blackboard, students continued to work individually on the activity.

Figure 6 Student writing strategy on the board

The student called to write her solution on the board had numerically calculated the amount of medicine in the body for three iterations. No other student was called to present their work using different ideas or strategies.

Students were not encouraged to speak with one another and unfortunately this meant that students who did not know how to proceed with the question remained stuck. One student spent this time busily ensuring her arrows were drawn perfectly with a ruler - thus giving the impression of engagement while not engaging with the mathematical content. Four students to the left of the blackboard were still struggling to start the calculation which clearly identified that they had not understood the concept of the problem.

Figure 8 Extending numerical solution

Despite the teacher initially telling the pupils there would be an opportunity for them to share their ideas once they had attempted the problem individually, this did not happen. A number of students added a constant amount each time and had not recognized the recurrence relationship.

At 15 minutes, while the first student was writing her solution on the board, it was notable that many students were not sure how to continue with the problem. At this point one student asked "Do we stop after one day?" The teacher announced that they should do their calculations for 5 days – this should likely have been pointed out at the beginning of the lesson. There was no discussion as to why the students should continue the calculations for 5 days and for many students it was just a mechanical exercise as they were not seeing the recursive element of the procedure.

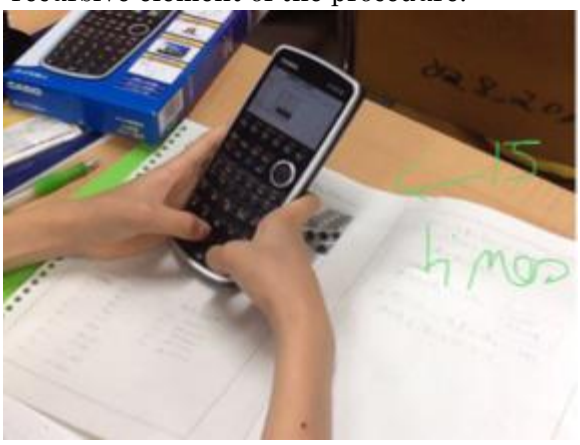


Figure 7 Making use of the graphics calculator

After this comment and with the strategy on the board, more students began to approach the problem numerically but it is not clear whether they were interpreting a link between the prior and next amount of medicine in the patient's body (the Now-Next relationship outlined in the lesson plan).

Two students began to use their graphical calculators; however, they seemed unsure why they were using them. One pair of girls seemed to be looking at their calculator together. On closer inspection they were simply looking for a button rather than discussing any mathematics. The two students adding the constant amount continued to do this, including one of the students producing a linear graph of results.

The teacher led discussion, which began 28 minutes into the lesson, and only focused on the numerical strategy written on the board.
He asked students how they could explain these iterations more clearly, which did not seem to encourage many initial responses, but a small cohort of students engaged with the teacher in describing what the numbers related to: "the medicine in the body".

During this *neriage* or discussion, the majority of students continued to work individually, paying little attention to what the teacher was describing at the board. Others who copied the notes from the board into their books but did not engage in the conversation.

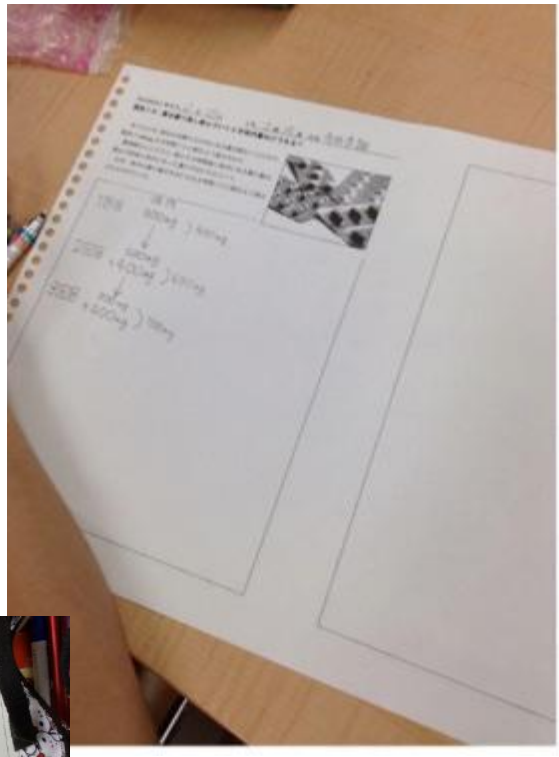
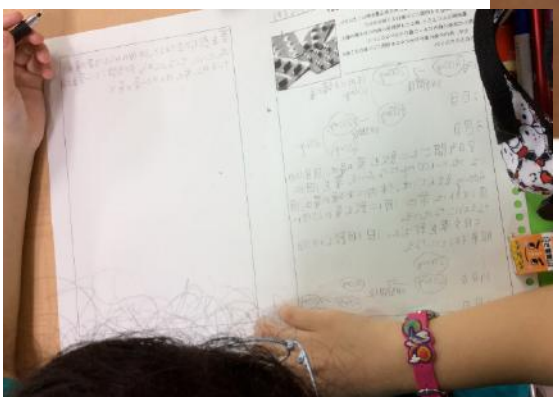
At 32 minutes, the teacher introduced the Now/NEXT relationship to students. We found this discussion to be poorly conducted on the part of the teacher, who, despite having traversed the room and viewed most students' work, did not choose a sequence of students to participate in the discussion nor referenced different strategies students may have reached. At this stage the teacher suggested that the pupils keep repeating the procedure [Now] *÷2 +400=[Next]*. He asked students what the [Now] and [Next] meant but very few students were able to answer, one boy suggested that the amount 8 hours ago becomes the new amount after each calculation , his words were 'it keeps going around'.

Figure 9 Introducing the Now-Next relationship

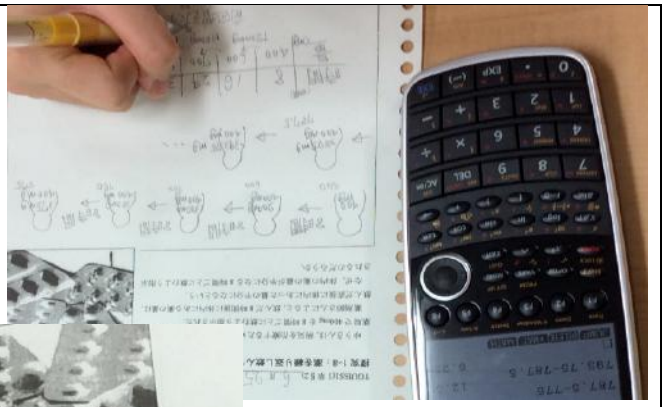
There were missed opportunities for paired work which would have provided opportunities for more students to be actively engaged with the mathematics and possibly get themselves onto more efficient/correct strategies.

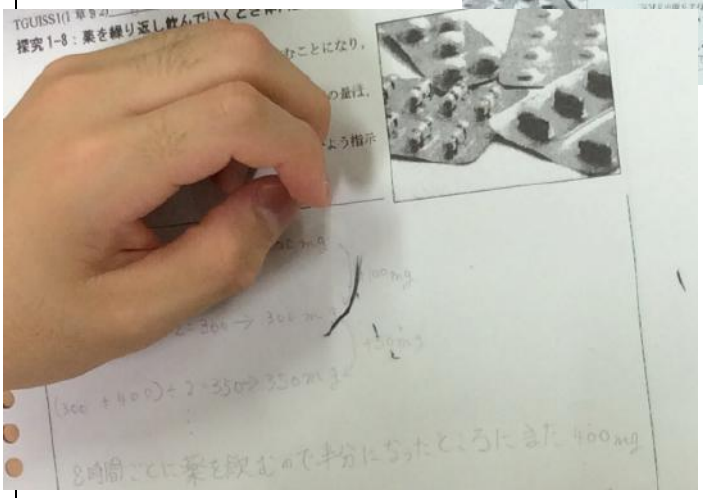
At 45 minutes the teacher suggested that students use the graphics calculators in attempting to define what happened to the level of medicine in the body over time. Students were shown (or it was revised) how to use the ANS button to generate the recurrence relationship. Some had mastered the use of the ANS button but it was not clear if they understood why they could use this button on the calculator and what each result was producing. During this exposition no reference was made to the

Figure 10 Using the graphics calculator

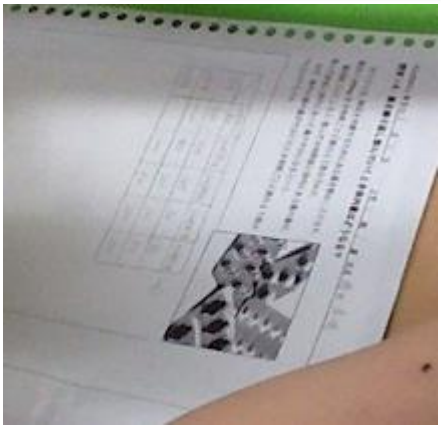
	students who had already begun to attempt to answer the question using the graphics calculator and no link was made with the word equation. The majority of students then began to use their calculators but we are uncertain as to whether they understood the purpose of using the calculator and the link with the NOW-NEXT equation defined to them on the board. This meant the activity was stand alone and lacked purpose as there was not enough time to explore limits of the sequence.
3. Presentation of Students' Thinking, Class Discussion	**Student Thinking / Visuals / Peer Responses /Teacher Responses** Photos to document chronology We had originally expected students to approach the problem numerically, with a table, or describing the equation. A number of students approached the problem numerically, quickly adding up the numbers as a trivial numerical task. There was no indication however that students were beginning to identify a relationship between prior and subsequent answers although this was difficult to interpret on our part due to the language barrier. A number of students began to use a mix of numerical answers with a diagrammatic sign of what was occurring with the medicine at each interval. The majority of students stopped their calculations after two or three iterations. We think this was because the teacher initially spoke about how much medicine you take in one day at the start of the lesson – this would equate to two or three doses of medicine, depending on where the students start.   This student calculated one day of medicine and the student repeated the same calculations in her explanation.

More iterations here and tabulated results also evidence of working out size of difference on the calculator.





Student calculations recording decrease and increase.

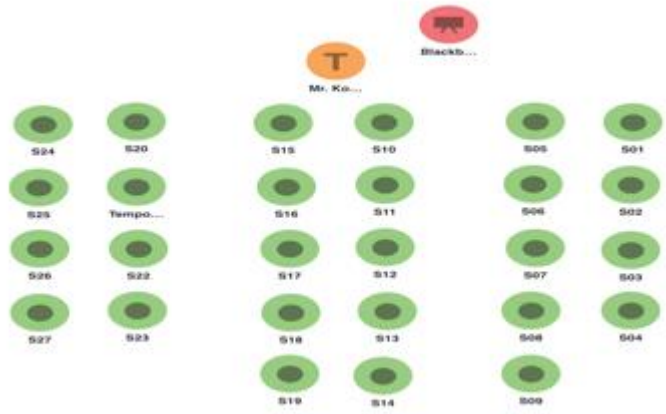


One student began his problem with a table documenting the recurrent change at each iteration. This was an innovative approach to the problem but unfortunately, did not include the total amount of medicine in the body at each interval and the student would therefore have been unable to conclude anything about a limiting value of the problem.

One boy began to graph his data but the graph did not seem to make sense or correlate with the problem. This may have been explained by the student in writing that we were unable to translate.

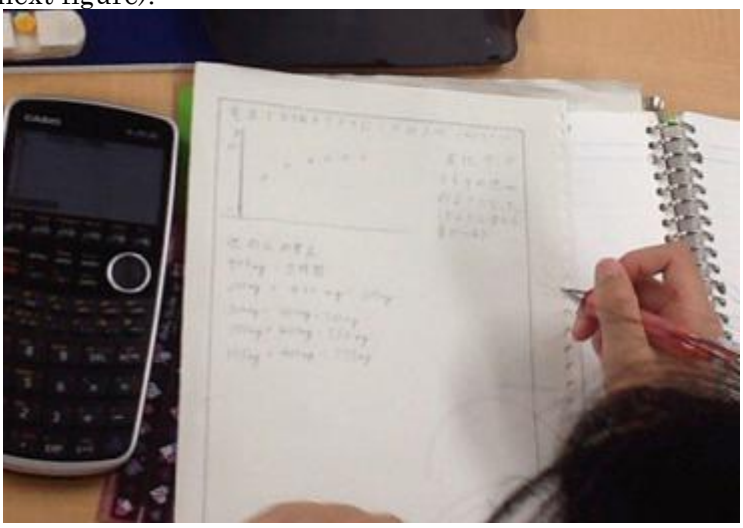
The teacher didn't make any reference to this graphical solution during *neriage* or when travelling around the room, so if this boy was on the wrong path, there was no way that he would have known.

During the class discussion the teacher only called on six students. Despite there being 18 girls and 8 boys in the class, five out of these six students called upon were boys they are S01, S02, S03, S05 and S06 in the seating plan below, all these students called out their answers. The only female participant was student S24, at the front of the room.



Seating Plan of Classrooom

There were many quiet, studious children who were not called upon to discuss their answers, despite having made very good attempts (like the girl seated at the back of the class who had found a numerical solution which she then graphed shown in the next figure).



During the discussion (*neriage*) and aside from the six participating students, the rest of the class seemed to be just copying down the work on the board. The teacher asked twice: 'Is everyone OK with this?' and both times no one answered.

The teacher did not utilize students' feedback in noticing the decreasing increase of change of overall medicine in the patient's body. He did not optimally build on students' observations in building a discussion around the recursive relationship.

In his conclusion of the lesson, the teacher incorporated the graphics calculator as a way of showing students what happened to the total level of medicine in a

	patients' body if they took the medicine for 5 days as was specified in the prescription. As part of this portion of the lesson, the teacher used the projector to show students the calculator and prescription again. He also showed students a graph of the values converging towards 800mg – although we do not feel that students had any sense of the meaning of this value or of the convergence.
4. Summary /Consolidation of Knowledge	Strategies to support consolidation, e.g., blackboard writing, class discussion, math journals. Unfortunately, despite several approaches being used, only one strategy was documented on the board. While the teacher did attempt to orchestrate a class discussion, it included only about one fifth of the class and we observed many students who were either not engaged with the conversation between these few students and the teacher or were unable to access the content of the discussion. The class discussion consisted of closed questions which related to the numerical calculations within the problem and did not delve into deeper underlying issues of the recursion pattern. The teacher did get students to identify the instant for which they were calculating the level of medicine within the person's body, and students correctly identified this as immediately before and immediately after taking the medicine. However, the meaning of these calculations converging to a limit of 800 was not highlighted as an important element of the problem. While this was the first lesson of the sequence and it is likely that the teacher would follow up on the mathematical content of the question, we do not feel that the majority of students' learning was consolidated within this lesson.

What new insights did you gain about mathematics or pedagogy from the debriefing and group discussion of the lesson?

From the post-lesson discussion it was interesting to note that the feedback focused on the teacher drawing the problem back to the context of the medicine. The teacher was advised that in order to motivate students to cognitively engage with the problem, the context around taking medicine at specific times which could have been then referred to in the conclusion of the lesson.

There were also comments made on the fact that only one solution was presented and the choice of that example, this meant a narrow discussion of the solution rather students internalizing the problem in its context. The teacher agreed but was concerned about time.
It was also noted that the teacher rather than the students had developed the word equation and they were concerned that students had not understood. The teacher agreed saying that when he had looked at the work they were not yet using the word equations.

Participants in this discussion were curious as to the prior knowledge of these students in asking when they had first began using graphing calculators and questioning whether they had sufficiently mastered it in incorporating it as part of this problem.

Teachers who observed the lesson focused on students' learning in the post-lesson discussion and

noted that, in their opinion, not all students had realized the meaning of the medicine stabilizing at a value of 800. They advised the teacher that the conversation around context should have been extended at the end of the lesson to provide students with conclusive reasons for having engaged in the problem. These teachers also questioned if students had 'internalized' the word sentence derived from the problem which was the objective of the lesson.

What new insights did you gain about how administrators can support teachers to do lesson study?

It was interesting to learn how all teachers came together to observe and reflect on the research lesson. The teachers' colleagues recommended ways to improve the lesson by, for example, having students first define the problem in words before attempting a mathematical solution. Teachers also suggested that the context of the question be utilized more in having students find and define an answer.
Aside from the discussion, it was very interesting to note how mathematics education professors are invited to the schools as the knowledgeable other to reflect on the lesson in terms of both content and pedagogy. This practice seems to be very beneficial for all teachers in attendance and provides much food for thought in further reflecting on the lesson.

It is worth noting the important role of the administrators in allowing the classroom where the research lesson occurred to remain free for the post-lesson discussion. It was also necessary that the conducting teacher not teach another class immediately following the research lesson in order to discuss with and respond to his colleagues' observations.
The administration further supported teachers in inviting external observers to the school from other districts in the area, and indeed international observers. This practice seemed to benefit the local teachers in sharing a broad range of experiences around mathematics through their collaboration in lesson study.

In relation to this lesson, a mock lesson to colleagues during planning time may have given the conducting teacher more of a feel for what could be done in a certain amount of time and how different strategies could be used effectively to promote mathematical thinking for the whole class.

Overall, collaboration of a group of teachers seems to be a more effective way of addressing the issue of promoting mathematical thinking instead of one teacher individually planning a research lesson.

How does this lesson contribute to our understanding of high-impact practices?

A contextualised problem should have a very definite learning objective:
This lesson contributes to our understanding of high-impact practices in realising that contextualised problems which may contain very rich mathematics, should have a very definite learning objective within one lesson. This was a very good context-based task for students to attempt but the objective seemed confused between having students calculate the iterative sequence, define a sense of a limit, utilise the graphics calculator, or identify a NOW-NEXT relationship. The learning objective should remain very focused and finite within one particular lesson.

Various strategies should be explored and attended to:
Interestingly, the teacher only showcased one student strategy on the board for this lesson where there were a wide number of different strategies which he could have explored with students. In contributing to high-impact practices, various strategies should be explored and attended to within a

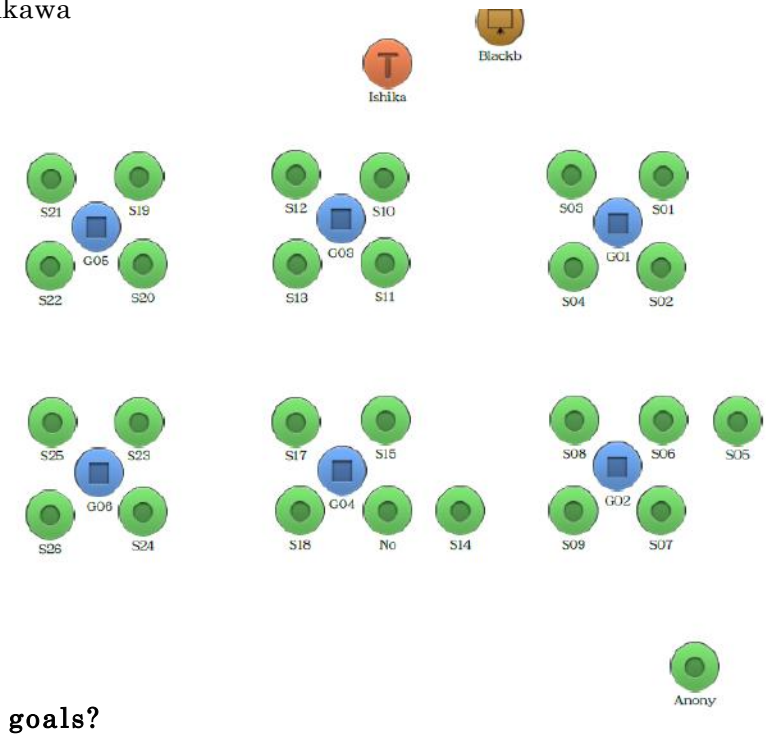
mathematics lesson. These strategies should be specifically chosen and be met in a particular sequence which will support students' mathematical understanding.

Sharing of mathematical thinking:
Student communication of their mathematical thinking can support their learning, particularly for unfamiliar activities. In this lesson, students did not have the opportunity to share their strategies nor justify their thinking with one another. In the whole class discussion, only a handful of students were willing to speak about their strategies with the teacher and the majority of students were disengaged in the mathematical content and conversation. Employing peer-learning strategies where students explain their mathematical thinking with their neighbour can be a very positive high-impact practice which was unfortunately absent from this lesson. Related to this point, there needs to be careful attention to allocation of time within the lesson where students are provided with appropriate time to work individually, communicate and collaborate within the lesson.

June 26: Oshihara Elementary Secondary School

Research Lesson Observation Form: Sarah Seleznyov and Kalai Shanmugan

School : Showa City Oshihara Elementary School
Time :1:50 p.m. to 2.35 p.m. **Date:**26 June 2015 **Day:** Thursday
Grade :3
Name of the unit: Let's think about Division! (Division with Remainders)
Name of Teacher: Yuji Ishikawa



What are the primary lesson goals?

- For students to understand the problem situation, represent the situation with a maths sentence and find the answer to 9 ÷ 2
- For students to discuss how to deal with the remainder based on the problem situation
- For students to generalize that there are problem situations where the quotient can continue to be divided
-

Where is the lesson located within the unit (in relation to previously studied topics and ideas to be studied in the future)?

This is the final lesson in a series of four units on division. The research lesson is marked in bold below.

Unit 1
Lesson 1 & 2: understand how to solve division problems with one digit solutions and the meaning of remainders
Lesson 3: Understand the relation between remainders and divisors (that remainders are less than divisors)
Lesson 4: Understand that division with a remainder can apply to partitive problems
Lesson 5: Understand how to check answers for division problems resulting in remainders
Lesson 6: Practice calculating division with remainders

Unit 2
Lesson 1 & 2: Represent a division situation with a calculation and find the solution, including the remainder
Lesson 3: Practice problem solving using division
Lesson 4: Explore how to deal with a remainder which can continue to be divided (eg into a fraction of a whole)

In Grade 4, students will learn to divide using decimal numbers.

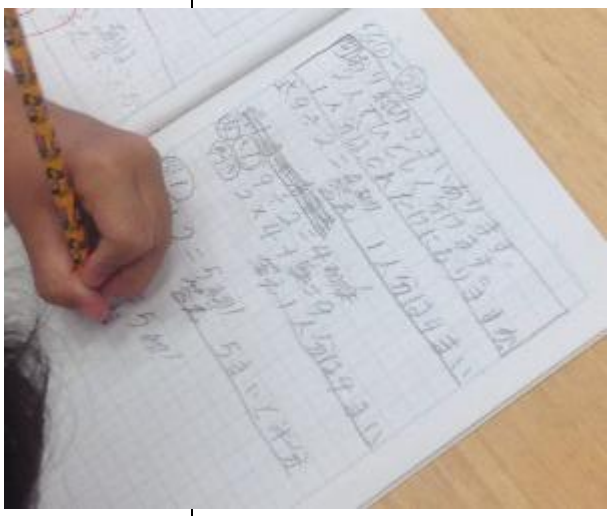
Start &End Time	Lesson Phase	Notes
	1. Introduction, Posing Task	**-Strategies to build interest or connect to prior knowledge** -Exact posing of problem, including visuals The lesson began with a quick warm-up activity, with clapping around the class. The teacher explains the first problem orally, uses concrete materials (nine origami papers stuck on the board) and engages students with these by asking them to count the number of papers with him. He also asks students to record the problem as a mathematical calculation and to relate it to a calculation they can understand, namely 9 ÷ 3 =   Several student questions support the understanding of the problem, including questions about what 'equally' means, where the 9 came from, that the problem is looking for the amount (which they have not previously done), etc. The teacher is open to hearing and addressing these question, showing he values them by recording the child's name next to the query on the board. The teacher ensured students had a clear understanding of the calculation: dividend, quotient, and divisor. The teacher also reminds the students of previous work done on revision by reminding

		them of a problem tackled using people and seats. When introducing the final two problems, the teacher takes the time to explore students' understanding of the two questions, for example by discussing whether it is asking for an answer in terms of number of pancakes or people.
	2. **Independent Problem-Solving**	**-Individual, pairs, group, or combination of strategies?** -Experience of diverse learners - Teacher's activities There was no paired or group talk in this lesson, but there were two periods of individual work, after the setting of the initial problem and after the setting of the final two problems. During the individual work, the teacher did move around the room checking students' work and occasionally talking quietly to certain students. After the given time for individual work was over, answers were reviewed by the teacher at the board through *neriage*. In terms of students responding to questions and/or being asked to come up to the board to demonstrate their learning, there is inequality of participation, with boys more likely to be asked to contribute than girls (see below).   S08 still thinking what to write Students' responses to initial problem: 9 ÷ 2 = 4 r1 (3 students) 9 ÷ 2 = ¼ (1 student) 4 sheets (1 student) 4 ½. (1 student) Students' responses to two final problems: One student represents this pictorially using the same symbols as are used on the board (people and origami – instead of pancakes) and gives each person five 11 ÷ 2 = 5r1, answer is 5 1/2 .

	3.Presentation of Students' Thinking, Class Discussion	**Student Thinking / Visuals / Peer Responses /Teacher Responses** Photos to document chronology (use new box for each new student idea presented]

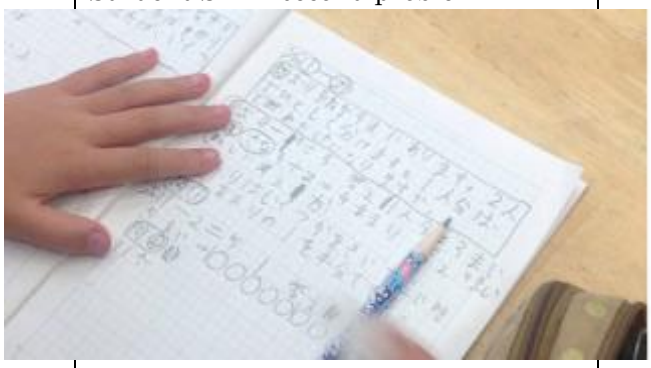
Student S14

Student S15

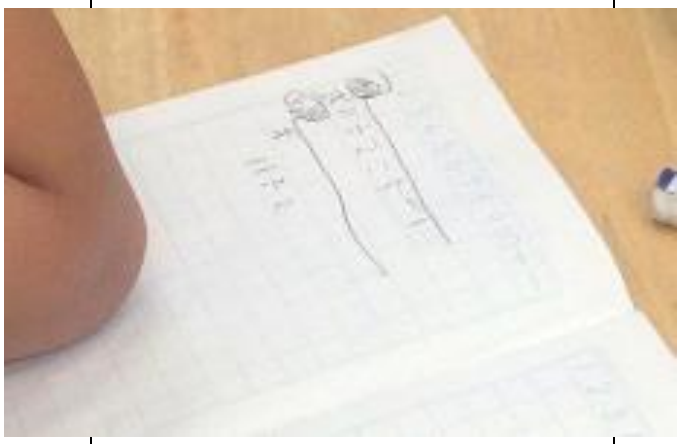


Student S10

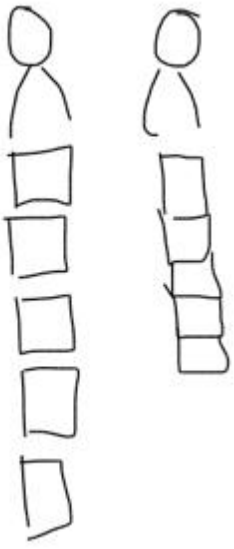
Student S14 – second problem



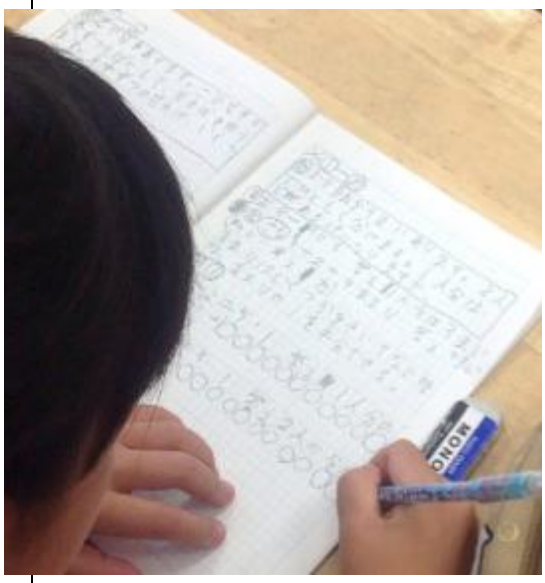
Student S17



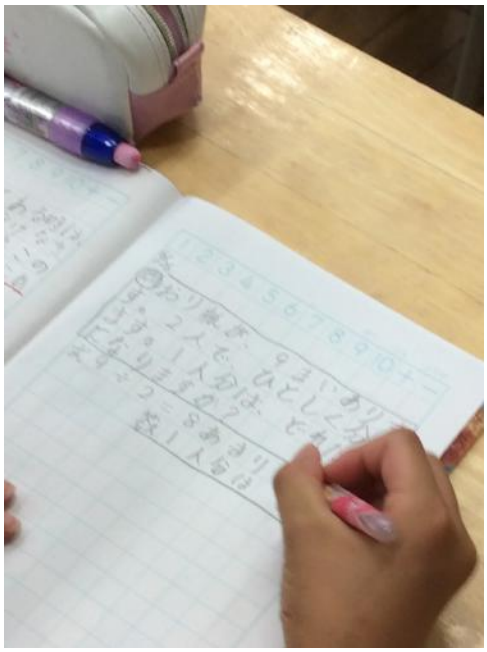
Student S18 (my representation of her work)



Student S14



Student S07



Student S07

Student S0

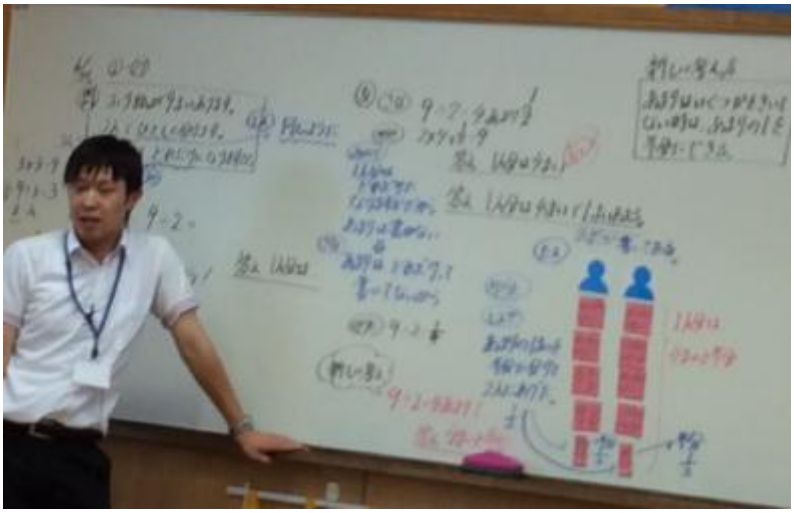
Student S09

	4.Summary/Consolidation of Knowledge	Strategies to support consolidation, e.g., blackboard writing, class discussion, math journals. There is a probing discussion with pupils about what we should do with the remainder where students' thinking is clearly articulated: - *Two people equally divide so we don't need to use the remainder in the answer.* - *He isn't asking what remains so we don't need to write the remainder.* There is also a good discussion about the meaning of half and this is modelled using the origami paper – rejoining the paper which has been split. End-up the lesson after writing the reflection session. There are some missed opportunities to unpick misconceptions and/or deepen mathematical understanding in relation to division: - When the student says the answer is ¼, he is not given the opportunity to explain his reasoning, nor to use the origamis papers to model what ¼ actually is and whether it is relevant to this division problem. The student comes back to this problem later in the lesson, but again it is not fully explored. - The teacher records half using mathematical notation (1/2) instead of words so we cannot be sure wther the students knew and could use this knowledge in this problem context (this could also have linked back to the discussion about ¼) - When the student says that cars cannot be divided further, the students are not asked for suggestion of objects within problems that can and cannot be divided further – this could have been developed further using partner talk - When the teacher summarises learning in the middle of the lesson (after the first problem has been resolved) and at the end of the lesson, students could be asked to summarise what they have learnt. This would mean the teacher would be able to instantly assess the success of his teaching and address any remaining misconceptions through neriage. - When one students says (about the second pancake problem), *we could cut everything into pancakes then share*, this is not taken on board or explored There are several opportunities for the children to engage with the concrete apparatus on the board (the people symbols, origami paper and the pancakes), but not all of these are used by the teacher: - When modelling 9 ÷ 2, the teacher uses the people and the paper himself, instead of asking a student to do this - Concrete apparatus is not available to students at their tables and this is a missed opportunity to support students who are struggling with these concepts – paired work using concrete models would have perhaps been a good idea - One student is encouraged to use the origami paper to model cutting it in half (although this was raised as an issue in Japan, in another context the idea of cutting an origami paper in half would not be problematic) - It is unclear to the observers whether students respond to questions that check understanding, for example: *Do we all understand?* When questions like these are asked, either responses are too quiet to be heard or not visible to observers. It would perhaps have been productive to ask individual students (and perhaps those who have

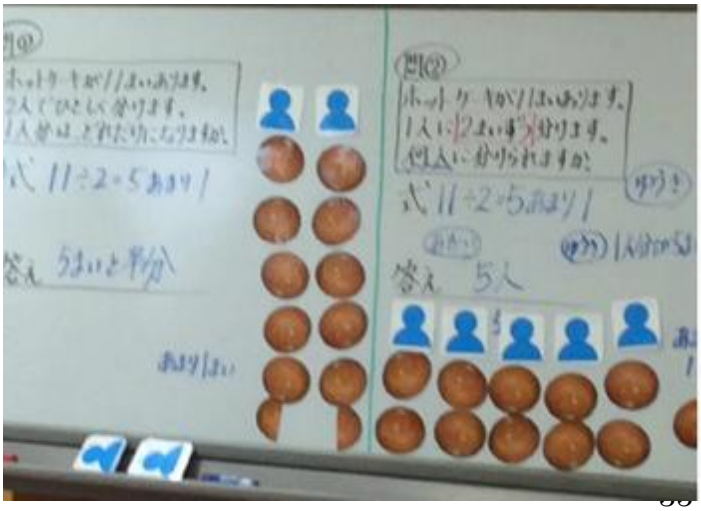
		not raised their hands) to explain their understanding in order to check it. If this direct intervention were felt to be too threatening, the teacher could have asked students to discuss this with their partner. There was a good example of 'revoicing' at the end of the session when the students were generalizing about when you can and cannot continue to divide. One student said *We can divide the remainder into two when the number of things is fixed for each person.* He is asked to repeat this by the teacher. Unfortunately, the other students are not given an opportunity to discuss this with a partner and no other student is asked to explain it, so we cannot be sure how many students have understood this and with what depth. It is at this generalization stage that one child places his head onto the desk and several others begin to have puzzled looks on their faces (as noted by the kochi). It would seem therefore that replying on one or two students' explanation of the rules is insufficient to enable the majority of students to understand and use this rule. These rules would need further exploration and reinforcement in a subsequent lesson, perhaps through looking, sorting and/or designing examples of problems which can and cannot continue to be divided. Students' inability to articulate end of lesson reflections demonstrate that there was not a full understanding eg *Today I did a very difficult division.* Or *Today I learned something new in maths.*

Boardwork:

First problem



Second problem



An analysis of interactions shows that the neriage was heavily dominated by boys (see table below), despite the fact that there were only 11 boys compared to 15 girls:

Student	Number of interactions noted	Gender
S02	1	F
S03	2	F
S05	3	F
S07	3	F
S08	1	F
S12	1	F
S13	0	F
S14	2	F
S15	1	F
S16	0	F
S18	1	F
S20	1	F
S21	1	F
S24	1	F
S26	2	F

Total: 20
Range: 0-2
Mean: 1.3

Student	Number of interactions noted	Gender
S01	2	M
S04	11	M
S06	4	M
S09	3	M
S10	5	M
S11	3	M
S17	2	M
S19	0	M
S22	3	M
S23	1	M
S25	3	M

Total: 37
Range: 0-11
Mean: 3.4

What new insights did you gain about mathematics or pedagogy from the debriefing and group discussion of the lesson?

There were several interesting discussion themes during the 45 minute post-lesson discussion and the presentation by the kochi:
- the issue of what objects can and cannot be further divided when they see a remainder eg the idea that a single car can never be further divided, and that this could have been further pursued or developed
- the level of difficulty and whether it was appropriate for the class in question: whether they are ready for fractions when decimals are normally used in this context; whether it was appropriate to offer both problems simultaneously given the challenging nature of the lesson
- whether sufficient children participated in neriage, and it was interesting to hear that the teacher wants to include ideas from quieter children as well as those who raise their hands to contribute
- theneed for careful selection of numbers related to the notion of halving (which relies on having one as a remainder and dividing by 2)
- the need to connect everyday experiences of division to calculations (and whether the selection of origami paper was appropriate in this context - this is very culturally-specific), including whether it is useful to explore the concept of further dividing the remainder with students as it brings them back to a concrete understanding of what division actually means and enables them to resolve 'problem' remainders
- the two responses that were not followed through as effectively as they could have been, namely:

'1/4' and 'just cut them all in half and then share them out', which raises the need to balance the progress of the lesson towards the goals against the need to follow students' lines of thinking
- the need for diagrammatical representations as well as calculations; whether the teacher placed enough emphasis on this during the lesson and how this might have supported those who were struggling; whether giving these students access to the concrete materials to model the situation might have helped their understanding
- that the two different concepts of fractions in relation to division need to be considered eg 9 divide by 2 is 4 and a half, but also half of 12 is 6
- the fact that the two 'rules' written up at the end of the lesson were not actually correct because depending on the object represented by the two different numbers, you could or could not continue to divide the remainder in both problem contexts

What new insights did you gain about how administrators can support teachers to do lesson study?

The most interesting aspect of today was the post-lesson discussion which had a real flow to it (a neriage?) with comments building on comments. There were also lots of comments that focused on specific observations of students and their work, and this helps make the discussion more concrete and meaningful. It felt as if there were distinct threads that I could follow and which had relevance to the lesson I saw.

It felt as if that today's lesson was a shared effort, rather than the sole responsibility of the focus teacher, as this aligns more closely with my understanding of how lesson study can work in the UK. When the teacher was questioned, members of the planning committee often answered for him or backed up his answers, explaining that these were collective decisions.

It was very interesting to hear that teachers are assigned to watching particular groups of students during the lesson as this matches the practice some of us have adopted in our lesson study projects.

It was also a welcome change to see a female chair and she played a strong role today, backing the decisions of the focus teacher.

There was a strong collaboration between administrators and teachers focused on improving teachers' classroom teaching and learning strategies.

How does this lesson contribute to our understanding of high-impact practices?

Aspects of mathematics that appear to be straightforward (eg the concept of division with a remainder), hide several layers of complexity. If these are not fully understood by teachers and explored with students, it is likely that student misconceptions will emerge in the future. The process of lesson study can help teachers explore and understand the complexities of mathematical concepts in order to ensure that learning for students is more carefully constructed.

June 27: University Yamanashi Model Elementary School, Lesson 1

Research Lesson Observation Form for Group Facilitation and Report -

Lesson 5 –University Yamanashi Model Elementary School; June 27th 2015
Class: Grade 5
Teacher: Sayuri Kasai

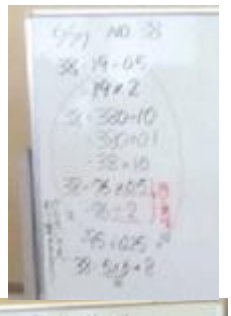
Sandie Blakesley; Bridget Clay; Mariel Laureano

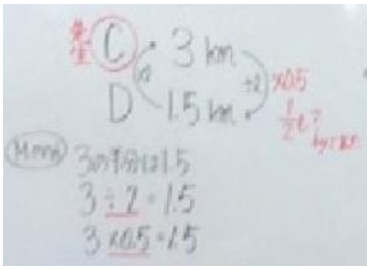
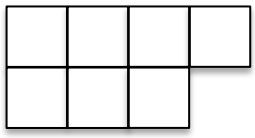
What are the primary lesson goals?

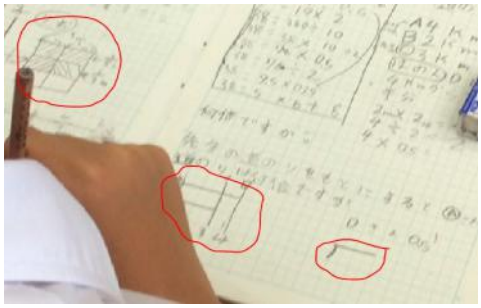
The goal was that students should understand that fractions can be used to express the relationship between two quantities using the idea of 'times as much' and the principle of 'quotitive division'

Where is the lesson located within the unit (in relation to previously studied topics and ideas to be studied in the future)?

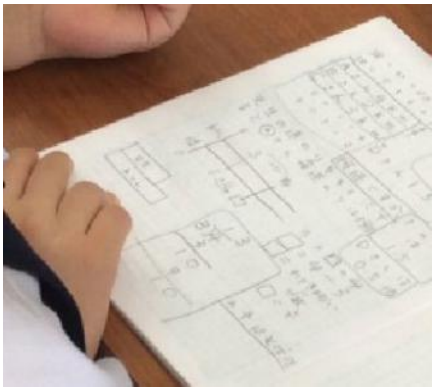
The lesson is number 3/6 in a unit which is about developing students' ways to think about and represent fractions and also the relationships between whole numbers, decimals and fractions so that they can deepen their understanding of fractions. The main question in this unit is 'Can we express the quotient of whole number division precisely using fractions?' Students will therefore have already considered in previous lessons that the quotient from a whole number division can be expressed as a fraction and they will already be familiar with the idea of 'times as much' with whole numbers and decimals and the use of double number lines as a strategy to represent these relationships.

Lesson Phase	Notes
1. Introduction, Posing Task	**-Strategies to build interest or connect to prior knowledge** -Exact posing of problem, including visuals There was an initial problem – a warm-up or starter activity, using multiplication or division by decimals or whole numbers to generate a result of 38. This seemed to relate to previous lessons and generated some discussion about equivalent statements such as 19 x 2 and 19÷0.5 etc.  Teacher then posed the question – how far do you live from school? Starting from a familiar situation which students experience every day lead to lots of engagement and laughter from students and offers of distances travelled and comparisons Discussion about nearer/further, how much further, leading then to – how many times; 'times as much'. 

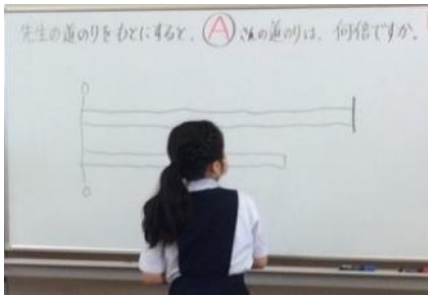
	From this, the main problem for the lesson was drawn by looking at the distances from school for students ABCD. Starting simply with A = 4km and B=2km the extending to C = 3km and D = 1.5km Discussion about the relationship between 3km and 1.5km, inviting students to give their reasoning. For example, a student stated 1.5 is half of 3 which the teacher wrote up on the board. Equivalent statements were considered: 3 ÷2 = 1.5 and 3 x 0.5 = 1.5 was clearly explained by one student working at the board. It was clear the teacher was steering the reasoning towards 'times as much' rather than division methods, but all the time exploring equivalent statements as well as linking back to what students already understood about whole numbers and decimals.  Exploring relationships and equivalence
2. Independent Problem-Solving	**-Individual, pairs, group, or combination of strategies?** -Experience of diverse learners - Teacher's activities When extending to comparing other distances rather than straightforward times as much by a 'whole number', students worked on this problem predominantly on their own. The main problem was to look at the multiplicative relationship between 3km and 4km. There was very little interaction between students. Some students looked back at previous work. There was 'productive struggle' for many, as well as some confusion for a minority of students. There was a lot of rubbing things out and restarting the problem. The teacher circulated to observe and gather student responses/strategies.
3. Presentation of Students' Thinking, Class Discussion	**Student Thinking / Visuals / Peer Responses /Teacher Responses** Photos to document chronology (use new box for each new student idea presented] Students used a range of strategies-  1 .Reviewing previous work  2. Double number lines and  3. Some students draw squares/tape diagrams, as above



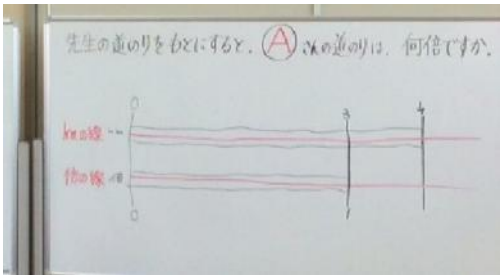
3. Using a variety of representations -



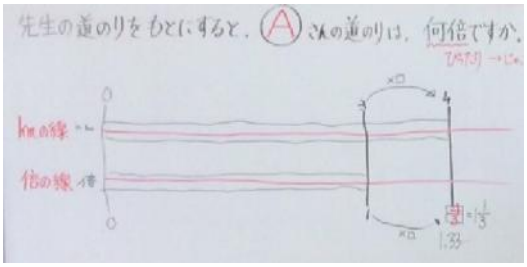
5. Another student explores a range of possible strategies and representations, including division



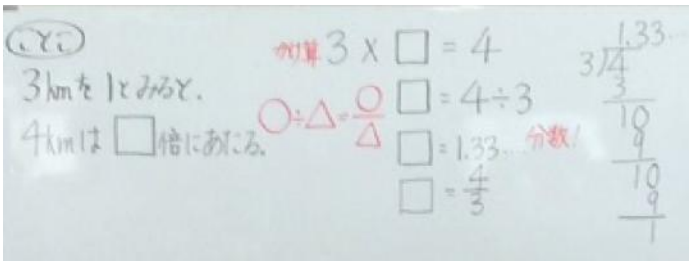
6. Student explanation and reasoning at the board using bars/tape diagrams.



7. Teacher input to explain relationship between double number lines and therefore that bars are not necessary. Importance of labeling also included and discussed.



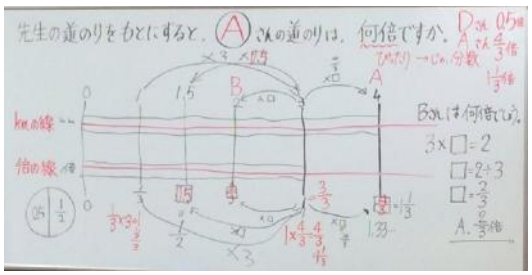
8. Developing the double line diagram with teacher questions and student input



9. Teacher led discussion moving to symbolic form; prior understanding of division methods and back again to diagrams (photo 8)

Lots of discussion about using fractions and acknowledgement that we haven't yet learned about using fractions in this way. This is the first time. This really generated lots of comments from the students, possibly some relief that this is new that's why it's hard!!

4. Summary /Consolidation of Knowledge	Strategies to support consolidation, e.g., blackboard writing, class discussion, math journals. Image 10 above demonstrates where the teacher used a further problem to check and consolidate (and for some extend) understanding.



11. The central board has continued to be annotated throughout the lesson through dialogue, discussion and key questions – is the story of the lesson still clear to students?

12. Teacher summarises the learning; linking different aspects of boardwork with students' ideas and questions in bubbles

Lost interest because it's been too difficult or too easy?

What new insights did you gain about mathematics or pedagogy from the debriefing and group discussion of the lesson?

In some ways, this consolidated and confirmed my beliefs that finding many right ways to right answers is a powerful tool to develop students' mathematical thinking. It enables students to realize that there isn't one correct method or route of thinking/reasoning but that there can be several. The consequent importance of discussion and reasoning can help students to understand which ways are most efficient and easily applied beyond the initial problem. Really the approach today was about thinking like a mathematician, rather than being told this is what you do and follow this process. Clearly the latter approach, doesn't engage the learner or their thinking skills! The approach used today has the potential to develop reasoning and thinking, however keeping everyone involved at a level that supports but challenges is difficult – see last photograph.

What new insights did you gain about how administrators can support teachers to do lesson study?

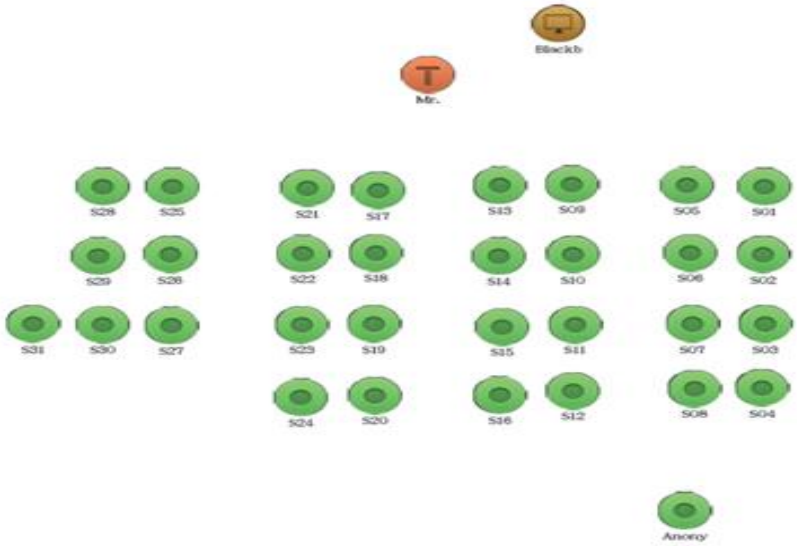
Possibly that professional development can happen outside of the working week?? This is maybe something we need to consider in UK where it is increasingly difficult for teachers to be released from classroom teaching (and the cost involved). Also that, administrators really need to facilitate lesson study, support and manage post-lesson discussion with a clear focus and link to whole school developments. Without leadership that is clear about what needs to be developed and how to support this, any development will not be successful.

How does this lesson contribute to our understanding of high-impact practices?

- Being clear about next steps for students.
- Clear understanding of progression in key concepts.
- How to develop reasoning, knowledge and fluency in key concepts through a problem-solving 'lens'.
- Focusing on 'how to' not 'what to'. Not concentrating on endpoints but the journey – not where to go but how to get there.
- Using available research to inform teaching sequences.
- Collaborative practice, discourse and planning which informs post-lesson review, evaluation and next steps – what do we want to know, what have we found out, how does this help us to understand what works and what will we do next based on what we have learned.

June 27: University Yamanashi Model Elementary School, Lesson 1

Research Lesson Observation Form
Sara McKee, Christopher Nazelli and Hana Al-Ashwal
Mathematics Lesson Plan: Investigating Change
Research Lesson Place: The Attached Elementary School of University of Yamanashi, Faculty of Education and Human Sciences
Place: Multiple Purpose Room, 2nd Floor of Aogiri Hall
Teacher's Name: Kuniyuki Yamaguchi
Class: Grade 4, Class No. 3 (31 Students)



What are the primary lesson goals?
The lesson goal for this unit is highlighted below

Goals of the Unit:

- Students develop knowledge for investigating and identify the relationship of two quantities that change together, using tables to represent and express these relationships symbolically in math sentences.
- Students notice the merits of using tables for investigating the relationship of two quantities that change together and showing the relationship simply, using math sentences with ¨ or ¡¡. Moreover, they are eager to use math sentences in their daily lives and their learning. (Interest, Eagerness, and Attitude [IEA])
- Students investigate the relationship of two quantities that change together and skillfully express the relationship in math sentences with ¨ or ¡¡, demonstrating their grasp of the relationship. (Mathematical Way of Thinking [MWT])
- Students are able to interpret the characteristic of the relationship of two quantities that change together by creating a table and expressing the relationship using a math sentence with symbols for the unknown (¨ or ¡¡). (Mathematical Skills [MS])
- Students understand the method for investigating the relationship of two quantities that change together using a table and a way to express a math sentence with symbols for the unknown (¨ or ¡¡). (Knowledge and understanding [KU])

The research theme of the department is encouraging the "characters and abilities necessary for learning toward harmonious living". To achieve this, they seek to have students compare others' ideas with their own.

Where is the lesson located within the unit (in relation to previously studied topics and ideas to be studied in the future)?

This is the first of four lessons investigating change in two related variables. The relationships between the two quantities progress from having the same sum, to same difference to same quotient.

<table>
<tr><th>Lesson Phase</th><th>Notes</th></tr>
<tr><td>1. Introduction, Posing Task</td><td>-The teacher shows the students the clock and makes sure that they understand how to read hour from the clock. He then shows a few times on the front and asks kids to guess what time is on the back. This builds some excitement and intrigue from the students- who exclaim out loud. Teacher showed students the mysterious clock that had a rule of (□ + ○) = 15 when the numbers in the front-side (blue clock) represented □ and the backside(red clock)represented ○ . He asked ‘what will be on the back now?’
 
 
(S04 and S08 were very excited as the lesson was launched)
-Teacher writes “Let’s investigate the secret of the mysterious clock!”
(Problem is posed)
Blue clock red clock
1 2
8 9
4 Teacher asked students what you think now. Students replied 5 (but the red clock was 11) students said WOW let’s see it once more. teacher showed them the blue clock (10) and asked them to guess the red clock some students said 11 , teacher showed them the red clock and the time is (5). Some students exclaimed ‘You must be cheating!’
- Teacher had to make it explicit which way to ‘flip’ the clock as this generated discussion amongst students
- Some students suggest making a table to organize the responses more accurately
- Teacher drew on the board a table and filled in what they had done
 
 
<table>
<tr><td>Front</td><td>1</td><td>2</td><td>4</td><td>5</td><td>6</td><td>7</td><td>8</td><td>9</td><td>10</td></tr>
<tr><td>Back</td><td>2</td><td></td><td></td><td></td><td></td><td>8</td><td></td><td></td><td>5</td></tr>
</table>
</td></tr>
</table>

2. Independent Problem-Solving	- Teacher drew the table on the board and wrote the time that showed it to the students before, and asked students what do they notice, students said one clock is different. Teacher distributed the clock among students and asked them to complete the table. Students used the clock and tried to complete the table, after couple of minutes teacher started to complete the table with the students. -Some students finished filling in the table (both correctly and incorrectly) before the clocks were handed out.   (S04 simply fill in 1-14 in both rows) - Teacher roamed around and assisted some students by pointing to their tables to draw their attention to the pattern  - Students discussed with the person next to them on numerous occasions - Some students looking at 'difference' between the two times in their table - Some students had finished task within a few minutes - Some students were 'stuck' on the concept of which way to flip the clock- this seemed to distract some students   
3. Presentation of Students' Thinking, Class Discussion	Teacher started the discussion at 10:21. He asked a student (girl) to come to the board and represent her work. The student said that, the front side clock increased by 1. Teacher asked the other students what does that mean. A student replied each time we add 1, another student said -1. Most students agree with + or -1 without any link between the two quantities.

Teacher said let's think about what we have, that the front side clock increase by 1 and the back side clock Decrease by 1. A student said it's difficult. Teacher asked students if they have another idea .A students (girl) said if we add the front to the back the sum will be 15, teacher said ok what about 2 +1 = 3, another student said if the time is 2 pm that is mean its 14.teacher said if we change 2 to be 14 it will be more clear. So when we add the front and the back clock the answer will be 15, teacher wrote 1+ 2 =3 , 1 +(14) = 15 . Then he said let's do it again …..

-Students took long time to discover the relationship between the front and back clock.
-Most the discussion was based on guessing not mathematics.
-In this phase of the lesson a few students engage on discussion while most students just listen.

-Most students get hung up on the horizontal patterns (+1 and -1), not the relationship between the two quantities.
(Horizontal thinking)
-Also have issue with 1,2 pair and 2,1 pair…this leads to some problems with 24-hour clock issues and the horizontal pattern (+11?)

-Not until 10:31 when a girl offers up the "add up to 15" observation. There is a huge gasp from the class…but after they return to the 24-hour clock diversion.

-Following that, they pull together an expression using square + circle = 15 and use it to get circle = 15- circle (Front hour is square and back hour is circle).

- Teacher then asked what could the next clock be- could it be 13? 14? 15?
- We want to make a clock where Triangle and Circle=?
- Students then work independently on task whilst teacher roamed and assisted
- Student then shared his work with the class

4. Summary /Consolidation of Knowledge	-The mysterious clock generated some initial excitement, but students did NOT discover the constant sum despite the teacher leading them to create a table. -The blackboard work got bogged down in the horizontal +1 and -1 listings, as did the discussion. -Many students were disengaged throughout the lesson. More needed to be done to involve them in the discussion and/or check in with them to gauge their understanding. -There was no time for a reflection piece at the end of the lesson. - Students did not reflect with each other- the lesson ended abruptly perhaps due to timing 

What new insights did you gain about mathematics or pedagogy from the **debriefing and group discussion of the lesson**?

The discussion was abbreviated and disjointed due to the lesson being paired with a previous lesson as part of the open house. Therefore it was less helpful than previous debriefings. The pre-briefing was helpful because it helped put the lesson in a bigger context as well as presented a different example (water in tilted containers) that might have proved to be a better option. The students became distracted by the 24-hour issue and this distracted the conversation considerably. At the end of the discussion the professor said to the teacher he should be careful when he chose the problem. This post lesson discussion would have been a beneficial one for participants to ask questions of, as there were some elements that were unclear as to why they were chosen.

What new insights did you gain about how administrators can support teachers to do lesson study?

The support of administrators is clear when he let the teacher meet his team several times during the year to discuss and prepare the lesson. The collaborative culture and respect for lesson study was apparent, as evident in the amount of teachers viewing the lesson. The teacher also asked students to come to the school today, although this day is holiday for students. The entire Japanese system is set up to support lesson study, and this open house is a perfect example of that system. Without radical changes to the school schedule, American administrators would have to ask teachers to participate outside of normal school hours. Time is the biggest obstacle for American teachers and administrators to overcome. Here, it is built into the system. It is not impossible, but very difficult in the U.S., to find the time required to conduct an authentic lessons study cycle as we have seen it here.

How does this lesson contribute to our understanding of high-impact practices?

When we analyze the lesson and what happened during the lesson then link between them with the post– discussion we got lots of ideas such as how to observe the lesson, how students deal with the problem and focusing on goals achievement. Sometimes we learn from challenges that others people faced. His lesson serves as an example of a task that generated a decent level of initial excitement, but the anticipated mathematical relationship was slow to be recognized. Also, there were far too

many students who were not engaged. A different problem may have created a better examination of the common sum without being sidetracked by other issues specific to the clock, such as which way to flip the clock and what the 'magic' of the clock was. The high-impact practice that seems to have been absent here is the anticipation of student misconception and/or difficulty with using the table. Since this was the stated goal of the lesson, more work should have been done to anticipate and strategize responses to this difficulty.

June 30:Tokyo Gakugei University attached Koganei Elementary School

Research Lesson 7
Konagei Elementary School
Grade4, Mr. Takeo Takahashi, Tuesday June 30, 50 minutes

What were the primary lesson goals?
The over-arching goal of this lesson is to investigate the relationship between two quantities that change together. To achieve this goal, students need to be able to find patterns between the number of squares and the number of matchsticks to solve the problem.
Further, students need to have a feeling for the generality of the pattern.

Where is the lesson located within the unit (in relation to previously studied topics and ideas to be studied in the future)?
This lesson is the fifth and last lesson of the unit focussed on developing the ability to determine the relationship between two quantities that change together by investigating the relationship and representing it using a mathematical sentence. Three of the first four lessons focus on investigating the relationship between two quantities that change together when the sum (Lesson 1), difference (Lesson 3), or quotient (Lesson 4) is constant. The second lesson in the unit examines using a table and a mathematical expression to represent such relationships. This, the fifth lesson looks at the $y = an + 1$ relationship, between two quantities, but expressed in words. This will be extended further in later grades with a formal algebraic representation.

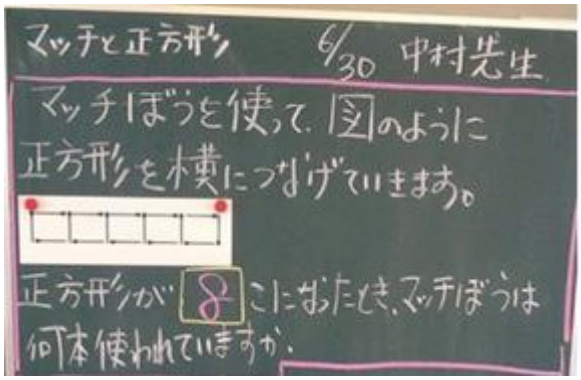
Introduction, Posing Task

Strategies to build interest or connect to prior knowledge
Takahashi-sensei wrote the problem on the board and posted the diagram of 5 squares.
The Task: How many matchsticks are needed to make these squares?

Takahashi-sensei also wrote: How many matchsticks are used when there are boxes?

Students had 15 seconds to copy the problem, then Takahashi-sensei wrote the number 8 into the box.

Students were asked to write out the reasoning for their answer.



Independent Problem-Solving

Students worked independently for approximately 9 minutes (18% of the lesson), beginning just after six minutes into the lesson.
Below are some photographs of students' work.





Overall, students used a range of methods, mainly creating a drawing of 8 squares with a variety of colouring options as though they were creating a pattern of how the matchsticks were put down.

For example, student S19 created a drawing of the 8 squares, with the matchsticks needed for each additional square in a new colour.

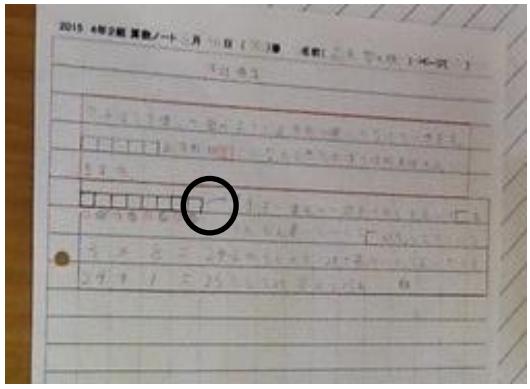
Takahashi-sensei walked about the room marking information on the seating chart. This gave him a record of who was using which strategy.

Student S11 has two different methods. Both used a drawing of the squares.

The first strategy seemed to be using the method of adding-on to the first square, while the second was adding the top horizontal matchsticks, then the bottom horizontal matchsticks, then the vertical ones: 8 + 8 + 9 = 25.

Student S35 has a drawing,
and has the equation: 8 x 3 + 1.

There is an arrow drawn to the matchstick which represents the one (circled).

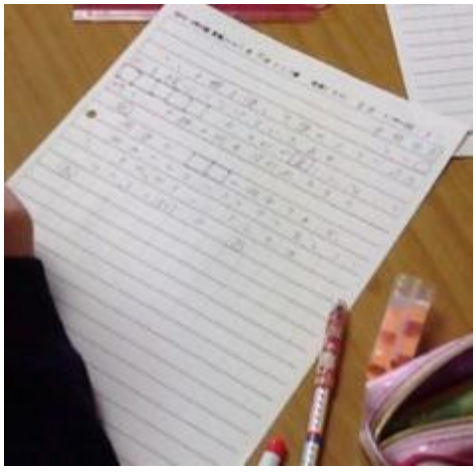


Student S23 has created a chart and not a drawing.

She has noted that the number of matchsticks increases by 3 for each additional square and marking it on the chart.

No additional computations were written.

Student S26 has only drawn a few squares, then an explanation in words, followed by the number expression: 4 + 3 x (8 – 1).



Presentation of Students' Thinking, Whole Class Discussion

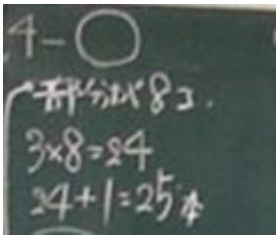
Takahashi-sensei asks for some solutions that students have found. There are a variety of answers. He records some of the answers: 25, 28, 31, and 27 matchsticks, on the black-board.

A student states that the 31 should be 24. This number was changed.

Female student S16 comes to the board.

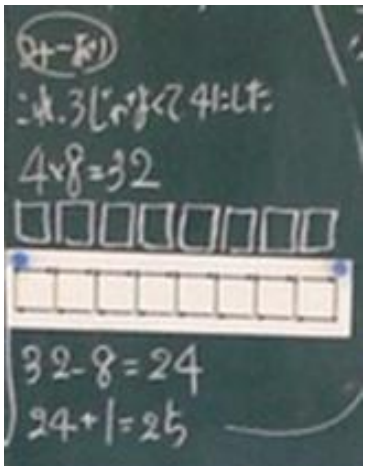
She says: "The first square has 4 sides. When you add the 2nd square the overlap is 1.

So, 4 + 4 – 1 and you will add 3 more for the 2nd square.



When you subtract the overlap, 3 x 8 = 24 and then one remains.

So add one. 3 x 8 + 1 = 25"



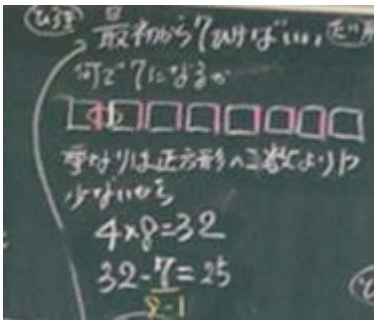
Takahashi-sensei: "Is there a different way?"

Female student S33 comes up to the black-board.

Her strategy is to have 8 distinct squares of 4 matchsticks and then subtract the overlap.

So, 4 x 8 – 8 = 24

Takahashi-sensei suggests that she needs to add 1.



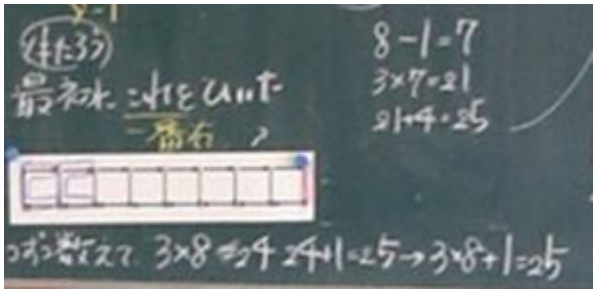
Student S22 asks why not just subtract 7 at the end since we need the last one.

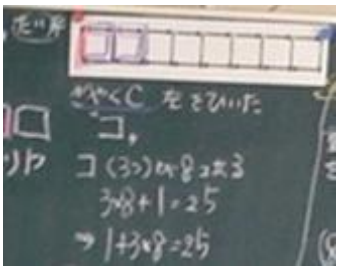
Shows subtracted matchsticks in red.

Unknown student suggests that the 7 should be written as 8 – 1 since it is the number of squares minus 1.

Takahashi-sensei asks: "What does everyone think?"

Boy S30 said that he took away the one on the end and then counted by 3's





Boy S19 said he took away the first one and then had 3 left in a shape like コ :

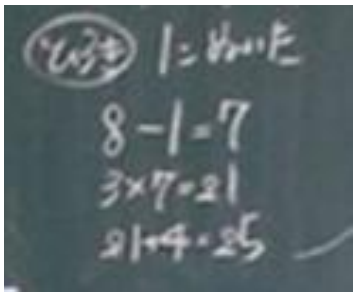
He had written this as 3 x 8 + 1 = 25

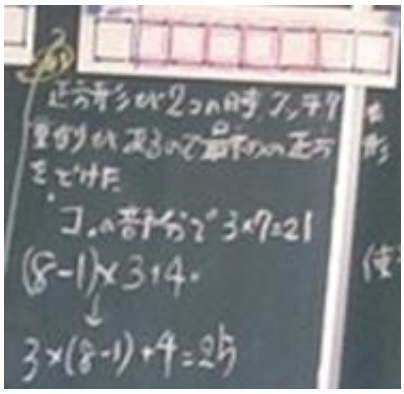
A student states that it is the same method as the previous strategy.

Another student states that this should be written 1 + 3 x 8 to show the process better. Then it is clearly different.

Student S15 says that they took off the first square, and then used the 3 matchsticks for each additional square.

Then replaced the first square.

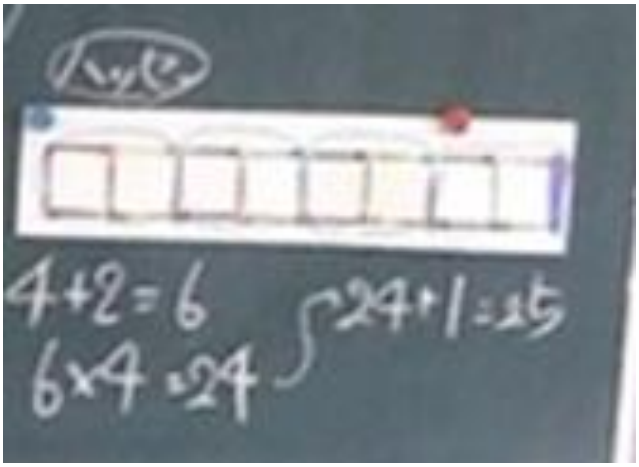




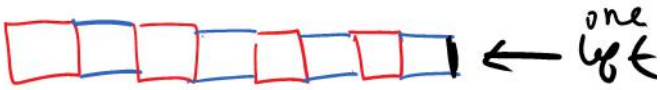
However, a student stated that it should be (8 – 1) x 3 + 4. But another student says no. It should be 3 x (8 – 1) + 4 to have the number of matches in each group first.

Takahashi-sensei says: "One more question" and it seems he is going to ask a different question on the number of boxes, but another student comes up and interrupts with their strategy.

Student S14 shows a different strategy.



The strategy is to use two boxes as a sum (of 6).



Summary and Consolidation of Knowledge

Takahashi-sensei reviews students' work displayed on the black-board.

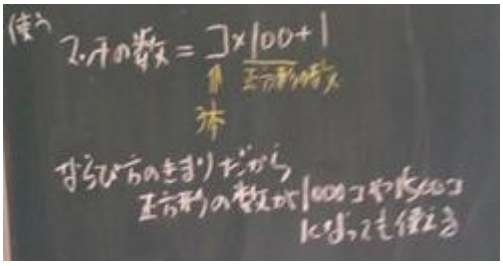
After presenting each strategy and connecting it to the match-sticks diagram, Takahashi-sensei asked the class how many matchsticks would be needed to make 100 squares.

Student S19 says 301 = 3 x 100 +1

Student S11 says 3 x 99 = 297 and 297 + 4 = 301

He then asked them to identify which of the strategies posted on the board corresponded to their strategy for solving this larger problem.

Takahashi-sensei asks whose idea is each computation strategy. Students answer with the names of the students who created that strategy.



Takahashi-sensei: "We will summarize."

He uses a shape ( ) that one student used in his diagram to write a number sentence and asks the class what is the number of squares.

Takahashi-sensei writes that the shape indicates the number of matchsticks. (see the above photograph). Takahashi-sensei states that the shape = 3, and asks "So can we use it for calculations? Number of squares x 3?"

He asks further, "Can we use it for any number of squares?"

Some students say "We think it will work." Takahashi-sensei writes a sentence on how to be able to use this on the board (in Japanese).

He says, "The title of today's lesson is *Matchsticks and Squares*" as suggested by one of the students.

The picture at the left is of the black-board at the end of the lesson.

New insights gained about mathematics or pedagogy from the debriefing and group discussion of the lesson

This debriefing was unusual in that it only included the IMPULS participants. One member of the group served as the moderator and another as the discussant. The remaining group members discussed their experience of the lesson, as well as a wide range of pedagogical and cultural observations. We were given the background information that Mr. Takahashi has been teaching for 20 years and that he planned the lesson by himself, and the children in today's class were his own students. The discussion was about three hours long including final comments by the discussant.

Mathematically, we were struck by the students' nuanced use of numerical expressions to represent their ideas. One student told Takahashi-sensei: "No, using 7 doesn't capture my idea of 8-1." Other students discussed the difference between 1+3x8 and 3x8+1, as well as 7x3 and 3x7. Takahashi-sensei spent time illuminating the distinction between 1+3x8 and 3x8+1, in both the representation on the diagram and the mathematical expression.

Pedagogically, our discussion about whether or not to use the diagram or actual matchsticks was instructive. The diagram is neater to use on the black-board and perhaps in the students' notebooks as well. It helps students to record their responses in their notebooks permanently, including with the use of colour to identify specific components of their strategy. It might also encourage students to move toward thinking with patterns rather than simply counting.

We had much discussion about organizing the board, with each strategy in its own column, instead of the flowing organization Takahashi-sensei used. While observational evidence seemed to indicate that students were following the organization he used, we felt that a column organization might have afforded some additional opportunities to elaborate on the similarities across strategies (by making them align horizontally) and to add the 100-squares expressions to each strategy at the end of the lesson. However, in the end, that students did not have difficulties with identifying each strategy, it was generally agreed that it was not an issue.

A question arose about Takahashi-sensei's use of the symbol "ko" during his generalization as representing the number 3 and whether this would create confusion between using a symbol as a constant versus using a symbol to represent a variable in future lessons. The IMPULS participants did not come to consensus on this topic, but agreed that it was an important point.

New insights gained

In his comments Alan, the discussant, emphasized that lesson study is about the impact of the designed and enacted lesson *on students learning*. Lesson study is not about how the lesson evolved as compared with the plan, which could be discussed without ever considering how a student responded to the lesson. This reminded us to focus on the students' perspective and experience of the lesson, and would be a crucial component for mentors to emphasize and model when working with teachers who are under-taking lesson study.

How does this lesson contribute to our understanding of high-impact practices?

Although there are a few high-impact practices exhibited in the lesson, we did not capture whether they had a positive impact on these students in this lesson. There was an effort to engage students in ownership of the mathematics of the lesson, by naming their strategies and referring to those

strategies by the students' names throughout the rest of the lesson, and by Takahashi-sensei's reminders to the students to address each other and listen to each other. He used a task that allowed for multiple entry points and strategies. This lesson was an example, however, of a rich task being insufficient, as the exploration ended for many students after they found one strategy to arrive at the answer. This raises the question, of course, was the aim to have students find multiple strategies, or rather to have students find at least one, and then present a range of strategies for public discussion?

Another unanswered question was that although there were at least two students who used a table of numbers and not a pictorial model, Mr. Takahashi did not call on these students to share their solutions with the class. The tables were in the lesson plan and it would be interesting to hear if he purposely chose to leave them out of the discussion or if he just did not see those particular students' work.

Lastly there was a discussion about checking up on who did not understand the discussion. Specifically we wondered about the five or so children that were clearly not participating in this lesson. Why did the teacher not do more to include these children? Was this another of the Japanese ploys to develop children's self-reliance, or something else? However, because we were unable to ask him directly, this question was left unanswered.

Discussant's Final Comments

The final comments by the discussant were interesting in that he felt the lesson was not as successful as we had thought. From his (USA) perspective he noted, (in Roman), and our thoughts (in Italics), that:

- A number of students were disengaged: *But as stated above, this may be deliberate.*
- Students did not record more than one solution: *But were multiple strategies the aim of the lesson?*
- Goal was to "Justify a way of getting to the answer.": *If this were true, then the lesson failed to provide opportunities for this.*
- The generalization question seemed to be rushed at the end: *Perhaps this was a link to the next lesson?*
- The lesson missed the students "Seeing the need of breaking the problem down": *This is a Western problem-solving procedure, but is it the only way?*
- Lesson was about matchsticks and not about connecting two quantities: *Student solutions all used both quantities connected by mathematical operations.*
- Thought the students did not know where they were going: *This we could not really tell but the evidence in our photographs showed student activity on target.*

He showed a few videos of different discourse techniques that have good individual results for discovery learning and the learning that can come from a struggle with a concept. Although we see the merit of these techniques, Japan is a different educational culture compared to the USA or the UK. The majority of teachers in the USA and UK do not use the techniques that were in the videos, while the majority of Japanese teachers do use quite consistent good teaching methods. Apart from whether or not these USA and UK techniques are high impact or not, the question is, can they be scaled up to be used nationally?

July 1: Sasahara Elementary Secondary School

Wednesday, July 1, 2015 Combined Research Meeting; Group B- Setagaya Ward, Tokyo- Research Lesson #8
Division of Decimal Numbers: *Let's Think About Dividing by Decimal Numbers*
Sasahara Elementary School
Grade 5; 28 students (on level)
Teacher: Oohashi, Yuuki

Rosa Archer, Kelly Goorevich, Pete Sides

What are the primary lesson goals?

- To extend children's previous knowledge of division and multiplication by decimals to dividing with decimals and finding per unit quantities.
- To understand the meaning of dividing by decimals and think of strategies to do so.

Where is the lesson located within the unit (in relation to previously studied topics and ideas to be studied in the future)?

This is the 1/11 lessons in the sub-unit, *Calculation of (Whole Number)÷(Decimal Number).* The main content of the unit is *the expansion of the meaning of division.* Children can divide by whole numbers to find per unit quantities and to share equally, they can also multiply by decimals, and they hold an understanding of decimal numbers and the decimal placement as represented in a base-10 notation. Students have also learned to use ▢ to represent an unknown and determine the appropriate operation to find the unknown. Additionally, while using the double number line during the *Times as Much* lesson, students discovered the proportional relationship between the numbers on the top line to their corresponding numbers on the bottom line. Within this unit, *Multiplication of Decimal Numbers,* students learn to think mathematically by connecting equations with words and the double number line. The double number line is used to deepen students' understanding because it is useful to distinguish mathematical expressions representing situations from the mathematical expressions that show calculation. With this lesson children are encouraged to reflect on the fact that they can divide by decimals in order to find per unit quantities. They are encouraged to justify how they can expand the meaning of division to division by decimals. Based on this new understanding children will be able to justify why when dividing by a decimal number less than 1 we get a greater answer.

Summary of strategies:

- To use the double number line to to represent the mathematical situation.
- To use the double number line to help them explain the mathematical expressions that show calculation.
- To articulate student thinking using mathematical terms by explaining how they extended their prior knowledge of division and multiplication by decimals to solve the given problem.
- To the ideas and puzzlements of others.
- To say, "I don't get it" during lessons and clarify what they do not understand so that the whole class can share the questions and make use of their own ideas to answer other students' questions.

The lesson plan stated that: "In addition to valuing each student's ideas, I also try to focus on students who say "I don't get it" during lessons. I encourage those students to clarify what they do understand and what they do not so that the whole class can share the questions those students have. Then, as students' share their ideas, they are encouraged to address those students' questions

and puzzlements. In this way, students' sharing has begun to shift from simply explaining their own ideas to making use of their own ideas to answer other students' questions. In order to increase student to student interactions, during the whole class comparison and analysis of solution strategies, I often have students sit in front of the blackboard with their own notebooks and pencils. I believe that the students have become much more conscious of others and listen to each other more intently. Some students are now trying to deepen their own ideas and to generate new ideas as they listen to other's ideas." This was evident throughout the lesson, in fact the teacher constantly encouraged children to articulate what they didn't understand and to share ideas with each other.

<table>
<tr><th>Lesson Phase</th><th>Notes</th></tr>
<tr><td>Understanding the task:</td><td>
-Strategies to build interest or connect to prior knowledge -Exact posing of problem, including visuals

Mr. Oohashi started by showing two bottles of juice and explained the following::

<table>
<tr><td>  </td><td>We went to buy juice to share with everyone. We saw one package containing 1 L of juice. We saw another package that contained 2 L of juice.

He asked, "Which do you buy and why? Remember you want to spend a little money as possible."
Roughly translated, Which is the most cost effective deal?
The students called out "How many litres?" " How many people?"
Mr. O: "Can I tell you the price?"</td></tr>
</table>

Then Mr. O wrote the following on the board:
<table>
<tr><td>A 1L</td><td>216 Yen</td><td>(Some students did not like this amount because it was not a nice round number)</td></tr>
<tr><td>B 2 L</td><td>420 Yen</td><td></td></tr>
</table>
Students worked independently for a short time (approx 3 mins) to think about this question independently.

Mr. O: Who thinks A? (Students raise hands)
Who thinks B? (Students raise hands)

Mr. O: Waoto, why do you think B?

Waoto: A is 216 Yen for one Liter, but B is a better buy because if you divide 420 by 2 you only spend 210 Yen for a Liter.

As Waoto spoke, Mr. O recorded:
A 216 Yen
B 210 Yen
</td></tr>
</table>

Mr. O asked students to raise their hands to show if they agreed with Waoto, then he called on another student to see if the student could summarize what had been discussed.

Mr. O: Who can write the mathematical sentence that shows the cost of 1 liter in B?

Students talked in pairs.

After a brief 30 second discussion, Mr. O called on a girl, Obara who very quickly said "you have to divide by 2."

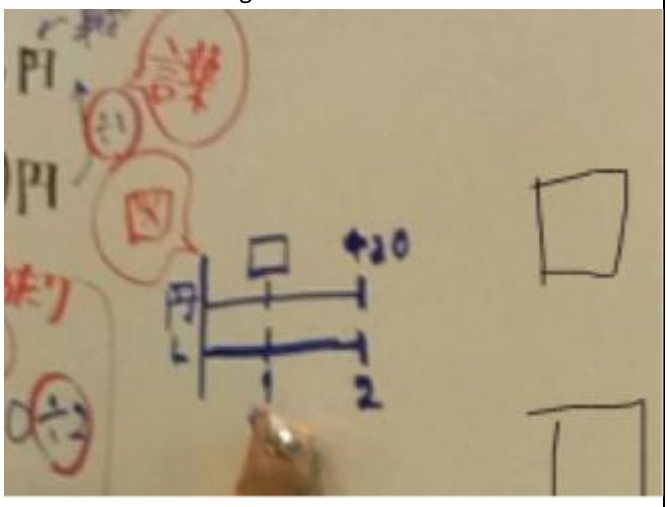
As Obara spoke, Mr. O wrote 420÷2 beside Waoto's response

Mr. O asked the children to show him how confident in how the math sentence was represented.
Another 30 second discussion among pairs of students.
Mr. O: How many are confident?
A quick show of hands indicated that most children seemed confident translating the problem into a maths sentence.

One boy noticed that B is the correct answer because even though you double the number of liters, you do not double the price.

Mr. O asked the students how we can SHOW how the calculations work in our math sentence.
Students agreed that they needed to show a diagram.

Mr. O called a girl to come to the board and show her diagram.
She drew a double number-line.



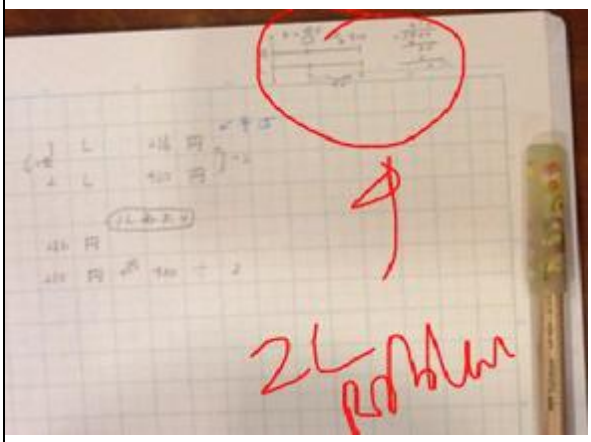
The girl labeled the number line:
▢ x 2= 420
▢= 420 ÷ 2

One student drew liquid containers while the majority of students observed used a double number line.

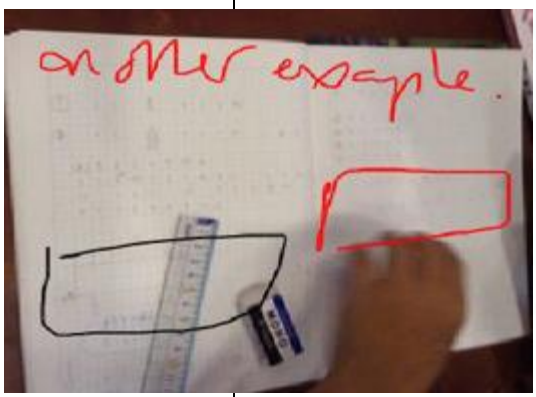
Mr O circulated the classroom asking for student ideas about what the girl had written. He asked "What do we need to make the same in order to

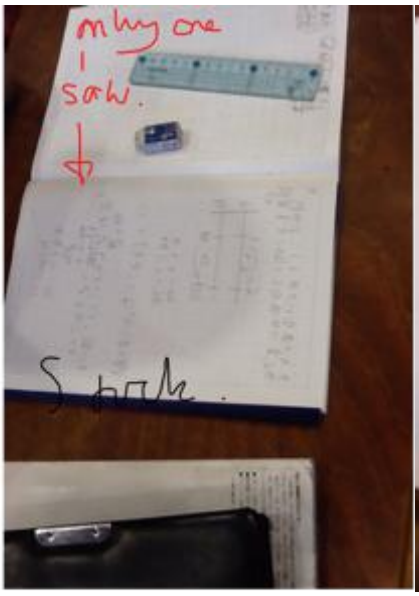
	compare?" Mr. O took some suggestion form the children on possible number sentences, these included "x2; ½; ÷ 2; make two group; Let's split it into 2 parts; make 2 equal groups." Mr. O: Do you see where the ÷ 2 is in (*the girl's) diagram?* A boy in class explained how the diagram written by the girl showed x 2 on the board as well as how her equation set could mean 2 in reverse. Mr O summarised the different ways of expressing "divide by 2" , including "one half", "to halve", "split into to two equal parts" "split into two equal groups"  Mr. O took another bottle from under his desk and told the children this was 1.6 L. Mr. O: *1.6 L is 320 yen What should I do? Which bottle should I buy now to get the best value?. Can I use the same idea from before to find the per liter price?*  One boy said, "I cannot split it," and Mr. O. replied, "You can if you think hard enough!" Students were expected to work individually for a period of time.
2. **Independent Problem-Solving**	**-Individual, pairs, group, or combination of strategies?** -Experience of diverse learners - Teacher's activities Mr. O asked the class, "What should I do? Can I use the same idea?" and gave them time to work independently on the problem encouraging them to write the maths sentence to get the price per liter. Many of the students struggled to use their previous logic to solve the 2L problem in this

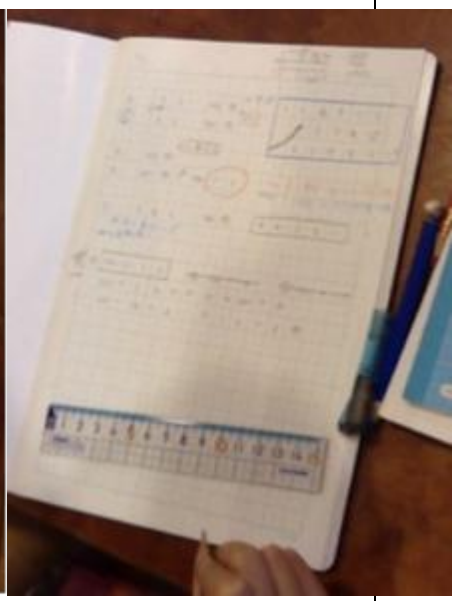
1.6L problem.

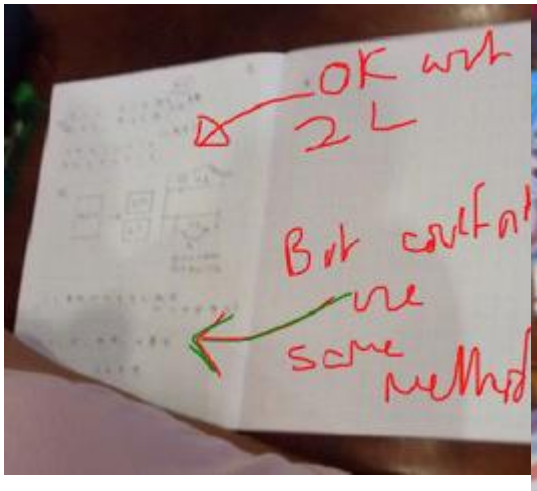
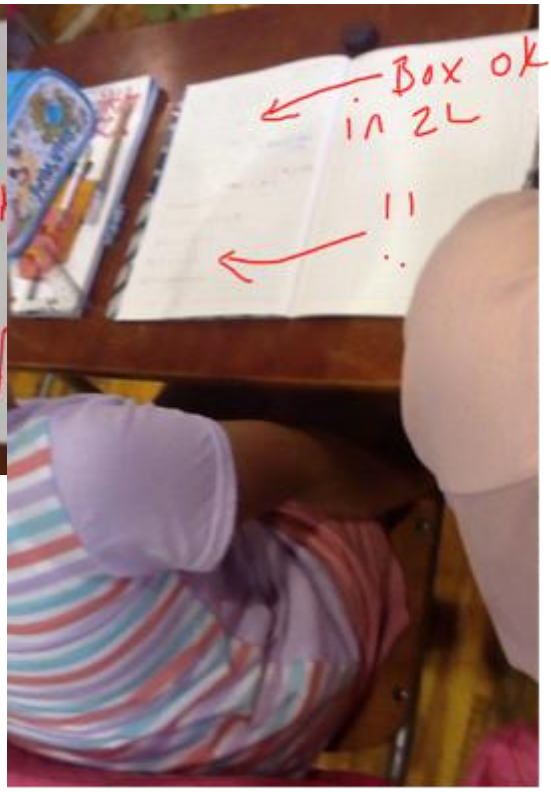
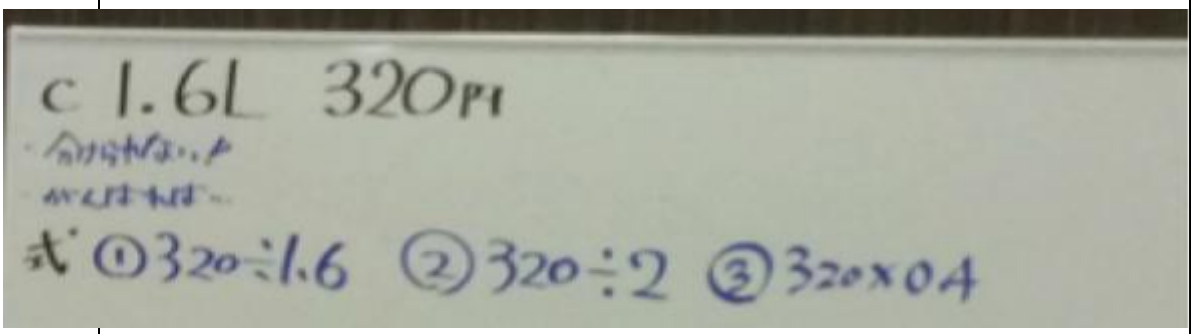


This student appears to have been able to apply the 2L method to her problem solving. She also correctly selected division as her operation to solve for the per liter price. I cannot understand her explanation.







	The teacher asked, can we really divide by 1.6, to get the cost for 1L?"
3.Presentation of Students' Thinking, Class Discussion	**Student Thinking / Visuals / Peer Responses /Teacher Responses** Photos to document chronology (use new box for each new student idea presented]   Majority of the students coped with the 2L starter problem and showed their l thinking using either a pair ines or in some cases a more ram e.g. a container.  utset the students found the much more difficult to tackle. f time on independent working the teacher ask the children for their lost children said 320 ÷ 1.6 while two children wanted to divide by 2 d said he didn't know and Mr. O told him, "You will be a star the lesson today." rote the different ideas on the whiteboard (including the "I don't know" ÷ 1.6 ÷ 2 3. 320 x 0.4  and asked the children to discuss in pairs which method they liked better. At this point not all children were discussing and some appeared lost.

Mr. O: *Let's take a vote. Which statement is accurate?*
7 students voted "I don't know"
Mr. O: Can we find the price per liter using 320 ÷2?
He then asked one child to explain why dividing by two was not a good solution.
The child said it was because the bottle was not 2L.

Boy: 320 ÷ 2 is incorrect because ÷2 is for 2 liters and 1.6 is not 2 liters.

Then one child said (I could not see who it was) that if we divide by two we will know the cost of 0.8L because the bottle was 1.6L.
This observation seemed to confuse the children.

Girl (4 left): 320 ÷2; maybe we should try 0.8L. 0.8 is ½ of 1.6
Girl (2 center): Why 0.8?
Girl (4 left): I don't know why.
Boy (2 right): 1.6 ÷ 2= 0.8

Mr O attempted to link the previous ways that divide by two were expressed and each time came to the conclusion that none made sense in the context of 1.6 e.g. divide into 1.6 equal parts, except 2 which could be replaced with 1.6 but while students agreed they should be trying 320 ÷ 1.6 to find the price per liter, they weren't convinced by this logic.

One boy said "We cannot make 1.6 equal groups, I am getting confused."

Mr. O recorded three options on the board and told the students to think about whether or not we should be trying 320 ÷ 1.6.

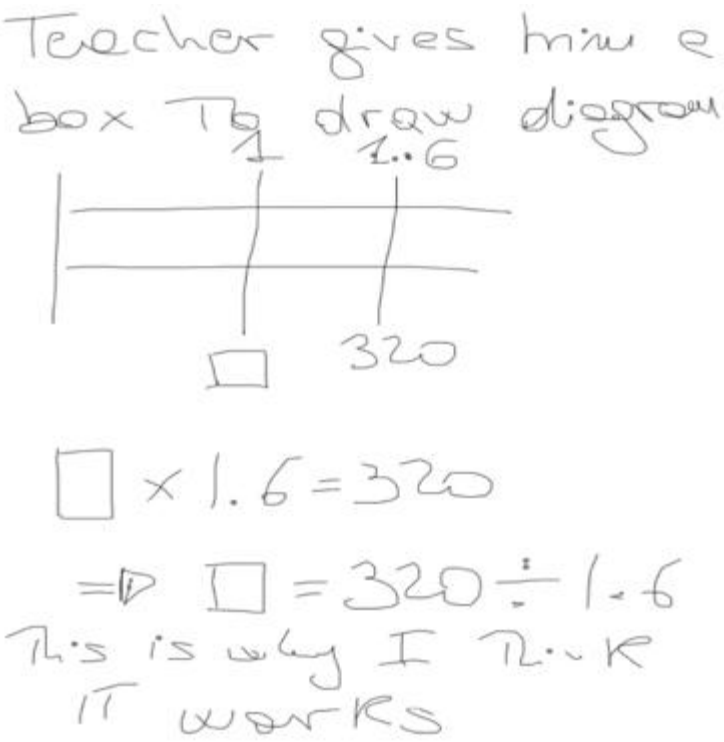
1. yes
2. no
3. I don't know (write down what you don't understand)

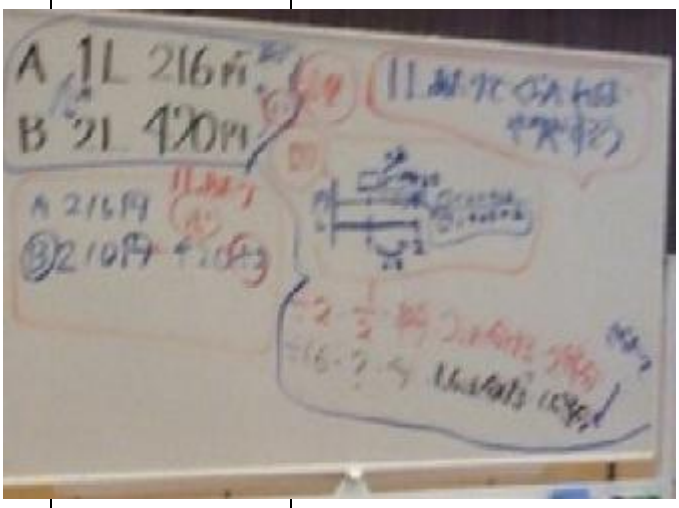
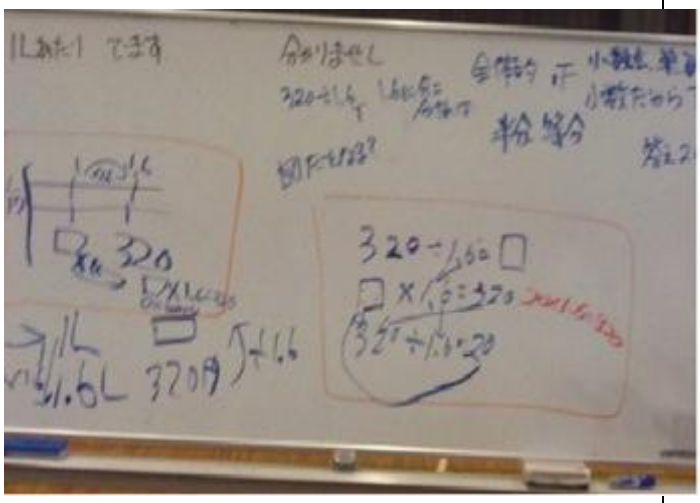
Mr Oashi asked the children to stand up and discuss in pairs what they are supposed to do and then to sit down and write what they don't understand.
At this point the children became really confused.

6 or 7 children that the translator could see just wrote "I don't understand" but had difficulties articulating what they could not understand.

Mr O recognised the lack of understanding and as a result chose to reorganise the class bringing them together to discuss their ideas. Mr Oashi explained in the lesson plan that he regularly does that in order to encourage the children to share ideas.

Mr. O persisted in asking the students what they thought rather than directly

	teaching them. Some of the responses form the children where: “I understand nothing” “It’s the decimal number that confuses me.” “It’s division with decimals. We haven’t learned that yet.” “I don’t understand the meaning of 320 ÷ 1.6” “I cannot divide into 1.6 groups” “If I diagram 320 ÷ 1.6 we haven’t used this yet.” “I don’t know how to calculate this if I diagram it.” “we cannot do it because we have not learned how to divide by a decimal.” One boy came to the board. Mr Oashi gave him some space on the board to write. The boy used the notion with an empty box to express his understanding.  Another boy came to the board and drew an arrow to the first diagram (below) stating, “I used the first diagram we used to help me think so I think we should divide 320÷ 1.6,” but he was unable to elaborate as to why. A final boy suggested that if you try 320 ÷ 10 you would get 32 and if you multiply 1.6 x 10 you would get 16, so 32 ÷ 16= 2. He was unable to expand on how this idea might further the understanding of the problem. At this point, the time for Neriage was over. As a result very little was developed or satisfactorly wrapped up.

	The teacher reassured them saying that division by decimals is difficult. We will talk about it more tomorrow."
4.Summary /Consolidation of Knowledge	<u>Strategies to support consolidation, e.g., blackboard writing, class discussion, math journals.</u> The children went back to their seats and Mr Oashi wrote: 320 ÷ 1.6 = □ Can this be used to find the price per liter? Yes, No, or I don't know and explain why you think what so. One last boy continued to try to discuss 320 ÷ 1.6 = 20 with Mr. O until he ended that conversation.   Girl (1 left): I can't explain why Girl (3 left): I think we need to x10 Boy (2 center): When I figure I get 20 which is too small. Mr. O.: I'll look at your notebooks and decide where to go tomorrow. One girl who was doing the final conclusions says: " I don't understand because it was decimals but I tried very hard. I will try again tomorrow."

What new insights did you gain about mathematics or pedagogy from the debriefing and group discussion of the lesson?

As stated in the lesson plan the teacher tried very hard to keep the task open and to allow the children to experience productive struggle. Whether or not this struggle proved to be productive, we will not know. It would have been interesting to find out how the teacher engaged the children in the days that followed. Did he scaffold the problem by presenting a more concrete representation or more logical numbers for the students or did he allow the students to continue to discuss and struggle the challenge as given? Was the struggle productive in the end or an exercise in frustration?

At what point does this become unproductive? There is an argument to say that a teacher should be able to recognise and intervene when too many students are lost or confused. The decision to

re-organise the class to focus the discussion on a particular issue underlined the fact that there was a problem to be addressed. At which point there perhaps needed to be an alternative to just listening to student's thoughts and the teacher could take the lead even though this my not have fitted the accepted pedagogy.
During the post lesson discussion people commented on the fact that the lesson was not about how to divide by decimals but about being able to confidently decide which operation to use when dealing with decimals. It seemed apparent that many students did arrive at the decision to use division early in the lesson, but were so challenged by the number relationship presented by the problem (1.6L for 320 yen), they were unable to explain their reasoning. Even the students who were among the most confident in the class early in the lesson quickly moved into the 'I don't know' camp. This ambiguity highlighted the need for the lesson aims to be clear and prior learning necessary for the lesson needs to be fluent if possible.
In my own experience I have seen many times children guessing which operation to use (an always going for the easier option) when dealing with difficult problems, therefore I felt that the lengthy discussion on why using division is appropriate when dealing with finding the per unit quantity was a very productive one. The teacher needs to decide before taking the next steps of learning whether more time needs to be devoted to the pupils' skill at selecting the appropriate operation, in this way the choice of division would be more apparent and the difficulty they would have to surmount would be that they recognise the need to divide by a decimal.

The use of the double number line is certainly very powerful and really supports children's understanding of proportional reasoning. However today this didn't seem to happen as well as expected, it would have been very interesting to see the next lesson and to see if the productive struggle today paid dividends next lesson. One teacher in the audience suggested that the problem was the fact that Mr Oashi did not clearly connected the mathematics sentence to the diagram (double number line); while other teachers suggested that the problem was the fact that children did not understand the double number line before today's' lesson and therefore could not use it properly.

I personally think that children were not clear on what they were supposed to do. Some believed they had to do the calculation and find the per unit quantity while others felt they just had to understand why division was the correct calculation to use. I think the teacher should have been more clear on what he was trying to achieve.
The knowledgeable other suggested three strategies to improve the research lesson further

1. In grade 1 teachers should be more careful when teaching scale factor. In fact the teaching of scale factor provides the foundations of understanding proportional reasoning. By encouraging children to understand what happens when we change unit of measurement we can help them develop proportional reasoning.
2. Use the double number line more carefully and systematically to support understanding of proportional reasoning.
3. take more care in highlighting the relationships between times a smany and decimal numbers.

There was a long discussion within the IMPULS group afterwards about which numbers would have better to use. Some believing that 330 Yen and 1.5 L was more appropriate to let the children see the problem before moving to less obvious cases, while others believed that this approach would have promoted procedural understanding and encouraged children to follow an algorithm.
Somebody also suggested extending the double number line to 3200 and 16 L.

The lesson seemed to struggle on a number of issues and yet the use of the double number line was used by the students confidently in the starter problem. However perhaps this is an issue of teachers

seeing students reach a level of competency in an abstract (be it pictorial abstract) and expect them to use this to develop an understanding of a new concept (divide by decimal) without stepping back to the concrete or at least concrete pictorial for this new learning.

Images linking the 2L problem's solution of double number line and a pictorial representation of a 2 litre bottle or a bar may not have been necessary but they would have enabled a link between the 1.6L problem and the double number line. Scaffolding a link to the more complex problem through the use of a pictorial representation or bar along with the presentation of a more logical problem such as 330 yen for 1.5L may have been a helpful step that would have clarified students' thinking. These students were asked to think about an abstract solution to a problem with no way of linking the more complex problem back into a concrete situation.

This was a point not picked up in the post lesson discussion and it appeared that persistence with the double number line was accepted and the way forward was either it would need smaller steps of explanation or that the students needed to fully master this first.

Disappointingly this was mirrored in the IMPULS discussion despite my representation that a pictorial concrete stage was missing. There was a blind-sighted view that 1.5L would not be a good alternative, after which further comments were blatantly ignored. This only served to underline the need for an effective "chair".

What new insights did you gain about how administrators can support teachers to do lesson study?

It was clearly stated to us, several times that the team had met several times to discuss this lesson and the approach to divide by decimals. It was clear that the planning team had gained a lot from this experience and that the lesson was only the tip of the iceberg. In fact the team had not only gained understanding by observing children learning in Mr Oashi's lesson they also gained a lot from the 8 meetings before the lesson. I felt it was important that most of the observers had taught this very same lessons before and therefore could discuss it with insight. Furthermore the fact that observers had a shared understanding of this lesson allowed the conversations to be deeper and therefore promote deeper understanding. The early release program on Wednesday afternoons is an effective way to support teachers in finding consistent time dedicated to collaboration, research, and discussion. Allowing teachers to undertake the same lesson and allowing time for discussions and planning would be a fundamental way teachers can be supported.

It was also interesting to observe how the planning team and the observers kept comparing this lesson to what is in the textbook. One of the IMPULS participants asked why he used 320 Yen and 1.6L instead of 330 Yen and 1.5 L. The teacher responded that he did so because this was in the textbook. He also stated that if the numbers were presenting a solution that was too obvious, the children would not have had a chance to really reflect on the meaning of division.

How does this lesson contribute to our understanding of high-impact practices?

I was very interested in the fact that the team said that they decided to teach this lesson for their research lesson because the topic is difficult to teach. This gave me a deeper understanding of lesson study. This really helped me to clarify the difference between a demonstration lesson, or master class, and lesson study. The teachers decide to do lesson study on a certain topic because they feel they need to improve their teaching of that particular topic. Observers are invited in order to support the planning team and develop the entire profession not to "see how to do it".

At the start of the lesson, when the boy said, "I don't understand", and Mr. O. said, "You're going to

be the star of the lesson today," it became apparent that there was a community of respect and trust established. Also evident was that this was a classroom that kept student thinking and problem solving at the heart of mathematics instruction and students in this community shared a responsibility for developing mathematical thinking and mathematical 'self-esteem'. When students engage in productive struggle and succeed, they own the ideas developed. When the mathematical ideas generated come from the students and not the teacher, the understanding is rooted. How this lesson progressed, we won't know, but I was impressed by the fact that the entire lesson was generated from the students' ideas and questions.

The knowledgeable other praised the teacher and the planning team for allowing the children to be involved with productive struggles. He pointed out that children inability to choose the appropriate calculation is a common problem in Japan and therefore praised the team on choosing this focus for their research lesson. and gave suggestion to improve the research further.

In tackling a complex issue the teachers may give rise to a series of connected lesson studies. In this case there are interesting issues that can be researched independently of each other, such as the need for fluency of the double number line, the fluency of choice of operation, the need for a pictorial concrete stage before pictorial abstract.

This process exemplifies that the lesson study approach is an ongoing process of research that often may raise more questions than it answers.

3 Reflection Journals

Anne Brosnan
IMPULS Lesson Study Immersion Programme
Maths teaching and learning in Japan and Japanese Lesson Study

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Participating in the IMPULS Lesson Study Immersion Programme captured for me the energetic tenor and illuminating insights into how central Japanese Lesson Study can be in promoting maths teaching and learning in its own right. The Programme also afforded me the opportunity to go deeper into the theory and practise of Lesson Study and what it can accomplish. I cannot do justice to the eight lessons observed and lectures received
on the IMPULS Lesson Study Immersion Programme. In the four themes I raise below, I can help to make explicit my reflections about maths teaching and learning in Japan and Japanese Lesson Study.

(1) The craft of teaching effective problem solving

Maths is taught through problem solving and as such problem solving is seen as a means not an end. It is a disposition and skill that students and teachers are clearly at home with. The didactic contract (so prevalent in Ireland) where 'the teacher is obliged to teach and the pupil to learn' (Brousseau and Otte,1991, p. 18), or at least to 'pass the assessment' was eclipsed in all the classes observed. Instead, it was discernible that
after the presentation of the problem by the teacher, the stage was set for students to work independently, or as in some cases with their partner, to develop solution methods. Students were encouraged to write mathematical expressions and words to explain their strategies. Guidance was given by the teacher if required. The help offered by the teacher was the type of help that left students with what could have occurred to them naturally. When the teacher presented focused story problems they never demonstrated how to solve them. These problems fell into 2 categories:
(i) appropriate problems that were clearly connected to the previous day's work, yet this prior knowledge did not give away the solution method in advance and
(ii) productive problems that lead to a new idea for students by reflecting on its solutions. In either case solving the problem was not the goal.
The main component of the lesson was the presentation of solution methods by
students to their peers (Neriage). Carefully guided by the teacher, their strategies were compared and critically analysed. The teacher started with the easiest method produced by students through to more sophisticated strategies. As students presented each
strategy (carefully selected by the teacher), they had to explain and justify their
individual reasoning to their peers. The teacher in turn highlighted and summarised the major points, slowly reaching the goal of the lesson. This pattern was evident in all the lessons observed and has been called 'structured problem solving' by Stigler & Hiebert (1999). This cultural script for

problem solving appears simple, but is an extremely
complex process, involving teachers in their own problem solving process. The craft of teaching problem solving is developed during *Kyozai-kenkyu* which is part of the process of Japanese Lesson Study. This will be commented on further below.

(2) Assessment for Learning: A "toolkit or an "umbrella"for teaching and learning maths"?

Assessment for Learning (AfL) has quite rightly received a lot of prominence in
educational reform internationally in recent years. The real significance of AfL is
bypassed if it is simply seen as a "toolkit" or its constituent elements as a set of skills to add on to a teachers' pedagogical approaches. I often feel that this is the reaction of many to AfL. In the lessons I observed, I gleaned that AfL is not a challenge or a set of skills to be negotiated on the part of the teacher. The use of teaching and learning strategies from the assessment for learning family were knitted seamlessly and
meaningfully into the classroom by the teacher. The assessment for learning family was akin to an umbrella, creating a safe environment to polish the craft of problem solving for students and teachers, which I found intriguing. Again, I must refer to *Kyozai-kenkyu* as many AfL strategies are developed and refined during *this stage in Lesson Study* in a non artificial way. Consequences of AfL for students' engagement and quality of learning in the research lessons observed are reviewed briefly below. This list is not exhaustive.

- Specifying the learning intention
  This occurred in an unforced way, at the beginning of some lessons which focused the students' efforts and it was clear that students could assess their own progress towards this goal. In some lessons, the teacher asked students at the end of the class: 'What should we call today's lesson'? This allowed the teacher to listen to what the students said and could gain a clear understanding of what they had learned
  during the class.

- Using questions and feedback to enhance students' learning
  The type of questions posed by teachers were not of the type that lead to right or wrong answers. Consequently, no students were excluded or afraid of giving the wrong answer. When students were working on the problem or presenting their ideas the teacher gave them the time and opportunity to think further to their (i.e. the teacher's) questions. This sent out positive signals and, as a consequence, there was great participation by students. This also created a safe environment for students to think about questions and venture answers in the classroom. For the teacher, it
  revealed students' thinking, even if it contained errors, and allowed teachers the
  luxury of probing further and this promoted discussion. The "hands up" policy, so often seen in Ireland, only occurred when the teacher signalled with their own hand that
  students could do so. This was used in isolated cases when the teacher wanted to know who would agree with a particular student's response. All of this lead to a
  relaxed atmosphere in the classrooms with students focused, involved and
  cooperative.

- Cultivating self-assessment
  Students were well rehearsed in practicing self-assessment. At the end of each lesson students

were required to write a reflection on what they had learned in the lesson. In a very natural fashion, students wrote up what they had learned and often identified what they still did not understand. The teacher collected these reflections at the end of the lesson and thus could follow them up the next day and target what difficulties needed to be clarified and addressed. Interestingly, the textbooks we viewed showed students examples of how to write reflections and class notes. In their reflections,
students are also encouraged in these exemplars to take down all the solutions from their peers that are on the board, to reflect as to how their strategies compared to their peers and to decide if their strategy was more efficient or not. From a students' perspective this brings them closer to their own learning.

(3) Japanese Lesson Study: Integral to the landscape of the teaching profession

In Ireland, as in many countries internationally, reforms and significant developments are taking place that will shape the landscape of professional practices. These
reforms and developments in Ireland are listed below:

- The significance of PISA
- Key Skills
- Assessment for Learning
- A National Literacy and Numeracy Strategy
- School-Self Evaluation which sees a shift from the traditional forms of inspection to one where Inspectors are playing a more supportive role
- Reforms at Junior Cycle (the first three years of post-primary education)
- National Framework for Continuing Professional Development (CPD)
- Leadership Practices.

Many teachers view these reforms as extra add-ons to an already overburdened workload. What struck me about Japanese Lesson Study is that it promotes and achieves these reforms (listed above) and more besides in its many variations whether it be at school, district or cross-district level. To view Lesson Study as a
technical cycle of collaborative planning, teaching and observing, analytic reflection and ongoing revision is a very simplistic and naive understanding of it. Participating in the Immersion Programme broadened my understanding of how profitable and
creative Lesson Study is in achieving what all the reforms listed above set out to do. It offers the scope to provide an enduring implicit, rather than explicit pathway to
negotiate these reforms for the teaching profession. The organisation of Lesson Study is concerned with forms of school leadership that are hospitable to a culture of
leadership capacity and bridges the tensions between the demands of leadership and administration. In the organisation of Japanese Lesson Study at school, district and cross district level it addresses issues of time and planning and extends the benefits of research lessons to other schools. It offers different categories of need in CPD and cultivates teacher networks. It gives teachers ownership in their professional
development, supports and sustains good practice in CPD. The post-lesson
discussions show how discernible teachers can be as reflective practitioners and builds sustainable subject departments within schools.The post-lesson discussions
involves a partnership between schools and universities. The importance of these links cannot be stressed enough. At the heart of it all, it cultivates students as active and responsible participants

in their own learning as mentioned above.

(4) *Kyozai-kenkyu:* Paths to discovery

There is a strong research dimension to Japanese Lesson Study, predominantly the lesson plan. The ideas and practices of the research lesson plans yield to effective forms of problem solving. The implementation of these research lessons provide teachers with deep insights into students' learning which can significantly enhance teachers pedagogical capacities. However, I found that it is *Kyozai-kenkyu* that is the fertile ground that affords teachers the professional scope to become a Level 3 teacher and develop the attitude and desire to continue learning. *Kyozai-kenkyu* also dissolves the rift between theory and practice. During *Kyozai-kenkyu* teachers become problem-solvers themselves. While *Kyozai-kenkyu* occurs before the actual development of the lesson plan and entails the study of many aspects of teaching and learning, which are beyond the scope of this reflection, what struck me most:

- was the knowledge and anticipation teachers had into the various strategies students could possibly produce in solving the problem
- how the teacher eventually uses the students' solution strategies to develop this new idea in the classroom.

To me, this anticipation and studying of possible students' solution strategies that contributes to effective problem solving and the unforced manner in which teachers are able to assess students' understanding along the way. Without these, a problem solving lesson can turn into a show and tell. Instead, we saw in the teaching of the research lessons how the anticipation of students strategies shaped *Neriage.*

I have, in the four themes above, summarised my reflections on maths teaching and learning in Japan and Japanese Lesson Study. First and foremost, maths teaching and learning in Japan is not, as is in many cases in Ireland, in the grip of exam-centred attitudes and practices. It is impossible to discuss maths teaching and learning in Japan and Japanese Lesson Study separately as they cannot be regarded as independent of each other. On the one hand, maths teaching and learning in Japan through mathematical problem solving influences Lesson Study and on the other hand, Lesson Study draws teachers to be problem solvers into how to develop lessons for the purpose of improving students' ability in problem solving.

Finally to the IMPULS Team, programme organisers and graduate students as well as the principals, teachers and students of the schools involved, I wish to send a hearty thank you for a truly memorable and rewarding experience.

Aoibhinn Ní Shúilleabháin

IMULS 2015 Reflective Journal
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Reflections on Japanese Lesson Study and Mathematics Education

As a representative of mathematics education in Ireland and as a teacher educator, it was an exceptional opportunity to participate in the IMPULS 2015 programme. While I have participated in and conducted research on lesson study, the IMPULS programme offered a unique opportunity to learn about very many aspects of Japanese mathematics education, lesson study, and educational culture in a rich and collaborative environment. It was fascinating to take part in observations of research lessons and post-lesson discussions in schools where "lesson study is like air" (as described by Pr Fujii), and to be a peripheral participant in the professional development practices which are central to teachers' continuous and embedded learning in Japan.

Figure 11 3rd grade research lesson

Various forms of Lesson Study

During the programme it was interesting to learn of and have first-hand experience of lesson study in its various forms.

School-based lesson study is the form most commonly referred to in the literature. I found this form most applicable to the introduction of lesson study as a model of teacher professional development since it is directly relevant to a particular school's teachers and students, collaboration and collegiality are central to the approach, principals often play a key role in the cycle, and post-lesson discussions are valuable and constructive to the conducting and participating teachers.

Figure 12 Post-lesson discussion in school-based lesson study

District wide lesson study contrasted to the school-based form since there were very many observers in the research lesson who had not contributed to the planning of the lesson and the post-lesson discussion similarly included many more people. Hence there was often not sufficient time to in-depthly explore issues of content and pedagogy within the lesson. However, these 'open house' post-lesson conversations were useful in terms of large-scale professional development where teachers broke into smaller research groups to reflect on the lesson and fed their

Figure 13 District wide research lesson

reflections into a broader discussion around learning.
In lectures we were told about, but did not observe, a *national lesson study* held on a much larger scale but where the research lesson is like a lesson demonstration, since the conducting teacher usually plans the lesson on their own.
Another form, not often documented in the literature, was the lesson study collaborations between universities and attached schools. There were often a range of collaborators in these groups including teachers from the school, other teachers from other attached schools in the district, and

Figure 15 District post-lesson discussion

Figure 14 Reflection groups in district post-lesson discussion

university professors. This form differed to school-based lesson study since the lesson was often planned by the conducting teacher with only some contributions from their colleagues. The approach to planning and post-lesson discussions did not seem to be as collaborative as the school-based approach and the conducting teacher sometimes seemed to have to defend rather than discuss the decisions taken within the lesson.
In all of these forms of lesson study, the knowledgeable other played a key role in concluding the post-lesson discussion and in introducing more ideas on the content or pedagogy within the lesson (Takahashi, 2014).

Figure 16 Research lesson in University-attached school

Figure 17 Knowledgeable Other in district post-lesson discussion

This knowledgeable other was often a university professor or district expert in lesson study and their contribution demonstrated the respect paid toward experienced professionals within the culture.
It was very informative and enjoyable to observe these various forms of lesson study. I feel the school-based form would be most appropriate to promote and include within teacher education in Ireland since the associated teacher community would best promote teacher learning and the introduction of new ideas in both content and pedagogy.

Mathematics Curriculum & Textbooks

The detailed sequencing of mathematical learning through primary school and middle school was very evident in the lesson plans and post-lesson discussions. This careful planning of students' learning trajectories in the curriculum seemed to provide students and teachers with clear objectives and direction in building mathematical understanding for each class and year group. From the eight research lessons we observed, and from the lectures provided by Pr Fujii and Pr Takahashi, it was apparent how precisely the curriculum builds on students' prior knowledge throughout their education.

Figure 18 Double number line used in elementary mathematics

This specificity of curriculum objectives for each year of schooling seemed to add to students' learning experiences, where learners could clearly define and reflect on the mathematics they had already experienced. This was notable during research lessons where students were able to declare "*I know we haven't learned this yet*" or "*we learned something like this in grade ,2 but we haven't done this exact type of problem yet*". This recognition of mathematical learning may have also been a feature of students' regularly reflecting on the mathematics they had learned in class - an important feature of learning through problem solving (Schoenfeld, 1992). Nonetheless, I was surprised to notice how students often had a clear idea of the mathematical topics they had already met, since these comments would not be common in Irish classrooms.

It is often marked as a negative feature of classroom practice that teachers be too dependent on the textbook and I was surprised by how often teachers utilised activities from the textbooks in their teaching. However, textbooks take on a different role in Japan where texts are written by mathematics education specialists and academics, and all texts are approved by the Ministry of Education. The careful sequencing of curriculum was directly supported by the textbooks, which also championed a problem based approach to learning. This correlation of content and pedagogical approach between the curriculum and the textbook seemed to strengthen the teaching and learning of mathematics at primary and middle school level - where teachers utilised the textbook as a tool (but not a basis) for teaching and learning.

Textbooks in Japan are carefully written with well chosen, specific tasks which built on students' mathematical understanding and I was fascinated to learn that these activities are designed and modified based on research lessons as part of lesson study. This development of activities through collaboration of teachers of varying experiences and professors of mathematics education greatly added to the richness and value of tasks – which sometimes led to extensive post-lesson discussions from our international observation perspectives on the IMPULS 2015 programme. Furthermore, the detail and depth of planning these mathematical tasks was astounding and has led me to reflect on the writing of classroom textbooks here in Ireland.

Mathematics in the Classroom

Problem Solving & Neriage

One of the most illuminating points of the lesson observations and associated lectures from was the contrasting approach to introducing mathematical concepts. In Japan, there is a focus on solving unfamiliar problems as a way of introducing students to new concepts. As pointed out by Pr Takahashi on the first day of the programme, students are busy solving problems at the beginning of the lesson with teachers facilitating *neriage* or discussion at the end. This is an opposing approach to traditional teaching that is often referenced in the literature and I found it very informative to see

this problem based approach to learning mathematics in primary and middle school classrooms, where students were encouraged to share their various strategies in attempting to solve a problem.

During lessons students were usually asked to communicate and discuss the various strategies and this *neriage* provided students with ownership of their mathematical learning as well as purposefully and sequentially building students' mathematical understanding. As well as building problem solving skills, I believe this approach gave students a broader sense of 'Mathematics' as an evolving body of knowledge rather than as a subject which stands alone as an already-solved body of facts. Within *neriage*, teachers' 're-voicing' of students' strategies assisted in students developing their skills of communicating their mathematical understanding. This teacher practice also necessitated teachers listening to and interpreting students' strategies during the lesson.

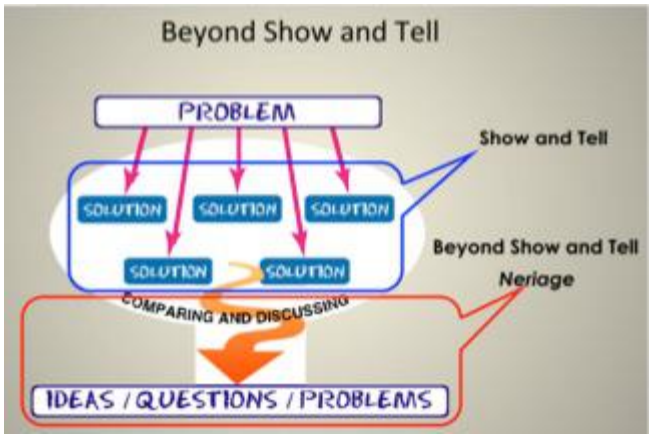

Figure 19 Problem Solving Approach: Lesson Study Alliance

The problems introduced in each of the research lessons we observed were based in contextualised, concrete situations and this emphasis on context and visualisation parallels with the constructivist-based primary and post-primary mathematics curricula in Ireland. It was interesting to observe the common classroom practice of working on a single problem for the duration of a lesson when introducing a new topic, since the real learning happens at the end of the lesson during *neriage*.

Board-writing

Figure 20 Careful planning of board-work

The focus on board-writing seen in lesson plans and in lessons themselves provided much food for thought. With the increase in technology in classrooms, we have seen a move away from traditional board work to the use of PowerPoints in classes. Observing the careful use of board work in presenting students' strategies and in building students' understanding of a particular mathematical concept has highlighted the importance of having a visual trail of learning within the mathematics classroom.

Teacher decision-making

Throughout the IMPULS 2015 programme, the rationale of each lesson was emphasised. Teachers' decisions in choosing particular activities, asking precise questions, sequencing students' answers, and providing opportunity for individual or collaborative work were purposefully thought through due to the rationale and mathematical basis of the lesson. I was delighted to see and learn from how carefully teachers anticipated students' strategies in their planning and how the sequencing in presenting these strategies was important to consider for students' learning.

Observing these Japanese research lessons has provided me with a starting point from which to introduce in-service and pre-service teachers to alternative views on introducing mathematical concepts. As a mathematics teacher educator, I have also learned much on the implementation of a problem based approach to learning which aligns well with our primary and post-primary curricula in Ireland.

Teacher Education and *Kyozai Kenkyu*

The idea of *kyozai kenkyu* is transformative in thinking about the continuum of teacher education. I was surprised that in Japan, a teacher is considered 'novice' if they have less than five years of teaching experience and is not considered 'experienced' until they have more than ten years of teaching experience. Teachers are not considered to be able to reach 'level 3' of their teaching until they have gained experience in the classroom (Sugiyama, 2008).

Japanese teachers value collaboration with their colleagues where they feel they can learn from discussions and reflections with their colleagues and, in this way, a solid professional knowledge is established for mathematics teachers. Teachers regularly access teaching articles and research literature in building their knowledge of teaching topics and share ideas on materials and resources with one another. This regular access of literature, curriculum, and materials is incredibly important to teachers' practices and is an important culture of teacher education which can be shared with other countries and which I hope to promote in Ireland.

Mathematics Education Community in Japan

The relationship between educators at all three levels of the education system was surprising to see since there are no formal equivalent relationships in Ireland. Teachers from primary and middle-school level worked closely with mathematics education professors in lesson study cycles and there existed wider communities of teachers in district and subject-based groups that collaborated in researching their classroom practices. Many of the professors were former, experienced teachers who had a deep knowledge of both primary and post-primary curricula. Professors were often invited as the *knowledgeable other* who presented a final comment and additional ideas during the post-lesson discussion.

In Ireland at present, there is no such community of teachers and professors at a wide, regional level and these collaborations in Japan provide us with something to aspire to. In addition I feel that retired teachers, who have a vast amounts of teaching experience, could be invited to schools as a *knowledgeable other* in Ireland and may provide us with opportunity to share and build on the knowledge already gained by mathematics teachers in Ireland.

Conclusion

As one of the 27 participants in IMPULS 2015, I am delighted to have had this exceptional experience in learning more about mathematics education and lesson study from our Japanese and international colleagues. I feel this has been an important and unique learning experience and I am ambitious about introducing Lesson Study as a powerful, voluntary form of teacher education in Ireland. While there are cultural differences between our education systems (Fujii, 2014), I believe we have a strong educational basis and respect for learning in Ireland and I look forward to the possibilities in teacher education with the further development of authentic lesson study throughout the world.

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Brian Doig

IMPULS 2015 Overall Reflection

Pre-lesson briefings

The background information on Japanese Lesson Study was distributed gently over a few days, and opened people's eyes to aspects of JLS that need attention, but are often missed by non-Japanese observers. This was evident in after-hours chatter among the participants: many a 'why did he say …' and 'what does he mean by …' questions were uttered. However, over time these questions were being answered, as the number of them dropped away, presumably through the experience of lesson study in practice.

For me, it was a good opportunity to refresh my mind on aspects of JLS as practised in Japan after three years of working with adapted versions in Australia.

The alternative presentations, to those I have previously attended, were also interesting to note different emphases by the IMPULS presenters compared to JICA presenters.

Lessons

The variety of lessons was a good mix, but some tended to be seen by participants as 'failures' or 'bad' lessons. These criticisms lasted until the middle of the second week, which surprised me. While I agree that some lessons were rushed at the end, the essentials of structured problem-solving lessons were ever present.

I think that a difficulty for observers is that viewing Japanese lessons through 'Western eyes makes things a bit tough. For example, many criticised any teacher who did not question, or display the work of, an equal number of boys and girls. Clearly, this cannot always be done: it depends on which strategies are being used by children of which sex, and the focus must be on the strategies. Again, there was much criticism of those teachers who did not engage children in 'small group work', another favourite fad of Western educators. And this, despite the evidence against its usefulness.

Personally I thought that achieving the goals of the lessons was of more importance, rather than balancing the questions to both sexes, and I believe that small group work is not a positive learning environment, and certainly not as effective as whole class discussion of individual's work.

This being said, there was not any addressing of this view: we were left to work through these differences pourselves and I think many did not think through why the JLS model is as it is, or why it does not resemble Western approaches to teaching and learning. I feel that it is a mistake not to find out where the participants are, in their thinking about pedagogy, rather than to make a definite plan to open up the conversation about what these differences in pedagogy are, and why they exist. This may, of course, be too difficult given the range of educational contexts people come from, but it seemsed to me that there was a general Western view-point that cold have been addressed.

In all, I would say that the lessons were not as good as others that I have seen overall, but to get access to so many lessons in such a short space of time was a miracle in itself, and that ensuring that they were all of the highest standard would never be possible. Of course, my favourite, Takahashi-sensei, always impresses, despite his imbalance in questioning and the lack of group work!

With two translators providing commentary on the spoken and written word, I think that we were more involved than in any other lessons that I have attended. This was particularly true of having children's work translated and summarized for us during the lessons.

A high-light of the lesson observations was the visit to Yamanashi: both the school and the area, including the hotel. The school's architecture was well worth seeing, and many asked the question:'Why don't we build schools like this at home?' A good question if ever I heard one!

Post-lesson discussions

Post-lesson discussions, or debriefings, that we attended, were an interesting mixture of Japanese

participants and IMPULS participants listening in on the Japanese teachers' comments. Fortunately, our two translators kept us abreast of what was happening and we benefited from the opportunity to note, to some extent, how different the teachers were in their comments compared to us.

The community

The most striking thing, for me, about thee group, was the similarity of the UK and US teachers. This clearly makes the work of the IMPULS team easier in addressing the very similar attitudes and even pedagogies of the UK and US teachers. For example, everyone was surprised, and concerned, that there was no small; group work undertaken in lessons (despite US research showing that small group work to be not an effective pedagogical strategy!). I have already mentioned, above, the focus on some sort of sex-based equality: my impression from watching lessons in Japan is that the solution strategies that will generate a discussion towards the goal of the lesson dictates which strategies are displayed: I now think that I may have been wrong all this time, and that there is a bias.

I noticed a shift in participants' thinking with respect to lesson goals and approaches during the second week, but some participants clung to the views that that they had brought with them, from their own culture, that the way 'we do it' is correct, and the Japanese approach is flawed in some way. This, despite the evidence from international studies of the different performance in mathematics between the West and the East, in favour of Eastern pedagogies.

However, those who found the JLS approach to be beneficial, were loud in their praise of the structural aspects of the structured problem-solving lessons, even while sticking to the small group and sex balanced questionning aspects of the West.

Conclusions

The use of an Internet site to file presentations and other related materials is a very good idea, and worked well. The student 'slaves' are to be congratulated on their sterling efforts in regard to this. The IMPULS staff who contributed expertise *via* slide shows and text are to be congratulated for their efforts in keeping us up-to-date and providing continuity post-IMPULS *via* the web-site.

I wondered whether it would be worth having the group prepare and teach a structured problem-solving lesson to one another or to some Japanese students (or the Masters students?). Would this have been a valuable experience too. Having talked the talk, could we have walked the walk? In my experience having to do it, makes all the difference to engagement and understanding.

Overall, the IMPULS experience was a period of hard work, thinking, and observing unlike any other most of us have done for a long time. For me, it was refreshing to hear some different view-points on topics of interest to me, and interesting to hear the other participants' views on things that I take as sensible and prodcutive: so they made me question why I thought JLS was best practice.

Bridget Clay

Reflective Journal: IMPULS Programme June-July 2015
Bridget Clay

This programme gave me a unique opportunity to visit eight different research lessons in Japan and gave me significant insight into both mathematical teaching and learning, as well as Lesson Study and teacher development in Japan. I have split my reflections into those around the Japanese education system and teacher development as a whole, mathematical teaching and learning, and Lesson Study.

My current role working for the Teacher Development Trust is to promote effective teacher

development across the UK and to support schools in implementing it. As such, my reflections have a particular emphasis on teacher development and Lesson Study. It is also worth noting that we did not visit any high school during this trip, which may have offered a different insight.

Japanese Education System

Whilst it is very difficult to separate these three strands, as they are all intertwined, there are two aspects to emphasise around the Japanese education system, which are particularly different to not only England, but the other Western education systems from which there were representatives (America, Australia, Ireland, England).

First, experience is highly valued in Japanese teachers. Teachers are considered to be novices up to ten years into their career. This means that there is a high expectation that teachers will develop and improve through and beyond that time. It seems that whilst in England we do have continuing professional development, in practice a newly qualified teacher (NQT) is often expected to teach as much and as well as there more experienced colleagues. Similarly, whilst there are many highly skilled experienced teachers, occasionally you see the assumption that an experienced teacher who has not moved into a more senior (i.e. management) role, is in fact an expensive burden, rather than a huge asset. This underlying context in England seems to manifest itself as teachers in Japan valuing their own development more than their English counterparts. It was also notable in Japan that school principals tended to be expert teachers, rather than expert managers and leaders, which you sometimes find is where the emphasis is placed in England.

Whilst in Japan, I had questions about assessing the performance of teachers. As far as I could tell, teacher pay related to experience, so didn't they find that some poor performing teachers were too well paid? And how did one deal with poorly performing teachers? The answer seemed to be that, where really necessary, there was *some* teacher evaluation and performance management, but it wasn't the driver it appears to be here. In general, teachers worked *very* hard to improve, and in general they did. Becoming a teacher is also more competitive than in England and they obviously have a strong programme of teacher development that means teachers do improve. Of course, cultural differences around work ethic are likely to come into play here.

Second, the shared knowledge and expertise really impressed me in Japan. At least within Maths education, although I assumed it went across all education, there is a body of very carefully researched and refined knowledge that *all* teachers buy into and use. This has a transformative effect on professional development and teaching as a whole; sharing practice and pedagogical discussions are of a much higher level, as the starting point is so different, teachers have *good* resources that are easy to find and that they know and can trust are good, and the quality of the curriculum is remarkably well thought through and structured. Compared to England, there are huge differences of opinion, many of which aren't research-informed, that mean that some teachers won't learn from others where there appears to be an ideological gap. Similarly, many beginning teachers are reinventing the wheel every year, school schemes of work are of hugely varying quality etc. To an English teacher, this shared knowledge and followed curriculum sounds very prescriptive and top-down, but in practice it appeared that teachers could still use their professional autonomy to adapt, refine and adjust to their own pupils and, importantly, the curriculum isn't stuck, it has a vast quantity of research behind it, but it also has a large amount that is still going on, ensuring that it is always of high quality.

So how can this come about? Researchers, schools and the Ministry of Education communicate and work very effectively together. It appeared that researchers are all, or at least often, former successful teachers and there is much more communication between teachers and researchers. For example, the 'knowledgeable other' in schools' Lesson Studies is linked to a university and can be a very senior professor. Not only that, but school Lesson Studies contribute to much of the research that occurs. There are also 'attached schools' which are free but independent schools (I understand that they are normally selective, too, but I'm not sure on what criteria they are selective) linked to a

university. These will have a number of student teachers, as well as experienced teachers who may go on to academia.

From this, a limited number of resources are produced. There are only six different textbooks in Japan that schools can use and all of these are well researched and will have broad similarities (certainly more similar than English textbooks). This means that all schools and teachers are working from a shared level of knowledge and understanding. In contrast, English textbooks are hugely diverse and some contradict each other (I imagine the English language textbook market is quite different to those written in Japanese, but still). This makes a huge difference to many aspects of Japanese education, including Lesson Study.

Finally, there are other noticeable differences, which are interesting although perhaps less relevant to Lesson Study. For example, there is a greater emphasis on pupil responsibility and independence; they serve and clear up their own lunch from their first year of school, they also often have a plant whose growth they are responsible for during each year at primary school. In addition, there is a greater focus on the skills a teacher may have around boardwork. There is a tendency for the progress of the lesson and different approaches taken to be stuck or displayed all across the board. As such, schools have much cheaper resources (no interactive whiteboard, for example) but use the space and display children's work much more effectively than you would commonly see in England. I also saw less evidence of particularly 'inclusive' practice, as we would see in England. This is not something we explored in great depth, but I understand there to be some differences in approach there.

Mathematical teaching and learning

As a former Maths teacher, I really enjoyed the mathematical learning in Japan. It was interesting, of course, but also just fun to see. Children had an exceptional understanding of prior knowledge and how different mathematical concepts relate. It made me want to go straight back into a Maths classroom!

Tied to my pervious reflections about shared knowledge and understanding, the Maths curriculum, at least for the primary age children we observed, was really stunning. It has been developed over decades and constructed in a way that is far more thought through than anything I've seen in England. There has been very careful thought about what order things should be learnt, and what knowledge builds on what understanding. Even to the level of what numbers work best for introducing a topic, as they will give rise to the least misconceptions. Of course, this is all build on many, many research lesson studies!

The other striking aspect of mathematical learning to take away, is that Japanese children learn far less content than their English peers, and yet they have the understanding and ability to apply it, which means that they still achieve more highly. This seems to be through the focus on different levels of teaching. The first level is just about teaching a method and a process, which anyone could do. The second is about helping children to understand why a method works, the basic reasoning behind Maths. Finally, the third level is to provide opportunities for children to understand this basic reasoning and become independent thinkers and learners. By a significantly stronger emphasis on the latter two levels, children appeared to be much more able to draw on prior knowledge, to apply their mathematical learning and to have much more in depth mathematical questions and conversations.

This was visible in their lessons by much more problem solving. In England, much of problem solving is "real life" and also taught collaboratively. In Japan, there appeared to be much less collaborative learning (which I felt was a loss) but much more carefully thought through problems, where there wasn't necessarily a tie to real life, but children *did* have to approach a problem to which they didn't yet know what type of skills they might have to use. The productive struggle that then followed, alongside other more 'consolidating lessons' seemed to produce very secure mathematical understanding. Within each lesson we saw, it was noticeable that far less content was covered, and

only one problem might be looked at. In fact, a subject such as 'dividing by decimals' was split into a whole lesson on 'when and why would you divide by a decimal?', before even getting to 'how would you divide by a decimal?'.

Lesson Study

The phrase 'lesson study is air' was used multiple times through this trip. It is hard to define Lesson Study in Japan, because it is so much a part of what they do. Also, because it's so common, Lesson Study is probably done slightly differently all over Japan. However, the research lessons I observed still gave some significant insights into the process, and how we might use it better here.

First, the process was slightly different to how I anticipated. Teachers involved in a Lesson Study spend much more time planning than I've seen in England. It might take 6-8 weeks to plan a research lesson and a great deal of groundwork will go into that. During the groundwork, teachers have a readily available body of expertise and knowledge (through the curriculum, textbooks etc. in a way that we don't), which they refer to, as well as detailed conversations about the lesson, and perhaps trials of the lesson.

The observation of the lesson then has many more people than I've ever seen in England. Due to our toxic culture around observation, in England it is normally only those who have planned the lesson who will do the observing, as it is their lesson to observe. They will sometimes also focus on particular 'case study pupils' to ensure that all through the lesson there is a very specific pupil focus. In Japan, it is common to have more than 30 observers, and even over a hundred at a district lesson. This means that the observers haven't all been part of the lesson planning and don't necessarily know your class. I personally found it hard to keep the pupil focus, when I didn't know the pupils and if I wasn't very, very secure on exactly what I should be looking for at each stage. (However, the language barrier probably played a part here, too.)

Finally, the post-lesson discussion was much more personal than I expected it to be. Whilst there is a definite pupil focus, the conversations are much more directed at the teacher and it must still feel quite pressured. By having observers who weren't part of the planning, the conversation potentially goes further than it would otherwise, as it is a chance for new ideas to come through. In addition, even though observers were not part of the planning, they still have a shared knowledge and understanding that means they can contribute to the discussion well. The discussion is also much longer than I've seen in England!

Also, the post-lesson discussion doesn't *automatically* lead into what the next lesson observation should be. There might be as much as a term between one research lesson and another and, whilst both will fit into an overall theme, they could be quite different. Each research lesson will feed into the next one, contributing to shared, ongoing learning, but it is certainly not a matter of re-teaching the same lesson, and it is likely to be a matter of teaching quite a different lesson.

There are also aspects around the structure and facilitation of Lesson Study as a process that are different in Japan. Time is a big pressure for schools in England. It seems that in many school districts in Japan (at least within and near Tokyo), schools finish early on a Wednesday to allow all staff development time. Much of this time will be used for lecture-style CPD, joint planning, but also Lesson Study. Whilst this would seem to get around the peer observation problems that many English schools struggle with, it's worth bearing in mind other factors, too. First, Japanese are more comfortable with pupils coming in during the weekend or after school for particular research lessons. Second, they are more comfortable leaving pupils to get on with their work whilst less supervised.

Lesson Study happens everywhere in every subject in Japan in primary schools, but it happens less and less often as children get older. This means it is far less common in high schools. I didn't observe any high schools, I have no idea how they differ culturally. In addition, there was no sense that this was a good thing; our colleagues *wanted* Japanese high schools to be doing more Lesson Study! However, Lesson Study is something that is growing in both primary and secondary schools in England, and I hope that is something that continues!

As discussed a little bit above, the culture and system within Japan allow Lesson Study to flourish. It was striking how much trust and openness to criticism there was between colleagues. Much of what was said in a post-lesson discussion would have been too challenging for many English teachers, despite maintaining a pupil focus. The willingness to develop and learn from each other and, perhaps, the compliance of teachers in Japan allows this to happen. In contrast, we have very high stake observations and accountability, which could threaten such an approach here. Similarly, we don't have a shared knowledge or understanding across schools, which would very much change the nature of the post-lesson discussion if there were large numbers of people.

The role of the final commentator or knowledgeable other is also significant in Japan. In England, this would be very hard to replicate as we don't have such strong relationships between schools and academia, and we also have a number of experts and consultants who are no such thing, so identifying expertise is hard. In addition, some staff, given the toxic culture around observation, might struggle with having an expert observe them. Some staff need to, at least initially, benefit from a non-toxic research lesson, where they feel free to innovate and research an idea, rather than follow a prescribed process (which some teachers are used to). Without systemic change, it is still important to begin to develop this role, and ensure that the ideas in a Lesson Study are underpinned by research and evidence.

Finally, I picked up some useful tools and tricks to help the Lesson Study process. A pen with multiple colours is very helpful for observation, using seating plans as part of your reflections helps with the pupil focus and the Lesson Note App is transformative!

Conclusions

The ten days spent observing and learning about Lesson Study in Japan were really transformative. As this essay highlights, there were a number of aspects that now need to be developed in England and I look forward to working with schools to build these in. However, it is important to be aware of the pressures and external limitations that might be present in England that don't exist in Japan, as well as the strengths that we have.

Christopher Nazelli

Before beginning my reflection on what I have learned during the 2015 IMPUS Immersion Program, I would like to express my gratitude to Professor Takahashi, Professor Fuji and the entire IMPULS staff—especially the tireless graduate students. I cannot imagine more gracious hosts or better ambassadors of lesson study.

I first learned about lesson study through a graduate course on teacher professional development. Intrigued by the potential for teacher improvement and student learning, I read many lesson study facilitation guides (by authors such as Catherine Lewis) and journal articles (many by the leaders of IMPULS) and began to work with local groups of high school and middle school teachers. To say that my understanding of the lesson study cycle was incomplete at that early stage would be a serious understatement; but, following the IMPULS experience, I now have a much better understanding of lesson study and how much more there was (and is) to know. My experience with lesson study has been very localized: concentrating on a small number of teachers from a single school. The IMPULS program helped me to place lesson study into a broader context, and how different types of professionals function within the system. In particular, I better understand the role of the Knowledgeable Other, how deep the study of the surrounding curriculum, other curricular materials and research on the lesson topic can be, and the power of lesson study to both transmit and shape the values of a school.

I feel that the areas of greatest learning for me during the IMPULS program deal with two areas that will be quite difficult to translate into an American context: the role of the Knowledgeable

Other and the Study of Materials (Kyouzai Kenkyuu).

Each of the different final commentators, or Knowledgeable Others, provided rich, deep commentary that allowed the teaching team and observers to consider the mathematics and the teaching in the research lesson against a national, historical, and curricular backdrop. For example, during the first research lesson's final comments, the Knowledgeable Other mentioned how the lesson's motivating problem (which examined the relationships among three different varying quantities) was well-chosen based on a particular weakness in Japanese students dealing with such relationships that was detected, by the Knowledgeable Other, using data from the 2011 TIMSS report. In the second and third research lessons, the Knowledgeable Others were able to reference mathematics problems and pedagogical approaches from the 1950s that could help to improve the particular lessons. Their suggestions stemmed from evidence of student difficulty and misconceptions and seemed to target issues that arose during the lesson itself. Whether the Knowledgeable Others anticipated these difficulties by looking at the lesson plans or were able to pull these examples from an incredibly well-developed repertoire of knowledge during the lesson observation, the ability to so precisely target and offer potential solutions for these crucial shortcomings was nothing short of staggering. For example, the third lesson's problem involved taking 400g of medicine every eight hours with half the amount taken remaining after eight hours. The students generated a sequence of numbers to represent the amount of medicine in the body over time, but their explanations showed a fragile understanding of all of the different relationships. The Knowledgeable Other sensed that the lack of understanding could be due to the original problem, and presented a more-easily stated growth problem involving a tree (and showed the page that he had pulled from a mid-twentieth century textbook). As an aside, I was simply awestruck when the Knowledgeable Other from the second lesson praised the teacher for her growth over the past ten years (which speaks to the coherence of their educational system that relationships of this length an depth) as well as her use of "reflection writing" as a way to finish the lesson (a technique that he had invented and that is now used throughout Japan). Even when the comments were critical of a lesson, the Knowledgeable Other's comments were always focused on showing how missteps in planning a particular lesson could affect other mathematics in the future. This comprehensive knowledge of the curriculum (both that came before the particular lesson as well as what would follow) allowed the Knowledgeable Other to point to both short-term and long-term ramifications of choices made during the planning process. During the IMPULS program, I saw how important the role of the Knowledgeable Other was in transmitting stored collective knowledge of many different teachers and generations, as well as his own experience and insights. Knowledgeable Others of this quality will be very difficult to find in the United States. There are many professionals who may be experts in mathematics or general pedagogy, but people who are masters of both, who can also speak the language of teachers, and, to be frank, believe in the value of all of these things, are not common. There are many obstacles (e.g. the lack of a common curriculum and the rift between most mathematics and mathematics education departments) that we in the United States will have to overcome in order to cultivate Knowledgeable Others who can approach the levels that I observed during the program. My first idea was to try to approximate the skills of a single Knowledgeable Other with a group of American experts (in the different areas mentioned above): a Knowledgeable Other by committee. After more time, I believe that an individual could serve in this role in a more local context. That is, if a mathematics educator could become an expert in the local district's curriculum, particular challenges, and begin to store and spread this knowledge to other such individuals, we might be able to begin the process of developing local Knowledgeable Others. Each local or district could then form a corps of experts to help lesson study flourish by enriching the post-lesson discussions with the type of information that the Japanese final commentators could drawn upon and incorporate into their presentations.

The other feature of authentic Japanese lesson study that struck me during the IMPULS program

was something that nearly all of the Knowledgeable Others mentioned during their recommendations: deeper material study during the team's development meetings. Again, the development of such a powerful resource—this time the shared stored knowledge of mathematics, teaching, learning and children in the form of materials that can be shared among educators—will take time. Although many local textbooks and curriculum materials come with teaching guides, there is a severe shortage of the collective teaching research information that seem to be so readily available to Japanese teachers. As with the Knowledgeable Others, I believe that we can begin locally and start to connect with others to tap into the fruits of their lesson study research. Some groups have begun this process, and much more needs to be done. Most of the Japanese teams mentioned that, despite the obvious deep materials study they had practiced, they needed more. Having read about the material study portion of the lesson development in American lesson study facilitation guides and research papers, I was shocked by how extensive and detailed the Japanese lesson plans were—reflecting how extensive and detailed the material study truly was. I will bring this new expectation to my lesson study.

I left the IMPULS program having learned so much, but I also left with many questions. I view this as a powerful, positive parting gift, because these questions can serve as the research questions for my own future lesson study experiences. One particular question may connect to own interest in pre-service teacher training. The second research lesson's teacher commented on how, as a new teacher to the school, the lesson study cycle (the first of the young school year) helped her to learn about the school's faculty, children, and values. Could lesson study help new American teachers during the highly volatile induction phase? I am interested in looking at the power of lesson study in easing the transition into the classroom and stemming the tide of new teachers leaving the profession.

I am looking forward to taking all of the new knowledge, new perspectives, and inspiration that the IMPULS program, staff, and participants shared with me and putting them to work with the teachers with whom I am fortunate to work. I am extremely honored to have been selected to participate in the IMPULS program, and I hope to honor the program with my efforts as I return to Detroit. Thank you.

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Hana Al-Ashwal

Mathematics teaching and learning in Japan and Japanese Lesson Study

In lesson study immersion program I attended all the workshops that held in Japan, I saw real lesson study classes, I joined the post- discussion , during this I had written my reflections and I discussed with the other participants the points that all of us observed in each lesson. In my point of view lesson study assess students understanding; provide feedback about their learning, and give the teacher deep understanding of the learners' needs. Lesson study is an ongoing, collaborative, professional development process that was developed in Japan in which teams of teachers collaboratively plan, research, and study their lesson instruction as a way to decide how students learn best.

After all, it is developing the habits of self-reflection and critical thinking through very personal collaboration with their colleagues and structured observation of their students. For more details and during the lesson study, the team researches write a lesson plan. They also write expectations

for the lesson; how students will respond to it, whether it will help them understand a certain concept better, and how it will teach them to understand that concept. It is particularly helpful for new and even old teachers. It's a great way to improve teaching and learning. It really helps teachers to think deeply about their teaching. They write down the expected student responses, and learn how to deal with errors in the lesson plan and how to change it. They get to see lots of examples of good teaching if they focus. A lot of small things add up to effective teaching, in brief Lesson study encourages teachers to know their students and learning will be meaningful. One more advantages are that, not only do the teachers who teach it learn, but the teachers who observe will learn also.
With focusing on improving students' achievement and the growing awareness of the strong performance of Japanese students in mathematics, The TIMSS (International Mathematics exam) results are highlighted the advanced performance and deeper thinking in mathematics by Japanese students.
Let's move to the key element of Japanese mathematics teachers' and students' success is their process of Lesson Study. Lesson Study involves a group of teachers working together on a goal and developing lesson plans that are observed, analyzed, and revised. Their focus throughout this process is on improving student thinking and making their lessons more effective.
The Lesson Study Process
The basic Lesson Study process is as follows:

- Choose a research theme. A group of teachers works together to come up with a research theme. This theme is focuses on a research question regarding their students that involves skills they would like to support. For example, "mathematics instruction that will nurture students who can think logically and express themselves".

- Focus on the research and Goal setting. The teachers select an objective and a unit of study to focus on and search for their students' abilities. And needs within this unit of study. For example, they may select a unit on division of decimal numbers, and the objective to understand the meaning of (whole number) ÷ (decimals) and be able to explain why division is appropriate calculation.

- Write the lesson plan. Collaboratively plan a "research lesson" designed to address the goals. The teachers select a lesson within the unit to develop, and follow lesson plan template. This lesson plan template focuses on questions to assess student thinking during the lesson.

- Teach and observe the lesson. The lesson is taught by a member of the team and observed by the other members and other teachers. The focus of the observation is on students thinking and learning not on teachers' abilities.

- Discuss the lesson. The team and the other observers go together to discuss the lesson and their observations. This is usually done after the lesson. So teachers can get immediate feedback on his/her lesson.

Throughout the process, the Lesson Study team focuses on understanding student learning. That means students are at the center of this process.
The length of this process varies, but it can take up to several months. The size of the team also varies, but typically involves four to six teachers (Teachers learn collaboratively, while focusing on a few ideas), sometimes with a principle and an outside expert (The process support teacher knowledge as well as contributions from outside experts).

The key components of Lesson Study were: student centered, teacher led, Collaborative, content focused and reflective.
The collaborative of Lesson Study helps strengthen the relationships among teachers and improves teaching. The research focus of Lesson Study helps to professionalize teaching. And the greatest reward of Lesson Study is the benefit that students gain by improving their mathematics performance and thinking.
Consequently, I think we need to implement the lesson study in our schools. Through collaborative work, teachers can learn from each other and gain content and pedagogical knowledge. Usually, teachers talk about surface things after they observe a lesson, like the color of manipulatives. Teachers really need to learn how to observe a lesson effectively and talk about it. They need to learn how to observe, and focus on evidence of whether the lesson achieves the objective and determine if the lesson is contributing to students' learning. They have to observe how students are learning, how much they are learning, and if what they are learning matches with what they thought students would learn.
In my opinion lesson study is the most important thing for us to improve our teaching method or teaching techniques. We want teachers to be life-long learners not just students.
So after the summer vacation I will meet my colleges, I will explain to them my new experience that I had from lesson study immersion program and I will share my resources with them, I think we can do most lesson study process we have some difficulties with the text book if we teach the text book but as prof. Akihiko said "we cannot teach text book but we can use text book to teach ". So i see that lesson study is the right process at all the time.

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Jacquelyn Lomas

IMPULS Lesson Study Immersion Program Reflective Journal
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An amazing absorbing 10 days. A huge thank you to the IMPULS team for their generosity in openly sharing their knowledge and experiences and for organising this fantastic and unique opportunity to immerse in such a variety of research lessons.
Based on this visit I now strongly believe that any school or group of schools serious about embedding effective programs of professional learning for teachers with direct impact on mathematical learning for students, should carefully consider the lesson study cycle as used in Japan.
There is variation in approach, even in Japan, but there are some elements I would see as integral and also some nice ideas within the differences I would like to take forward. In this reflection I hope to show what I have learnt about the learning opportunities for both teachers and students if Japanese lesson study is used successfully. I have included some of the Japanese words for various aspects as it is interesting to see how single terms are used to cover seemingly more complex processes. It also gives an idea of how long lesson study has been used in Japan.
Central to the lesson study (jugyo kenkyu) cycle are the long term goals or the research themes. In the school model there is a whole school expectation led from the top, but driven by the teachers to

raise the level of their teaching practice and raise the mathematical thinking of their students. The ownership of the lesson is with the teacher who delivers it in terms of the initial design and the final decisions, but there is also ownership with the team that advise and support and the whole school as it feeds into the overarching theme/goal they are all trying to achieve. The commitment of the Principals, senior leaders and external experts (knowledgable others) to play their role in the research lessons means the process is given status and becomes part of the ethos of the schools and hence 'like air' for all Japanese teachers. The process places teachers as both learners and researchers. The lessons were occasionally planned by a single teacher, but I felt that the professional learning opportunities were greater when the lesson development was a collaborative process.

The cycle itself is clear enough, but the detail is more complex. Lesson study must start with an issue that generates a research question. It is strategic, the issue is difficult and developing solutions is valuable and belongs to the participants. You will not have a meaningful lesson study if you don't start with a good question. Seeing this in practice allows you to appreciate the impact on development of both subject knowledge and pedagogy, compared to generic led workshops or training session. The participants are developing transferable teaching skills and a deeper understanding of learning mathematics in their classrooms. It is not about producing a perfect lesson or resource but supporting a good teacher to become an even better one and this will be a continuing part of their professional learning as teachers throughout their careers. The process takes time, planning for a single research lesson may take place over several weeks and research themes may be in place over several years to ensure results and impact are fully embedded. The teachers appreciate they are taking part in life long professional learning and even the most experienced teachers will benefit from taking part.

The plan for the research lesson (kenkyu jugyo) is better thought of as a collaborative research proposal. It includes a clear aim, a rationale and method for collection of data/evidence. It does not stand alone as a single lesson but is put in the context of the unit of lessons as a whole and the curriculum of study. The Japanese curriculum and resources are already the outcome of extensive development through careful research. Part of planning a research lesson is the intensive study of this curriculum and instructional materials (kyozaikenkyu). This is essential for the Japanese teachers and supports their own understanding of both the subject knowledge and pedagogy. It will not be the same in the UK as we do not yet have access to the high quality resources in the context of the new national curriculum, however we do have some fantastic problem solving resources and the Japanese text books are available in English so can offer some valuable starting points alongside available published research. Applying lesson study effectively will not only support improved teaching and learning but also the further development of instructional materials available.

The plan includes predictors of student's responses, encouraging the teachers to think about how students will approach the problems, likely misconceptions and their own responses right down to the detailed presentation of solutions they will attempt to produce on the boards (bansho) to compare and contrast different solutions. Thinking about how children will attempt a problem involves the teacher thinking through the different solutions and they must also have a secure knowledge of previously learnt mathematics and tools the students have experienced. Looking at the final recorded display from the lesson was often an indication of the success of the lesson to meet the desired aims. The boards told the story of the lesson and the mathematical thinking.

Problem solving and mathematical thinking are at the centre of each lesson. Activities are carefully planned in terms of context, building on prior knowledge, making connections and developing depth of understanding of the mathematics. The lessons all had a similar structure starting with a problem posed (hatsumon), generally in context, which students attempted independently resulting in multiple solutions. The presentation and discussion of these solutions is thoughtfully facilitated by the teacher to allow students to express and refine their mathematical thinking (neriage), a clear

distinction from a simple show and tell of student's ideas. A single problem with solutions were often the basis of a whole lesson, there was no rush to move onto other problems, once a student had a solution they would often search for others or set about explaining their reasoning. There were tasks where we saw students working almost entirely independently and others where there were more opportunities for students to share and discuss their ideas with their class or with peers. When teaching through problem solving you hope to set a problem which engages students in mathematical thinking and an independent struggle to form their own ideas and connections, but if they can't access the problem then without some sort of guidance you worry about losing precious learning time or worse that students develop a can't do attitude when it comes to mathematics. We know that spoon feeding and method dripping are not effective for students learning of mathematics. In most of the research lessons we saw there was less urgency or worry to ensure all students were on the right track, the focus was more on them having a go. In some cases there were hints and nudges prepared and given as needed but they had been designed to support the students thinking rather than leading it. Where students were encouraged to share ideas working or sharing methods there were opportunities for more students to be involved in mathematical discussion and these conversations did move the students on with their own mathematical thinking. I was impressed at how all students even the very young knew it was their role to decide the direction they would take or persuade their peers and their teacher of their rationale. They were not looking for guidance or solutions from their teacher they were actively looking for understanding. The students' contributions to the lesson are central to the learning that takes place and therefore teaching and learning is a single integrated process (*gokshu shido)*.
The post lesson discussion is a formal event with a welcome from the Principal who is always in attendance, although there is variation in the amount they are involved with the lesson and discussion itself. I have talked about the role of the Principal in elevating the importance of the process, but it also strikes me that the post lesson discussion, listening to their teachers questioning and explaining, will tell a Principal a great deal about the teaching and learning in their school. There are various set ups but generally the teacher who delivered, the team who planned together and the knowledgeable other sit as a panel. There is also a moderator who facilitates and time keeps for the proceedings.

The discussions we attended were at least an hour and a half long and sometimes longer. In the primary schools the whole faculty would attend, in the district wide research lessons you would have over 100 teachers. Even though the delivering teacher wants to do a good job and you can see a frustration when it does to go to plan, feedback is not personal, it is about the teaching not the teacher and a lesson that does not go to plan can be a valuable learning opportunity for the participants and their colleagues through the post lesson discussion. At this point the lesson and what is learnt becomes the property of all involved and the challenge to improve is a collaborative one. I found that the most effective discussions were where teacher first discussed in groups or wrote down areas for improvement, problems and things that went well before the start of the formal discussion. Although we had been invited to observe the lesson study process, the project participants were now also involved in analysing the mathematical thinking in the lessons themselves through evidence collected and having our own discussions on how it could be used to influence improvement. It is important to remember that research lessons are designed to address difficult issues it will not always be plain sailing. You also need to keep in mind the aim of the lesson as different aims will mean different approaches and a distinct emphasis on each part of the lesson.

The teacher and planning team are given the opportunity to explain their rationale for the approach taken/task chosen, but this is not in a defensive way it is constructive and generates suggestions and solutions for what may be done next for this class or next time. The attention to detail in the

feedback means absolute rigor around the aims of the research from mathematical thinking to how students share their ideas or enjoy their mathematics. There was variation in the intensity of the feedback but all criticism was given and taken constructively. The role of the knowledgeable other is consolidated in the post lesson discussion. They are experienced teachers, subject and pedagogy experts as well as respected university professors with so much knowledge and expertise to draw on. The summary given each time was often like putting the final piece of a puzzle in place, drawing together the different strands of the research, the lesson, the feedback and the learning.

To use lesson study in this way in the uk there are a few changes in current thinking that will need to take place, however this is such a time of change in our curriculum it is a fitting time to put forward these changes. Moving away from generic standalone training sessions towards establishing a strategic and self-generating professional development process to develop subject knowledge and pedagogy simultaneously. The collaborative nature of lesson study will motivate teachers to discuss mathematics and pedagogy not only for the research lessons but hopefully on a more regular basis.

Mathematical thinking and problem solving have been given higher status in our new curriculum but we need to ensure they become central to the teaching and learning of mathematics not just a bolt on to what's already been done. Teaching through problem solving rather than teaching problem solving is not an easy shift and teachers regardless of experience will need support. A change from focusing on the number of problems a student can solve in a lesson to the quality of problem and what learning can be gained from it. Accepting and using multiple solutions with a focus on concepts and reasoning rather than final answers. If we can engage teachers with lesson study this would be a good vehicle to encourage all teachers to be researchers and really drill down and investigate what's required and the impact it will have. Research should be based on overarching aims for improvement, but with attention to detail that gives rigor to expectations for outcomes and impact.

A post lesson discussion involving an audience more than the participants is a new structure and will take some getting used to, however I think that the collaborative planning will give support and emphasis to the collective effort of a group making feedback less personal and more constructive. The presence of a knowledgable other adds to distinction of the process being a tool for learning and development rather than monitoring or judgement.

To make a start I am going to use an inset day where we have over 140 mathematics teachers coming together from 20 secondary academies to run three research lessons based as closely as possible on the Japanese model. On my return from Japan I sent out an email to ask for volunteers and I already have three academies who will plan and deliver the lessons. We have a meeting set in early September and I am very much looking forward to sharing this reflection and everything I have learnt from my visit with the teams. I am hoping that this day will then inspire some school based models which I can support through the year.

Jun Li

Individual Reflections on IMPULS
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I learned Japanese lesson study many years ago but I had not got a chance to observe how it runs by Japanese colleagues until I involved in the IMPULS Program, hosted by Tokyo Gakugei University recently. As planed, this program arranged various kinds of activities, such as introduction, teaching observation, discussion and reflection, workshop, etc. I have to say that this immersion program was organized so well and I really enjoyed the study.

Traditional culture is shared by Japan and China even today. I had more than twenty years' teacher training experience in China. So it is natural for me looking for similarities and differences between Japan lesson study and China teaching research activities.

According to my observation and understanding, I think the following aspects are similar: (1) develop students' mathematical thinking is the core of school mathematics education; (2) interactive whole class teaching combined with individual work leads to students' higher levels of thinking, so it should be used very often; (3) teachers' professional knowledge is developed in the process of solving their practical teaching issues with their colleagues; (4) invite knowledgeable others to provide outsiders' voices is helpful for school; (5) learning tasks (including contexts and numbers used in the tasks) are carefully designed before the class. Very often, people complain that what we have learned in school mathematics has very limited use in the real world. For the mathematics we will use, very often we could hand over them to computers. Probably, they are telling the truth. So teach mathematics knowledge is definitely not enough for school mathematics education, we should develop our students' proficiencies (such as problem solving, etc.) and high levels of thinking – everyone need them. In East Asia, teachers prefer to use more whole class teaching and individual work, but less group work. They believe that students could learn more from teachers, from whole class discussion, rather than from the peer discussion. But basing on my IMPULS experiences, now I notice the limitations of the interactive whole class teaching. I hope every student could have opportunity to talk mathematics and get timely feedback and supports from others. Similar to students' learning, teachers need peer earning, too. We should not rely on top-down lectures, instead, school teachers cooperatively dealing with their own practical teaching issues is a more effective approach of teacher professional development. But lectures from outside experts are welcome by teachers as they often bring some new ideas and new solutions to the same issues. Since we teach mathematics through problem solving, problems and the sub learning tasks are always discussed and selected very carefully before the lesson. We really care if they should help us achieve our teaching objectives in an effective way.

As for the differences, I identified the following points: (1) Japan lesson study has a clear prescribed research theme and teaching plans are made by all members of mathematics education research group in each school. The team's hypothesis is examined in after class discussion; (2) lessons are planned as a part of a unit. This makes some long term learning objects such as "attitudes" and "thinking" could be considered and planned. On the other hand, students' anticipated answers and estimated teaching time are carefully considered and planned as well; (3) students' work and their learning reflections at the end of each class are collected as a part of evidences of teaching effects assessment. All of these enhance the research role of lesson study. I think these are very good.

Besides of myself reflections on the similarities and differences of mathematics teaching research between China and Japan, I also learned a lot from other colleagues. Firstly, I am so impressed by Japanese colleagues' enthusiasm to their works. They take each of us carefully, no matter in work and in life. They organized a very successful study trip for us. Secondly, IMPULS website provides us a wonderful discussion space. Alan Shoenfeld shared with us his TRU math framework and some

his interesting reflections on the lessons. Thirdly, this trip also educated me that group work is valuable too – should not be ignored. I find that big changes have already happened in my own teaching and I believe my students will then get benefits from my Japan trip as well. At last, there are some schools that I know in Australia are going to introduce lesson study to their teachers professional development. Now, I know more about lesson study and I will do my best to help them.

Thank you all my Japanese colleagues. Wish more and more schools in the world value lesson study and practice lesson study in near future.

Jun Li

Kalaivani Shanmugam

REFLECTIVE JOURNAL REPORT
IMPULS 2015 LESSON STUDY IMMERSION PROGRAM

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Thank you

First of all, let me express my heartiest thanks to all those who involved in IMPULS 2015 program. Thank you very much for the opportunity given to me to gained millions of meaningful experiences through this IMPULS program. My heartiest thanks to Prof. Akihiko Takahashi, Prof. Toshiakira Fujii, Prof. Makoto Yoshida and Prof Tad Watanabe for all the fruitful knowledge shared as the project leaders throughout the program. My special thanks to Jennifer Lewis and Prof Alan Schoenfeld as invited professors and as knowledgeable others participated in this program. Not forgetting all the organising committee headed by Naoko Matsuda, Junji Nojima, Kiyoko Ishihara and other graduate students who were very helpful and provided a wonderful hospitality during our program.

Pre Lesson Observation Preparations

My first day experience a twenty minutes walking journey from the Mets Hotel to Tokyo Gakugei University was tiring but then interesting that I had enjoyed new view of Japanese houses and shop lots along our way. We were welcomed and guided by group graduate students to the IMPULS classroom. The opening session of IMPULS was much formal indeed with the professors and newly known course colleagues sitting around the classroom. Briefings about the IMPULS program and introductions among the course participants had inspired and improve my confidence to move on. Prof. Akihiko Takahashi had started the very first slot on getting to know on the essence of Lesson Study cycles, issues to overcome, designing the lesson, teaching the research lesson, post lesson and finally the summary sharpened up and polished my knowledge deeper on Lesson Study process. According to Prof Akihiko, Lesson Study should be continued and not to be ended in a short period. It was really touched indeed. Further, his slot on teaching and learning mathematics for various grade of students pulled my mind and soul back into an actual classroom lesson as well. However, beyond this on 'Why Lesson Study" was explained in brief. He also further emphasized on using problems solving methods for various grades of pupils with many problem solving examples

thinking skills adapted by Japanese curriculum on multiplications, divisions, number lines, additions and subtractions. In general, the overall preparations before every lesson observations was well planned and briefed in depth each day in the morning before the lesson observations in the afternoon. Without failure, Prof. Tad Watanabe and Prof Makoto Yoshida played an important role in briefing pre-lesson observations on the lesson plan designed by the teachers. They have done a good job to explain in depth on the units before the lesson and how the lesson was planned indeed. At the very beginning days I have got myself mentally and physically fit for the eight lesson observations throughout the program.

Lesson Observations

The lesson observations started at the second day of our program in secondary school for Grade 8 students. It was my first experience observing lesson in a Japanese classroom. It was something different in terms of lesson plan designed, classroom teaching and learning activities and post-lesson discussions. Different Japanese school environment clutch my mind towards the school culture in my country Malaysia.

The most inspired aspect for me on the lesson observations was the well planned compact lesson plans which were much varied from our planning in Malaysian schools. The entire review of pre-units of the topic to be taught was amazing. The past lesson review mentioned in the plan was very meaningful for the lesson observers to understand in depth on the content to be taught in the current lesson. The research lesson plan designed reflected the Lesson study teams' dedicative and collaborative team work.

Next, teaching and learning in the classroom context. Each and every lesson observations throughout the program exhibited a problem based learning which includes critical thinking skills among the students in the lesson. The whole class discussion concurred the most on the one or two problems posed to the students. Much difference experiences compared to our classroom which are rich with variety of teaching methods. Students' participations were noticed to be very individual based interactions with the teacher. However, they were seen focused in the lesson rather than not. The 'bansho' or the usage of blackboard was very meaningful in Japanese classrooms which were not practice much in our classrooms. I was mesmerized with the systematic board usage. Without missing most the board usage was captured in photos for my future reviews and sharing with my colleagues in my country. I will definitely share and learn to practice on how to use the board systematically after this program. Apart from this, I found that solving given problems and how teacher stimulates the students to think critically to solve was an important core crisp of the entire lessons observed throughout the program. The post-lesson discussion after the lesson was another meaningful awaited moment almost in all the lessons observed. The role of the entire observers and knowledgeable others were equally important to be considered while the post lesson discussion in progress. One of the post lesson discussions was conducted among the IMPULS participants. This was my first experience joining in the post lesson discussion session. At the beginning stage, I am so blurred with the comments posed by our course colleagues. Later, I understand that every participant posed their comments and view based on their own perspective and experiences gained from their country. I did posed my own view accordingly based on my own classroom experiences. The post-lesson discussions were very meaningful for all us and further enhance our confidence to observe the next lesson indeed. I noticed the role of the moderator and the final commentator is very crucial to sum-up the entire lesson of the day. Their role in preparing final comments earlier preparing a note and slides on reviewing the main points to be discussed was astounding. Apart from all, the teacher's persistence on accepting the comments and remarks was much appreciated. The reflections after the post lesson discussions among the course participants headed by Prof. Akihiko Takahashi after every lesson were also improved my in-depth understanding on the content of the post lesson discussions. Apart from this, I had always treasured the informal discussions with my

colleagues on our way home after every lesson observations. This discussion was enormously helpful for understanding what were in others mind about the lesson and the post lesson discussion. I grasped many different views from the course participants.

Insightful Japanese Lesson Study

Lesson Study provides great in-depth collaborative experiences in capturing the essences of the student's need in understanding the mathematical contents. The way of mathematical thinking process to be in calculated in students' learning in order to improve critical thinking process among the students were helpful for teachers learning process. Teaching and learning process is a pathway to capture students understanding in the pattern and process of mathematical thinking in the lesson. Through IMPULS experience, I gained more in-depth knowledge in the classroom teaching and practices. I learn how to stimulate students thinking skills in solving given mathematics problems. The stronger supportive from the school administrators and district level officers and teachers to carry out the research lesson at least once is a great tool to improve professional development model. I will try as much as possible to impose the process of Lesson Study which was observed in Japanese schools. I could adapt it accordingly to our Malaysian school culture. Thank you very much to IMPULS.

Future Planning

Well, after gaining an in-depth understanding in the procedures of conducting Lesson Study from the IMPULS program, I am excitedly continuing the coordinating projects between the Teachers Training Institute and schools while sharing with the lecturer colleagues about the Lesson Study. I had improved the collaborations with schools on promoting Lesson Study process as a teachers' professional development model. Further, I also planned to continue writing as many possible papers for conferences and publishing it. Finally, this program has been an 'eye-opener' for all the participants from the various corners of world. It was an enthralling, pleasant, and valuable experience. I believed that I could further learn more and more about Lesson Study continuously through this current network of IMPULS.

KellyGoorevich

Introduction

On the first day of the IMPULS Project, Dr. Takahashi said, "Ichigo ichie- Everything is a once in a lifetime experience." Indeed, the diversity, experience and openness of my fellow participants along with the IMPULS team in Japan, made this an enriching opportunity far beyond expectation. The countless conversations among this incredible group of colleagues provided a wellspring of knowledge and inspiration. I will reach out to my new network of colleagues for years to come. This opportunity will forever change me as an educator.

Such an experience is quite difficult to write about so soon after returning to the US as I am just beginning to process it all. Simply reentering life has begun to unveil my learning and deepen my appreciation for Japan and her culture. I will never forget the kindness and generosity of the people, the beauty of her gardens and architecture, the freshness of the food, or the rich sense of tradition and pride preserved by Japanese youth. Of equal impact was the collective dedication and professionalism exhibited by the educators. While career change is beginning to impact Japanese

culture (people leaving the profession after a few years) there is a history of commitment among Japanese educators in that once an individual enters the field, s/he stays in the profession dedicated to a lifetime of *gakushu-shido*. In Japan it is possible to say, 'Japanese teachers…' because it is the culture of the profession to see oneself as a lifelong student of content and professional practice. The term "*Gakushu-Shido*" means learning-teaching. This phrase is linked as the language itself does not separate the concept of teaching and learning. *Gakushu* means to learn or to know new things and *shido* means leadership, guidance, and coaching. I think the phrase, linked together poetically and accurately highlights the quest of the Japanese educators whom I observed.

Culture of the Japanese Student

Japanese students share a culture of responsibility. In many schools there are no custodians; students are responsible for cleaning up after themselves and caring for their school. They serve their classmates lunch, they use their break between lessons to take care of personal needs, and they arrive to class on time. Even the youngest students travel to and from school independently. This culture of personal responsibility is cultivated at a very young age and infuses classroom learning.

During the math lessons I observed that students kept their own journals in which they decided what ideas and information to record. They did not mindlessly copy notes from a board, but rather decided which ideas furthered their learning. Japanese students seem to understand that learning is a shared experience. Consequently, the mathematics classroom is a lively environment in which students call out their ideas and actively listen and question those of others. Students in Japan show respect and responsibility for themselves, for others, and for their community. I'd like to bring a bit of this culture back to my school and my students.

Other observations

Promoting gender equity in mathematics instruction has been an ongoing initiative at every school I have taught at in the US and Canada. Gender equity is important for furthering girls' math achievement, for improving their self-confidence, and it impacts how they value mathematics. We observed 8 lessons conducted in grades 3-8 in public schools, university attached schools, and IB programs. The lack of attention given to gender equity during each lesson was noticeable. There was no mention of attention to gender in any of the written lesson documents, which I found surprising given the level of detail to every other aspect of the lesson planning. In each research lesson, regardless of the class composite, boys were called on with greater frequency. At the Tokyo Gakugei University International Secondary School, we even observed a class of 26 students consisting of 8 boys and 18 girls. In this classroom, boys were called on in all but one interaction. During each Lesson observed, I noticed girls raising their hands while boys shouted out. Girls were waiting to be called upon and the teacher continued to call on boys. In several instances, girls audibly sighed and put their hands down not to raise them again. Additionally, of the 8 lessons observed, 6 of the 8 lessons were taught by men with most of the post-lesson discussion committees and knowledgeable others being male as well. While participants informally commented on this issue as well, none of us brought it up for discussion during the summation lectures.

Mathematics and Instruction

The emphasis on mathematical instruction in Japan is on problem solving, thinking, communicating, and synthesizing. The problem solving approach to Japanese mathematics instruction began in the 1920's when educators realized the significance of engaging learners in tasks for which the solution is not known in advance. A math lesson begins when a driving question or situation is introduced; one lesson, one problem. Unlike American classrooms where a mathematics lesson often opens with the learning goal announced and the teacher demonstrating a procedure, the Japanese lesson begins

with a seemingly open and accessible problem or situation intentionally designed to encourage the exploration of ideas and solutions. These problems have multiple solutions, they are designed to draw upon students' previous learning, and they present an unknown. After the task is introduced, students have an opportunity to question the problem in order to 'unpack' and understand the situation. Time again, I was impressed by students' abilities to discuss the target questions that enabled them to find an entry point into the problem; thinking. Too often, the American teacher models a concept without giving students time to think about the mathematics involved and the lesson deteriorates into an exercise of 'following the leader' or 'show and tell'. While students in traditional model may demonstrate the ability to find answers during class or on a test, these student may not be able to use the mathematics when presented with an unknown in other contexts or over time. Project IMPUS observed 8 lessons in 6 days and never did a Japanese student say, "I don't get it; I don't know how to do it; I need help," phrases so commonly overheard by every educator in American classrooms. Perhaps this is because the desired outcome in a Japanese mathematics lesson is problem solving and knowledge construction as opposed the American emphasis in finding the right answer. The difference in these two approaches is something I will reflect upon great deal this coming school year as I consider how to bridge the divide for my students.

Once the question is understood, Japanese students typically begin a 10-15 minute independent work period during which they draw upon what they know and make sense of how to apply their thinking to a new idea. After students have had time to gather their thinking, they share their ideas with a group or the whole class and build upon one another's ideas. This independent work time is critical early in the lesson because if students do not have any ideas independently, then they have nothing to share.

The whole class comparison and analysis portion of the lesson is called *Neriage*. During this time, students present their ideas, question one another about their thinking, and explain the ideas of their classmates. Students learn to listen and consider multiple approaches, to use their thinking to answer classmates' questions, and to dig for deeper understanding. Students do not appear sensitive when others are 'poking holes' at their ideas because they understand that ideas are improvable. *Neriage* is typically the lengthiest portion of each lesson, lasting upwards of 20-25 minutes. It was impressive to see the students' ideas leading the lessons. Most impressive however, was the fact that the written research lesson prepared in advance of teaching phase, consistently anticipated the majority of the ideas presented by students. This points to the high level of research and preparation by the teacher and planning team; *Kyozai Kanku*.

The Japanese lesson concludes with each student summarizing the Big Idea of his or her learning. I found this to be in contrast with mathematics as it is taught in the US where students practice the modeled solution and conclude their lesson with independent practice on multiple problems. The traditional approach to mathematics in the US promotes answer finding and shallow procedural productivity, while the traditional Japanese instruction promotes problem solving, discourse, deep thinking, and synthesis. When looking at these two teaching, it becomes clear why the results on the *Average Percentage of TIMSS Mathematics Topics Taught in School and the Achievement (Average Scale Score) of the TIMSS 2003* showed that Grade 8 students in Japan, having only been taught 74% of the material prior to the test, scored 64% correct, while American students, having been taught 83% of the material, scored 58% correct. Dr. Takahashi reminds us that if you teach for real understanding, students will do as well on skill development. "Students need a balanced diet of problem solving, practice, drill, etc. This produces high achievement on standardized tests and there is real research to support this."

A Japanese teacher is a knowledge building *facilitator*. In order to facilitate, the Japanese teacher must be able to pose a challenging problem, anticipate student responses, and plan how to lead the group toward deeper understanding. In order to do this, the teacher must become very familiar with what students already know, be knowledgeable about the concept progression (beyond the current grade level), have a rich understanding of the mathematics being taught, be able to anticipate student responses and common misconceptions, and be able to question students in order to help the class improve their theories and understanding. Additionally, this teacher must become familiar with a variety of teaching and learning materials, methods, and current content research. A teacher who is not prepared in this manner may not follow and further students' ideas because he or she cannot veer from what is planned or in a book. A teacher who is knowledgeable can be responsive to the needs of her students and can allow them to explore their ideas and deepen mathematical thinking. A teacher who is a *coach and facilitator* engages in *Kyozai-Kenkyu*. Japanese teachers actively seek *Kyozai-Kenkyu*. American teachers need Kyozai-Kenkyu.

What opportunities does Lesson Study provide teachers?

- In the US, professional development in public schools is typically a potpourri of topics dictated by the administration. These workshops are often led by expensive outside experts. While this approach may help administrators target District goals, these sessions do little to promote professionalism, expertise, or a community of FOCUSED learners among teachers. Professional development should take a long view of professional development and follow a directed and purposeful curriculum in much the same manner as student development. Lesson Study develops a community in support of similar goals that are derived organically within the context of research and authentic teaching. In this process, teachers are learning that their own questions are important and the teacher is taken very seriously. Lesson Study affords an opportunity to build the profession by developing expertise within the 'rank and file' and a culture of *gakushu-shido* develops where improvement is viewed as a collective responsibility. These features are lacking in the US.

- Lesson Study improves the culture of learning (both teacher and student) within a community (school, district, city). It is the way we open the door and break down the isolation in our profession. No one person is a MASTER. The idea of Master does not exist. We have a responsibility to our colleagues to collaborate.

- Lesson study gives teachers an opportunity to learn to give and take feedback. Through the Lesson Study process, particularly through research meetings and the post-lesson discussions, participants can see that thoughtful critique leads to improvement. A good lesson critique focuses on preparation, planning, research, instructional decisions and depth of knowledge; it is never personal. There is a difference between critiquing and criticizing. We improve with critique. We excel when we learn how to respond to critique constructively.

- A strong final post-lesson discussion can yield serious learning, even when the lesson was unsuccessful.

- Designing a Lesson Study lesson forces teachers to:
    - think through the entire process integrating research
    - focus on problem solving
    - anticipate student responses
    - facilitate student discussion without lecturing

- consider multiple perspectives
- think about how we assess and analyze student work
- organize the board plan for students
- teach effective note taking
- think critically
- collaborate intentionally

- Lesson Study reminds us that teaching and learning cannot be separated. They are an integrated process in which the students become the teachers whose role is to deepen understanding while the teachers become the students of content and practice.

- Dr. Takahashi emphasised that, "Lesson Study needs beer," and *Kampai* is an essential component in Lesson Study. From the outside looking in, *Kampai* simply looks like a post lesson party, yet it is an important continuation of the post-lesson discussion. The formal lesson debrief consists of an intense scrutiny of the research lesson where every word, writing, number and decision is poked and questioned. The formal post-lesson discussion is the teacher's and committee's chance to explain each decision made and it is the opportunity for mathematics experts to extend the knowledge of the community. At this time, each person participating is taking in information and making sense of it on his or her own, feverishly take notes around the table. *Kampai* is the continuation of the post-lesson discussion in an informal way. While drinking beer, 'Kampai-ians' discuss the lesson and the points made by the knowledgeable others. This is the time when participants share their ideas about the post-lesson discussion and celebrate their efforts. In the US, this part of the cycle is often skipped or teachers go off to talk in small groups. When this happens, the wellspring of knowledge that can be shared is lost. When Lesson Study is conducted properly, it should be filled with debate and critique, which can be heated and impassioned. Taking time to celebrate the completion of the research together, to reflect upon the wealth of knowledge acquired, and to find the humor in the quirks and surprises in the lesson helps participants feel unified and wanting to repeat the process.

- Lesson Study is a powerful and inexpensive form of professional development. Schools do not need to spend a great deal of money to conduct powerful research. What teachers need is TIME. In Japan, students are released early on Wednesdays and this day is devoted to school matters and Lesson Study. A lack of time in a costly barrier for American teachers. Teachers need time to meet, research, discuss, teach the lesson and debrief. Lesson Study cannot be effectively engaged using before and after school models. Teachers need weekly release time once the process has begun. This requires schools to juggle resources and possibly hire substitute teachers. Lesson Study is 'air' in Japan. It happens because it has been part of teacher development for a hundred years. American schools must first recognize the importance of this practice and then support its development with time for teachers.

Next Steps

Project IMPULS immersion has helped refine my understanding of the complete process of Lesson Study. Through authentic lesson observations, lectures, and numerous informal conversations with fellow Project IMPULS participants, I believe I am returning to the Ensworth School ready to move the process forward. As we prepare to begin a new school year, my next steps will be:

- To build a stronger foundation of Lesson Study within the lower school community by sharing the lessons and experiences gained from IMPULS.
- To support each grade level in the lower school to complete ONE Lesson Study

this year. This would enable me to 'coach' the process and make it possible for every faculty member to participate in the planning process.

- To connect with Peabody School at Vanderbilt in order to access mathematics research to further support our Lesson Study design.
- To develop a 'bank' of knowledgeable others to act as discussants at post-lesson discussions.
- To make Kampai standard practice as part of our Lesson Study.
- To support expansion of Lesson Study to the broader Ensworth community (middle and high school teachers and administrators).
- To teach parents about the process of Lesson Study in order to help them see teachers as researchers.
- To support dissemination of Lesson Study to other independent schools, to the Nashville Metropolitan Public School District, and to Vanderbilt University's Peabody School through "Lesson Study open-houses" and workshops.
- To lead to discourse beyond the specifics of the mathematics by influencing lesson structure and questioning in other subject areas; sciences, music, humanities, foreign language, and the arts.
- To learn more about TRU as a lense for looking at learning.
- I will be working to build a greater culture of responsibility among my students and within my school.
- I'd like to work to extend our IMPULS community to support one another in our work. To do this, I will continue to participate in BaseCamp through December, stay connected to IMPULS via Facebook, and plan to attend the Chicago Lesson Study conference in May.

Thirteen years ago I had an opportunity to dip my toe in the spring of Lesson Study while observing Lesson Study at the Greewich Japanese School in Connecticut. As a result, I spent the next twelve years wading in its waters. Now, because of this Project IMPULS immersion, I am ready to dive in to Kyozai-Kenkyu and support others in my school and region in authenticating our Lesson Study practice. This experience was among the highlights of my life and I feel so fortunate to have met so many people who care so deeply about education, who think about it and at such a level, and who generously share their ideas. The spirit and camaraderie shared among this year's IMPULS group was exceptional and truly an example of what is *Ichigoy-iche.* I am profoundly grateful to the IMPULS program and Dr. Takahashi, Naoko, Tad, Makoto, Professor Fuji, Ishiharasan, and the graduate students from the University for this opportunity. I look forward to thinking with you again in the near future. Kampai!

Mariel Laureano

IMPULS – 2015 Reflection
~Mariel Laureano

I applied to be a part of the IMPULS Immersion Program excited to be a part of a professional development experience different from the one-size-fits-all model. I did not anticipate the extent of the learning that I would experience. I learned so much about mathematics, teaching, learning and the Japanese culture that I have become a different, well-rounded educator and leader.

I am a leader in the Chicago Public School System and firmly believe that the only way to improve

our practice as leaders and educators is to make it as public as possible. The Lesson Study approach epitomizes this belief to the fullest extent. I was in complete awe as I observed the lessons in the Japanese classrooms but in greater awe of the intensity of the post-lesson discussions. To sit through a lesson that is clearly, strategically planned out to developmentally meet the needs of the learners in front of you is one thing but the level of reflectiveness that followed during the post lesson discussion is what EVERY educator and leader should engage in. Lessons were followed by feedback to push the teacher's thinking and practice. So often we get involved in the monotony of our routines and meet the requirements of compliance that we forget to look deeply at instruction and how students learn. The questions at the core of teaching and learning should always be "what are we doing? and "why are we doing it?" The experience that the IMPULS program provided took me through the process of deeply understanding this concept, hands-on. Teaching and learning is so much more than what can be captured on a rubric. I learned that it is about sitting side by side with a teacher, a team, planning, thinking, researching together to uncover the purpose of the lesson and to truly understand the learning that you want the students to walk away with.

I am a literacy person (I didn't put this on my IMPULS application) but through this experience I learned how the Lesson Study approach is well beyond content areas and is rooted in best practice. Learning math through problem solving is such "revolutionary common sense." This is the way kids should learn in every content area. Kids should be problem solvers, construct their own thinking. What was clearest through this process is how every learner is afforded an access point to learning. You don't have to be the highest achieving student sitting in the classroom to do mathematics. You do have to be a high achieving teacher, on a dedicated team, to present a lesson that every learner in front of you can access. This takes planning. That is what I learned Lesson Study is about, planning. One teacher, one teacher, planned some of the lessons we observed!! We are not talking about a one-pager that you submit to your principal on a Friday. This is a lesson plan that is a piece of a greater scope and sequence that truly aligns to how students learn. It wasn't designed with the purpose of achieving "distinguished" on a rubric or with the purpose of a putting on a dog and pony show. It was designed with learning at the core. There was learning at the core for the students, teacher developing the lesson, teachers and administrators observing the lesson. It was the marriage of teaching and learning as it should be, one dependent on the other. I learned that students are not the only ones that should learn from the lessons we present. As an adult I am a problem solver in my everyday life, in everything I do. While in Japan I experienced how students are taught to be problem solvers and how to engage in a productive struggle that led them to a deeper understanding of mathematics.

Japan is a country deeply rooted in culture and, what I interpreted to be, efficiency. As I walked through the streets of Japan I could not help but notice the cleanliness, uniformity and attention to detail. They believe in their country, their culture and in education. We visited a variety of schools depicting a variety of systems but in every one of the schools and classrooms that we visited it was clear that teaching was intentional. There wasn't a script to be followed or a rubric to check off on, it was about teaching and learning. In each classroom we visited there was a well thought out plan of practice and pedagogy. Teachers were not just going through the motions of teaching they were a part of the process and at the end of a lesson would come out with as much new learning as the students. There was not a minute wasted within a lesson, everything has a well-thought out purpose. The piece of the lessons, which I found most inspiring, was the board work. This is something that is so integral to a lesson but which we (CPS, myself as a leader, my teachers…) pay little to no attention to as a purposeful teaching tool. I learned the depth of planning that must go into the intended board work. The board work should reflect the access points and levels of thinking of our students. It is the story of the learning; it is an imperative detail to teaching and

learning.

Being a part of the IMPULS Immersion program was so much more than a professional development experience. It was about living beyond my comfort zone, learning beyond my comfort zone and learning along side people from around the world sharing in the belief that there is so much more to teaching and learning than a lesson plan, unit plan, a rubric. Teaching goes beyond a textbook and compliance. The IMPULS program pushed my thinking and contributed to my growth as a leader. Our experiences shape our perspective, who we are. The IMPULS program shaped who I am as an educator, learner and leader. I am excited about taking on a new academic year as a leader and bringing the energy of the Japanese culture and approach to teaching and learning to my school community. The experience is such that could not be fully captured in writing, or numbers.

Mary O'Connor

My reflection on the IMPULS 2015 programme (Mary O'Connor)

Tokyo Gakugei University

It was a wonderful privilege to have been selected to be a member of IMPULS 2015. Being a former mathematics secondary school teacher and now a mathematics educator I have always been passionate about ensuring that my students have a deep understanding about the mathematics they are learning. It is essential they have a relational understanding of why they are doing the mathematics and to be aware of how topics connect with one another. One way to ensure this happens is to develop student thinking through problem solving. Having heard about how the Japanese model their lessons around problem solving activities, I was intrigued to learn more about how this was done so successfully. When the opportunity to apply for IMPULS 2015 arose, I must admit that I was apprehensive about submitting an application. At the time I was attending a professional development course with other mathematics educators, where much of the time was spent addressing A-Level mathematics problem solving activities with regard to the new specification. As I am the lead tutor on the Subject Knowledge Enhancement course at the University of Birmingham, I am working with trainee teachers who have passed A-Level mathematics but often have no understanding of why or how the mathematics they learnt to pass the examination links together, they have usually been taught the syllabus in a very instrumental way. As a result of these factors I decided that I did not want to miss an opportunity of learning more about problem solving in my subject so I applied for IMPULS 2015. You can imagine my excitement when I received an email to say that my application was successful, I could not believe it! Prior to the trip to Japan, I was invited to attend a day at the University of Nottingham with the other UK participants. It was a great opportunity to meet my fellow IMPULS colleagues and also to learn more about Japanese lesson study from Malcolm Swan, Geoff Wake and Sachi Hatakenaka, in addition we heard a little about life in Japan and IMPULS 2014 from Lorna McCance, a participant from last year. After this day I could not wait to start my Japanese adventure so as to see Japanese lesson study in action.

So what did I learn about Japanese lesson study?

I learnt that lesson study is not new; it has been taking place in Japan for 100 years and is a mechanism that is being continually developed to improve mathematics teaching and learning. The Japanese have a long tradition of teaching mathematics through storytelling, setting up a mathematics problem through a story that will engage students from the outset. Once the students are presented with a problem to solve, the teacher will not intervene; the students are encouraged to start thinking about and tackle the problem themselves. This is unlike many UK classrooms,

where the teacher will often help the students by guiding them in a particular direction in order to solve the problem. The Japanese call this method of teaching, 'Show and Tell' and do not encourage it. In Japan, level 3 teachers provide their students with opportunities to understand basic ideas and support their learning so that students become independent thinkers, whereas a level 1 teacher will tell their students the basic ideas and level 2 teachers can explain important basic ideas so that students can understand them. Through lesson study novice teachers can continually learn from their more experienced colleagues.

I was amazed by how much time, thought and effort is put into the planning process of a research lesson; many hours are spent planning every single detail of the lesson by the research group, often consisting of teachers from different year groups within the school, the school principal and mathematics education university researchers. The most important part of the planning process is setting up the actual research question and then relating this question to the class to be taught, this ensures the lesson is personalised for this particular class of students. As the problem is always considered from a student's point of view, anticipated student responses and misconceptions that may arise during the lesson are carefully thought about so that teachers can prepare for these responses and adapt the lesson plan accordingly. The board work is also carefully considered, the way in which the board is set out is an important part of planning as the teacher will ensure that every relevant fact is written in a certain place on the board so that the students can always refer to this during the lesson. The broad work I saw in some lessons was meticulous and used different colours to highlight different aspects of the thought processes within the lesson. This whole process brings together a team of likeminded mathematics educators who use action research to plan effective lessons in order to develop deep understanding of mathematical concepts in the classroom. Such thorough planning has got to impact on how the students develop their mathematical thinking.

Lesson study is also a tool for developing the professional development of all teachers who become involved; they are exposed to new research developments through working collaboratively with colleagues from higher education, called the knowledgeable other. This enables them to continually update their subject knowledge and pedagogy by reflecting on their teaching strategies, through high level mathematical thinking and discussion, thus becoming reflective and proficient classroom practitioners. I also think that lesson study is a platform that gives many young teachers confidence in the classroom. It was enlightening to see less experienced teachers having the confidence to challenge more experienced teachers in post lesson discussions. As teachers work as a team throughout the whole planning stages of the lesson, no one teacher is responsible for the lesson, it is a collaborative process where the emphasis is on the teaching and learning of the mathematics, not the teacher who teaches the lesson. This immediately takes away the fear element that many UK teachers experience when they are observed as lesson study encapsulates the whole process of planning and teaching a lesson, it is a learning tool and not a performance management issue. The feedback in the post lesson discussion is seen as a very important part of the process which offers immense learning opportunities for teachers.

I have always believed that teaching and learning cannot be separated as it is an integrated process involving both students and teachers. This idea was definitely cemented through IMPULS 2015, where I learnt that in Japan there is just one word to describe teaching and learning, '**gakushui-shidou'**.

In most lesson observations it was a pleasure to observe that deep understanding is crucial, the teacher always emphasised that it is more important that achieving a solution. One particular lesson that I observed during the IMPULS trip definitely made this the main focus of the lesson. It was a grade 5 lesson at Sasahara Elementary School. The whole emphasis of the lesson was not on finding a solution to a division problem but on ensuring that all the students understood why they were using division in order to solve the problem. It was interesting that despite dealing with division by a whole number with ease as the students had prior knowledge of this concept, once the

divisor became a decimal number, the students suddenly found the problem far more challenging. This did not put the students off, they were happy to admit that they could not divide by a decimal and it was reassuring to see them so secure in admitting this to their teacher, who actually wanted to hear this response from them as he planned to develop the reason why, through mathematical discussion with the students. In doing so he changed the classroom setting from a formal one where the students were sat behind their desks into an informal setting by inviting the students to move so that they were all sat at the front of the classroom. The teacher encouraged the students to speak mathematically to their peers when they were explaining and despite the fact that by the end of the lesson the problem had not been solved the students had taken part in a mathematics rich lesson. I felt that there was no anxiety amongst the students or by the teacher at not having reached a solution by the end of the lesson. I wish I could have seen the follow up lesson as I wonder if the students will have gone home and researched how to solve the problem before the next lesson, I hope they did. After this lesson, whilst discussing the merits of whether to divide by 1.6 or 1.5 it was very interesting to hear Professor Fuji talk about how much thought goes into choosing specific numbers to use in problem solving. This really brought home the impact of the mathematical thinking that needs to be involved and addressed when writing mathematical problem solving activities.

The process of teaching and learning in Japan is highly organised, I think that a whole cultural shift is required in the UK to develop fluent thinking, reasoning and understanding as required by the new mathematics National Curriculum. The Japanese culture, where more trust and high status is given to teachers needs to be transposed into UK classrooms, the recent culture of 'teaching to the test' needs to be abandoned so that teachers are allowed to develop deep understanding and independent learning in their mathematics classrooms.

The way in which mathematics textbooks are produced in Japan differs significantly to the UK. Textbooks in Japan have been written by respected mathematics professionals who have spent many years researching and thinking deeply about the most effective way to teach a topic, the order in which topics need to be taught, the context of the problems, the most appropriate numbers to use so as to develop deep understanding as well as making the text books student friendly. Unfortunately, mathematics textbooks in the UK are often rushed to be published so that educational publishers can make a profit every time the curriculum or examination specification changes. Japanese teachers are given two years to prepare for teaching when any changes are made to the curriculum, which happens every ten years. Schools are eligible to apply for bursaries to support their research in preparing for the new curriculum. How different is that to the UK, where changes have been implemented continuously over the past ten years, with no time given for teachers to adapt to these constant changes.

The Japanese have a holistic approach where the foundations and groundwork are set in the early stages of development which means that topics do not have to be constantly revisited. I learnt that fractions are taught after decimals in Japan and at a later age than when fractions are first introduced in the UK. It was refreshing to see 10 year old students being so fluent and able to recognise that division by two and multiplication by a half are equal. I was impressed by the mathematics subject knowledge of the elementary school teachers that I observed; I initially thought they were mathematics specialists as their mathematics questioning was so impressive, they were able to ask deep and meaningful mathematics questions to the students with clarity and ease. From the standard of mathematics witnessed in the elementary school classrooms it is evident that lesson study improves subject knowledge and pedagogy. In Japan teachers who have been teaching for 10 years can still be thought of as being inexperienced which is very different to the UK, where, due to a shortage of teachers, a teacher with 10 years' experience will often be a head of department or a senior leader in a school.

In my role as a teacher educator, I plan to use lesson study as a means of developing and improving the way trainee teachers and their mentors plan effective lessons that will have a positive effect on

teaching and learning. As most mentors are ex-students of the university by working in collaboration with the university I hope they will appreciate the strengths of using lesson study to enhance teaching and learning in their own departments. One particular area that I wish to focus on is the anticipation of pupil responses as trainee teachers regularly fail to recognise when misconceptions have been raised by the students they teach, and as a result miss perfect opportunities to discuss and develop mathematical thinking in their lessons.
To conclude, I am so grateful for having experienced this amazing learning opportunity in Japan. I enjoyed every single minute of the trip. I am immensely fortunate to have met so many likeminded individuals who care so much about the teaching and learning of mathematics. It was a privilege to have been chosen to participate in IMPULS 2015 and I will endeavour to improve the teaching and learning of mathematics forever after this unforgettable experience.

Matilde Warden

Reflective Journal
Matilde Warden, Maths Hub Lead, East Midlands West Maths Hub, UK
Curriculum Leader for Mathematics, George Spencer Academy, UK

'Lesson Study' is currently a buzz word in the world of professional development in the UK. Many courses advertise lesson study as a key aspect. However, having been involved in many of these, I have noticed that there are varied interpretations of what lesson study is. I have heard people talk about having 'done a lesson study' when what they have done is planned a lesson together over an hour and then observed each other teach it. For me, Project IMPULS has been an opportunity to be immersed in authentic Japanese lesson study, to help me understand what the key elements of authentic lesson study are, and to try and bring these back to the UK as a workable model.
It became apparent early on in the project that we are missing an essential component in the UK, which means any attempt to recreate it is quite superficial. In the UK, although we do have a National Curriculum, how it is delivered is left to each individual school. There are textbooks and schemes that schools buy into, but these vary in quality, and do not build up mathematical concepts year on year. As a result, the use of textbooks in the UK has been frowned upon over recent years. One of the first things I noticed in Japan was the consistent use of high quality textbooks. The textbooks have been developed expertly over years, with every single example and number that is used considered carefully. This is not true in the UK, and in my opinion it makes our curriculum much weaker as a result.
This lesson shows one example where this was apparent.
University of Yamanashi Elementary School, Saturday 27th June.
Grade 5.
The aim of this lesson was for students to understand that they can use fractions to express the relationship between two quantities using the idea of 'times as much'. The context that was used was the distance from home to the school – something that the students could easily relate to.
During this lesson, it was clear that all students were familiar with the bar representations and double number lines used in the lesson. It was also clear that they were familiar with the idea of 'times as much' from previous work. At one point in the lesson the teacher asked where they had come across this idea before. Students answered 'length of hair', 'length of candies', 'weights', 'how much flour we need to make pancakes', 'the size of giants compared to small characters'. It was clear that there was a common approach throughout their schooling on the idea of 'times as much' that they were able to link together to aid their understanding. This was the first time they had come

across fractions in this situation, but because of a common grounding, they were able to work through the problem.

The textbook examples have been developed carefully and thoughtfully over many years. When teachers plan their lesson and engage in Kyozai Kenkyu they often start by comparing examples in the six available textbooks and the teacher guides. This again, is very different to how we tend to plan lessons in the UK, where we often create our own examples from scratch, or use resources created by other teachers. The examples we choose are rarely thought about in depth. They may or may not connect to prior knowledge, as that varies so much from class to class and school to school. When we observe lessons, the examples, numbers and manipulatives we choose would not usually be commented on in such detail: in the UK, observations are usually based around pedagogy, rather than didactics. It has made me realise that this is a huge oversight on our part, as these details certainly produced the most useful and insightful post-lesson discussions we saw.

Sugekari Elementary School, Wednesday 24th June.
Grade 5.
This was the second lesson we observed. After the lesson had taken place myself and several colleagues who were watching had expressed how much we had enjoyed the lesson. In the language of the UK education system, it would probably have been graded Outstanding. It was a lesson that had built on the previous day's lesson on conditions for congruency of triangles. If a triangle required three pieces of information, could a quadrilateral be drawn using exactly four pieces of information? We observed students thoroughly engaged in the problem, and apparently succeeding in understanding the requirement for a diagonal or angle to be fixed.
We were surprised, therefore, when the teacher at the start of the post-lesson discussion apologised for her omission of the manipulative that was intended to be used. I wrote in my reflection that evening that I hadn't thought that had detracted from the lesson, and that the students had seemed to understand despite this.
It wasn't until this lesson was discussed the following day in our University session that I started to comprehend the importance of ensuring the students truly internalised the mathematics in which they were engaged. Dr Takahashi explained how he had walked around the classroom and had been disappointed with how many students were using two or three angles to draw: they were not thinking mathematically, nor building on previous knowledge. He was sure that had these students seen and engaged with the manipulative, then they would have really understood the mathematics behind the problem. The teacher and planning group had planned to use this manipulative for a reason, and to omit it meant that there was a gap in the pupils' understanding.
So why had this not been raised at the post-lesson discussion? Here came another revelation for me. The post-lesson discussion was not as harsh as it could have been as the teacher was still a 'novice', having only taught for ten years! This highlighted for me how the Japanese teachers have a culture of always improving their craft through research and study. The role of teachers as researchers is key.
After the lesson that day we all joined the teachers from the school in a post-lesson study celebration at a local restaurant. It was a show of appreciation of how hard the teachers had worked to prepare the lesson. It was the culmination of many hours of study, research, careful thought and discussion. The celebration showed the school's camaradarie, with everyone, including the Head Teacher and Deputy Head present and celebrating together as a team. What a fantastic way to end the day!

Showa City Oshihara Elementary School, Friday 26th June.

Grade 3.
This lesson was 'Let's think about division!' (Division with remainders). In this unit of work, students were learning about division problems with remainders, their calculation method, the meaning of remainders and how to use remainders.
What struck me about the lesson plan was the paragraph which described four ways to describe remainders. This level of detail is something that would just not happen in lesson planning for grade 3 equivalent students in the UK. I doubt there are many teachers in the UK who are aware that remainders can be classified in four different ways!
This lesson also gave an example of where lack of consideration to the examples used can cause confusion. The attention to detail in the post lesson discussion was something I had not experienced before. The context of the lesson was how to divide 9 pieces of card between 2 people. The lesson plan had explained that the teacher would use pieces of card to demonstrate this. However, in the lesson, the teacher had decided to use origami paper instead of card.
In the post lesson discussion, much was made of the fact that the teacher had used origami paper to exemplify division with remainders. This was seen as a vital error: origami paper cut in half is useless! Students rightly answered the question 'If you divide 9 pieces of origami paper between two people, how many pieces will each person have' with the answer 4, and one left over. When one boy suggested the origami paper was cut in half, the class gasped!
However, this was not the biggest oversight in the lesson. The post-lesson discussion also concentrated on the teacher's decision to move away from the textbook examples and to look at a problem which focussed on grouping rather than sharing. The kowledgeable other, Professor Fujii in his summary at the end, showed photographs of students at various stages of disinterest who had become lost with the change of focus. He explained that we cannot experiment on children in our lessons. Although this seemed very harsh, this was taken in the manner it was intended by the teacher, and did not cause offence. Once again, I thought about how such feedback would be received in the UK, where observations are mainly seen as a judgement about teacher. The comments (and photographs) certainly would not be received in such good humour. Professor Fujii went on to explain that if a teacher was to veer off the well-researched and planned curriculum, there had better be a very good reason!

Another area that was discussed widely during our time in Japan was 'Beyond Show and Tell'. Some of the best lessons we saw had the teacher expertly bringing together the students' thinking for the whole class. The use of the boards to share pupils' examples in these lessons was beautiful (not a word I would usually use when describing board work by a teacher, certainly not my own!).

Tokyo Gakugei University Koganei Elementary School, Tuesday 30th June.
Grade 4.

The matchsticks problem is an old favourite of teachers all around the world (it would seem!) and so it was interesting to see a familiar problem in a new setting. I thought that the teacher's 20+ years' experience shone through in the Neriage part of the lesson. He was able to expertly draw together the pupils' different approaches to the problem, comparing the visual representations in ways I haven't seen before (after my own 20 years' experience). The lesson plan had included all of these anticipated responses, and as such, he was able to call on students in the correct order to develop the understanding.
I loved the subtle way he drew out the differences between the approach where students started with their diagrams from the left hand side compared with those who started at the right. Being explicit here highlighted that the two expressions 1 + 3 x 8 and 3 x 8 + 1 did result in the same solution. This is really important when introducing algebra later on, in my opinion, and makes a nonsense of

the way we teach BIDMAS in the UK. The order of 3 x 8, and not 8 x 3 was also explicitly mentioned, which is another detail we rarely discuss here. The teacher was able to question the students in a way that drew out great understanding. For example, when one boy in the class said 'I would like to call 7, 8-1 because I took one away at the start.'
When working on the matchstick style problems in the UK, pupils would simply tabulate numbers of matchsticks used in the patterns, then use the arithmetic sequence to find the nth term. Only afterwards would they consider how the nth term would relate to the structure of the matches. This is due to our focus on the method used to find the nth term, rather than using the context to develop the mathematics.

Now I have returned to the UK, and have had time to contemplate everything I have learnt, I think there are three things that that can be easily transferred immediately without the worry of cultural differences. They would make the process of Lesson Study in the UK far more meaningful and focussed on the mathematics

· Planning

In the lesson studies I have been involved with in the UK, the planning has taken place over a couple of weeks prior to the lesson. I have seen that this does not lead to the amount of thought, discussion or detail that I witnessed in Japan. The lack of detail results in a less detailed post-lesson discussion. We cannot easily change our lack of national programmes of study, but we can research which numbers and manipulatives we should be using and which diagrams and representations we should be using. We can try to anticipate all student responses, despite their backgrounds if we have long enough to do so.

· Context

All the lessons we saw had a context that the pupils could relate to. The best lessons returned to this context constantly throughout the lesson. This is quite a contrast to our lessons that are very process-heavy. Students in the UK spend much of their time become fluent at procedures. When we do use a context, it is often to make a lesson 'fun' rather than it being the best way to bring about the mathematical thinking that is the goal of the lesson. Our new national curriculum has three clear aims: fluency, reasoning and problem solving. Using a well-thought out context when introducing new ideas will help us to focus on the reasoning on problem solving, and not just the fluency.

· Neriage

The amount of time spent planning anticipated responses means that the Neriage stage of the lesson is not left to chance. It is not enough for students to just share their work for the sake of it (beyond show and tell), but the shared responses must be chosen carefully to guide the pupils carefully through the lessons towards the goal. Anticipated responses that don't appear, but that are helpful are also shared.

There are many other aspects that are very important too, but some of these will take much longer and much more thought to be able to implement as they require a culture change in institutions over time.

Finally, I would like to thank everybody involved with Project IMPULS for this career-changing opportunity. I feel I have a renewed enthusiasm, and look forward to taking what I have learnt and using it in the UK.

Reflective Journal – Matt Woodford

1. What opportunities does lesson study provide for teacher learning?

During my time in Japan there were two main reasons for Lesson Study that stuck out to me. Firstly, it provides the opportunity to establish shared knowledge and secondly it ensures that teachers are focused on the primacy of mathematical thinking.
Central to improving teacher learning is the importance of a quality lesson plan (developed in conjunction with a team). The lesson plan should be carefully thought through, so that there are no surprises in the student responses through the lesson. Kyozaikenkyu ensures that teachers look deeper than just the textbook that their school uses. It provides the impetus to look at other textbooks, look at the context of the curriculum and look at what research says about the topic. Anticipating responses ensures that the lesson is developed to maximise learning opportunities for the students. This method for improving teacher learning ensures that the focus for teachers is on developing students' mathematical reasoning.
Furthermore, Lesson Study helps teachers to see the context of the lesson within the bigger picture. The whole process helps train them to see that their lesson is part of the continuum for learning. It is not about developing a one off lesson that makes little reference to prior or future thinking.

2. What am I now thinking about teaching and learning?

My experience in Japan has helped to clarify that students learn if teachers have clarity on how to develop mathematical thinking. In the United Kingdom there has been a laudable development in general pedagogy over the last ten years. There has been a focus on Assessment for Learning and ensuring that all students are progressing. However, we have lost focus in Mathematics on developing mathematical thinking. It may sound a trivial example but in Japan we saw considered and thought out opportunities to illustrate multiplication as both repeated addition and as representing a scale factor. Both of these are important in themselves, but also to make sense of future concepts within division. I fear we have lost this careful thinking in the United Kingdom, and too often focus on the process of calculation and not on the development of concepts and understanding.

Seeing the focus on learning through problem solving is a timely challenge. Again, too often in the United Kingdom we see level 1 and level 2 instructions in lessons rather than the third level of students solving problems themselves. In particular, I found the following quote so important in helping develop my beliefs "Ten pages of mathematics understood are better than a hundred memorized and not understood, and one page actually worked out independently is better than ten pages clearly but passively understood" (J.W.A. Young, 1908).
It is important to note that a problem on its own is not sufficient. The different stages of the Japanese lesson ensure that the learning opportunities that the problem gives are maximised. The problems are well thought out but could still be badly used if other parts of the lesson weren't in place. Consideration of hatsumon shapes what the students do in the lesson and where their thinking goes. If the context is not well thought through then there can be negative effects on the understanding and thinking of students. Similarly, I was struck by how the teachers in Japan observed students thinking during kikanshido. In the United Kingdom we can be so busy rushing around trying to help students or manage behaviour that we don't get the opportunity to recognise what every student is doing. By observing methods, Japanese teachers didn't dwell on any students

for too long and have an excellent overview of all the methods adopted in the class. This then feeds in to the neriage stage which is so vital in developing problem solving skills and allowing the students to critically analyse solutions.

3. Thoughts about education systems.

Lesson Study is a valued and vital part of the Japanese educational system. There is an expectation that all teachers are a part of it (whether actually delivering the lesson, or being part of the planning team). Time is given to teachers to work together and plan together because of the benefits that this brings. This provides an immediate challenge to us in the United Kingdom. Most teachers teach for around twenty hours a week and then need to mark and plan on top of this. We must face the problem of finding the time for teachers to work together.
Secondly, we have issues around the area of transition between primary and secondary schools. Many students experience a slowing down in progress as they move from primary to secondary school at the age of eleven. This effect is reduced in Japan as there is continuation in the curriculum and a trust that those principles have been done effectively in the early years.
Thirdly, it's worth noting the difference in culture and the subsequent valuing of educational systems. There is enormous respect for schools and teachers in Japan. Students are lively and energetic but are aware that when the lesson starts they are there to learn. They are able to focus and speak politely whilst remaining enthusiastic during the lesson. This can be a challenge in some classrooms in the United Kingdom and we must seek to re-enforce high standards of behaviour.

4. Next steps.

It is so important that we don't rush in to Lesson Study and create a pale imitation of what we experienced in Japan. There are essential elements of Lesson Study that we must put in place otherwise it will become discredited. Lesson Study in the United Kingdom will rest on three legs without which the stool will fail. We need a coherent and well thought out curriculum, we need lessons planned with a focus on Kyozaikenkyu, and we need post lesson discussions with knowledgeable others steeped in the experience of the UK National Curriculum.
Vital to me is that we create a well thought through curriculum with clear objectives. It's not enough to say "multiply two-digit and three-digit numbers by a one-digit number using formal written layout" (UK National Curriculum, 2014). Using a previous example we must make it explicit both what and why we need teachers to give students opportunities to see multiplication as both repeated addition and as a scale factor. By doing this we will ensure that lesson study is not seen as isolated lessons but as part of a coherent whole.

In particular, I will look at both the Singapore textbooks that ae being trialled in the United Kingdom and the Japanese textbooks to understand the principles behind them. Working with a local University we can create coherence and clarity. There are a number of schools in my network using the Singapore textbooks and these will be ideal schools to trial Lesson Study. They have a curriculum context that has coherence and deliberate evolution of thinking.
We will also look to run a small scale lesson study within the mathematics department at my school. By keeping control within the school we can ensure that lesson study develops to the highest standard. We can ensure lessons are planned in teams and that Kyozaikenkyu is thought through. Without this there is a risk that we focus on judgements of teachers and general pedagogy over developing mathematical thinking.

Finally, I've also seen the value of celebrating with other teachers through Kampai. Being part of a Lesson Study could be an intimidating and isolating experience for a teacher. However, in Japan teachers were able to listen to constructive criticism and not take comments personally. It doesn't matter if the lesson is a 'success' the teachers will still celebrate working together, and celebrate improvements in shared knowledge.

Melissa Warner
07/31/2015
Final Reflection

Japan was an extremely valuable learning experience and re inspired my love of teaching and learning. The following sections will reflect on whole child awareness, building community among teachers, student-driven unit, and show-and-tell vs. objective focused teaching.

Seeing the first Japanese elementary school was overwhelming. There was constant bustle, laughter, and a variety of intentionally thought out rituals that added value and meaning in the classrooms and school. In one room, students were hard at work sawing pieces of wood to be used in an architectural plan. In another, paint and brushes were spread out among tables as students created beautiful calligraphy letters and colored paintings. Every school has a swimming pool and students swim daily. Home cooked lunches are prepared with care from lunch room staff and served by children to their classmates at lunch hour. Before lessons begin, teachers make small talk among students, asking about their lives outside of school, sharing stories about themselves, and telling jokes that elicit laughter from classroom. I was immediately struck by the level of focus put on the "whole child". There were so many opportunities throughout the day for children to have social and emotional needs met. In one school, students would have to know they were cared for implicitly by school staff just by the quality and maintenance of building, as well as home cooked, learning themed lunches that were served every day. All of this doesn't take away from the rigor and intensity of lessons but, I would argue, adds to them. Were students able to concentrate and invest at the level required in each lesson because they had so many outlets throughout the day to release energy and connect with peers? In the U.S., are we treating students with dignity and putting emphasis and focus in the right places?

Another thing that stood out to me was the quality of community among teachers. In all schools viewed, there was a specific room that housed all teacher desks. Walking by, you could hear multiple conversations among teachers and see firsthand collaboration taking place. In post lesson discussions, the feedback could be pointed and harsh. The teacher that taught the research lesson would typically listen to feedback and answer questions related to lesson for over an hour before final comments from knowledgeable other would take place. At first, I was a little shocked by how little praise or positive reinforcement the teacher of record would get during the discussions. I was also surprised by how critical many comments would be from fellow peers. However, the teachers never seemed phased or appear discouraged. They took everything in stride and were fully engaged through all discussions. In contrast, Kampais were friendly and full of friendly bantering and positive words. How could there be such a disparity between the post lesson discussions and the Kampais that followed? I believe teachers viewed themselves to be part of a professional community, where practice was analyzed like a business deal. There was no room for personal feelings or intentions when talking about the mathematics lesson at hand. It was very clear that the focus was on mathematics, not the teacher. Receiving this type of feedback was very normal for

teachers, as they would have multiple opportunities through the year to be an observer and evaluator of research lessons. If the emphasis was business during the lesson, it was definitely celebration during the Kampai. It was clear this was as important in the process as the research lesson. Anything in need of repair or reinforcement was done during this celebration. It seems you can't put emphasis on one component without the other if you want to build teacher community and maximize learning during post lesson discussions.

A knowledgeable other helped answer my question regarding student reflections and the process of planning and preparation when he said, "Reflections should drive unit planning, but make sure students come up with tasks. Teacher plans first lesson, but all the rest should be created with student questions and challenges in mind." We hear the word "student-driven" a lot in education. This couldn't be a more authentic example of what that process could look like. As a teacher, I spend lots of time planning out scope and sequences, designing lessons and anticipating student misconceptions and responses, and leave little to no space for lessons based off student needs and interests. My belief was that if I taught the lesson "well enough", students wouldn't have any challenges and the next day's lesson would fit perfectly into the learning objective from the day before. But isn't one goal of a successful lesson to provoke conflict and mathematical questioning? If the next lesson in the scope and sequence isn't addressing students' thoughts, is it really meaningful? How can we plan enough, stay on "pace", and still leave room for student voice?

Someone stated throughout the course of the week that you can learn just as much from a successful lesson as you can from an unsuccessful lesson. We saw a few lessons that were pointed out to be "show and tell". We learned this term meant students were asked to share various strategies to solve a particular problem, but there wasn't a clear objective for analyzing their work. Student work should not be presented on board without a clear reason. Are you comparing? Is it a common error the majority of students were making during the lesson? Do you want them to analyze which strategy is more efficient? Universal? Advantages and disadvantages? Make connections to previous mathematics? If explicit objectives aren't executed, a student could draw their own conclusion whether correct or incorrect about the lesson. Everything needs to be intentional to maximize learning.

Learning the importance of focusing on whole child, building community among teachers, creating student driven unit plans that highlight student questions and conflicts, and being more intentional in executing learning objectives were just a few of the valuable learnings I took away from our trip to Japan.

Monica G. McLeod

Project IMPULS 2015
Final Reflections

Monica G. McLeod
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National Context for the Teaching and Learning of Mathematics

The context in which mathematics teaching and learning operate in Japan is radically different than the context in the United States in general, and in Detroit specifically. While that is

an obvious observation, I feel the need to mark a few salient points. I was awed by the efficiency, elegance, and effectiveness of the coherent, coordinated educational system which I saw on display in Japan. In Japan, a national curriculum, which is thoughtfully developed and incrementally implemented, is augmented by curriculum materials which reflect the most up-to-date knowledge of teaching and learning mathematics, gathered from the experience of stakeholders at all levels. There appears to be a shared definition of quality teaching and learning, at least at the elementary-school level, evidenced by a collective pursuit of teaching through problem solving. A collaborative and system-wide commitment to professional development through Lesson Study provides a robust and responsive system for collecting, disseminating, and expanding professional knowledge.

The United States has staunchly resisted a national curriculum, though the Common Core State Standards are an attempt to establish shared expectations. There are a plethora of textbooks and supplemental curriculum materials available, of wide-ranging quality. While districts adopt specific resources, there is a professional norm that teachers often disregard those resources in favor of others they prefer. A shared understanding of high-quality mathematics teaching and learning has not been established, and professional development experiences are often disjointed and isolated. My experiences as a teacher and teacher leader in Detroit have laid bare the lack of the coherent, coordinated educational system in which my Japanese colleagues work. Yet, Project IMPULS has allowed me a glimpse of what could be, and has helped me identify the components that are within my sphere of influence to affect. Lesson Study stands as a powerful process for implementing change in my local context.

Defining High-Quality Mathematics Instruction: Teaching Through Problem Solving

Professor Takahashi identified that the target for research lessons (and presumably all mathematics instruction) is teaching through problem solving. This is a shared standard, written into the national Course of Study, embedded in textbook lessons, and held up during research lessons. My experiences during Project IMPULS have given me an example of a system-wide approach to implementing and improving teaching through problem solving.

I have not altered my expectations for high-quality mathematics instruction, based on what I learned in Project IMPULS, but I have developed a deeper understanding and appreciation of thinking profoundly about planning and instruction. In particular, collaborating on the planning of a research lesson facilitates and magnifies the insights of any one individual teacher. I have also begun to realign my emphasis from attending to how the lesson was executed to how the lesson was experienced from the student's perspective. Lesson Study is a tool through which my understanding can continue to expand, as well as a way for me to develop and participate in a community of learners with a shared goal of implementing teaching through problem solving.

Lesson Study as Highly-Effective Professional Development

As professional development, Lesson Study incorporates many dimensions of the endorsed practices for effective professional development. Adults prefer to set their own objectives for learning, and Lesson Study is driven by the questions teachers have from their own practice. Effective professional development should also be embedded in the daily work of teachers and sustained over time. Lesson study powerfully meets both of these criteria.

Each non-negotiable component of a lesson study cycle supports the essential elements of highly-effective professional development. By beginning with a question, Lesson Study establishes the habit of career-long curiosity, research, and reflection. Collaborative planning insists on the cooperative nature of effective school communities and provides a mechanism for transfer of expertise among teachers. Research lessons both open practice to peer scrutiny and keep that scrutiny focused on the impact instruction has on the students. Post-lesson discussions and presentations from knowledgeable others situate each classroom and school in the larger context of

understanding and research on mathematics education, keeping practitioners and researchers connected and accountable to each other.
Lesson Study considers student learning from the student's perspective, but also teacher learning from the teacher's perspective. Overall, Japan's systematic coordination and commitment to Lesson Study works to simultaneously benefit individuals (students and teachers), classes, schools, the mathematics curriculum, the education profession, and the educational system. Just about every circle of influence and import in mathematics education is supported through Lesson Study.

Project IMPULS as Professional Development
A goal of Project IMPULS is to reveal the secrets of Japanese Lesson Study so that it might be used to support high-quality teaching and learning of mathematics outside of Japan. To this end, I offer a few humble suggestions for how Project IMPULS might have better helped me see the secrets of Lesson Study. It would have been helpful to include a reflective discussion among the Project IMPULS group following each research lesson, in which the lesson would be evaluated using the standard of teaching through problem solving. Additionally, the insight of Professors Takahashi and Fujii on the points raised, or not raised, during each post-lesson discussion would have helped me as a learner in discerning essential and quality components of these discussions. The comprehensive presentations on the first and last day of the program were important and helpful bookends, and I would have additionally benefitted from daily evaluations to help me process what I was experiencing.

Next Steps in Detroit
I am walking away from my experience in Project IMPULS filled with many questions about how to support the transformation of teaching and learning of mathematics for teachers and students where I live and work. I am comforted, though, by Professor Fujii's observation that you cannot be a good life-long learner without good questions. First, I want to determine a way to enter into Lesson Study for my own professional development as a teacher. To that end, I have reached out to a group of my peers from different schools to initiate a Lesson Study group as a collaborative support system for each of us. I also hope to design opportunities to work with university colleagues in the implementation of Lesson Study as a model for professional development and capacity building in the school in which I work and other schools across the region.

Pamela Maslyk
Anchorage, Alaska

Reflection on Project IMPULS: Teaching and Learning in Japan

The Lesson Study Immersion Program 2015 was my first experience with observing the Japanese Lesson Study process. Although many articles were read in preparation for this program, I can honestly say that the experience gave me a much deeper understanding of Japanese Lesson Study and a greater positive inspiration than any article or book could convey. After taking much time thinking about what topics to include in this reflection, I opted on the main areas that arise in conversations about my experience since returning to the U.S.

Japanese Lesson Study in Mathematics

Upon arriving at Tokyo Gakugei University, I realized that Lesson Study is a professional development approach to assistance teachers in improving their teaching and learning. A group of teachers choose a goal or meaningful task, create a lesson plan, teach the research lesson, have a

post-lesson discussion and reflect on the lesson. In general, the lesson is not taught again as part of the cycle. Although the process sounds simple, it requires much more time and dedication than one would realize. What surprised me the most about this process is the willing collaboration and non-competitiveness amongst the teachers, administrators and staff. Lesson study is not just a process that one school uses, but it is a cultural curricular practice throughout the country to improve education.

Choosing a Goal & Preparation for the Lesson

After a group of individuals is formed, they will choose a goal or identify a topic or theme in which students struggle, for example, division of decimal numbers. This is followed by a study of materials such as text books, articles, Japan's Course of Study (similar to the U.S. Common Core), manipulatives and other resources to prepare a lesson plan. I did not take part in this process, called Kyozai-□kenkyu, but know that it is much longer and deeper process than imagined.

The Lesson Plan

The Japanese Lesson Plan for this process is like a typical U.S. lesson plan on steroids! I discovered quite a few differences in the Japanese lesson structure as compared to the U.S. and also the depth that they go into when preparing for the research lesson. First, the Japanese lesson is centered on a single meaningful question based upon the research goal selected where the students do not know a particular method for solving the task. Students are placed in a problem solving situation where the focus is on discovering different methods for solving the task or to deepen the understanding of a concept and not the "answer" to the question. I've learned that not only is the task important, but small changes to numbers used within the question can lead to a deep learning experience.

The lesson plans are quite detailed and contain information about the goals of the unit and lesson, information about the unit, how the lesson will connect with prior knowledge and a chart that outlines the flow of the lesson. This portion had quite an impact on me as the "flow" contains entire anticipated conversations and student outcomes from the problem solving task, expected diagrams and charts student may use, evaluation, how the teacher will support students, a seating chart and even the blackboard writing plan. The team creating the lesson may teach pre – lessons to each other to see if any changes in the flow are needed.

Teaching the Research Lesson

All schools have a half day of teaching when a research lesson is to be taught. This allows other teachers and staff to come and view and take notes on the lesson. Many of the participants did not think the half day would be a viable change within their school or districts. Watching a 45 minute research lesson was one of the most remarkable mathematical experiences I have had in my lifetime. It was like watching a conductor leading an orchestra, except there are people milling around and within the orchestra taking notes and pictures.

I was very impressed by the student's ability to focus on the lesson task and not become too distracted by everyone milling around them. In general I thought the students had an amazing ability to relay their work to the teacher or write it on the board while speaking to the class. At times the perceptive mathematical insights from the students created a collective gasp from us non-Japanese observers!

A very critical portion of the lesson is in the whole class discussion and the interaction with the teacher. It is here that the teacher needs to elicit students' thoughts, check for understanding, at times change the class focus and redirect where needed through thoughtful questions. This is an area where teachers would grow the most through experience. How does a teacher handle an answer that they did not intend that is throwing off the lesson focus? How long should a teacher allow a class discussion to continue before they should redirect because it is not having a fruitful outcome? It is amazing to watch a skilled teacher redirect through careful questioning and watch the students gain understanding.

Post Lesson Discussion

The discussion generally began about 30 minutes after the lesson finished and could last for around an hour. The three key people are the moderator, the teacher of the lesson and a final commentator. The team that created the lesson as well as other observers also joins in the discussion. The teacher is given the opportunity to share their reflections on the lesson and then the discussion moves into a dialog amongst the group. The final commentator critiques the lesson and gives a report.

I was quite apprehensive about this portion as many U.S teachers would view this critique as criticism which is generally not well accepted. After watching a few more post lesson discussion, I could see that the process was regarded as a tool to understand more about teaching and learning and that the teacher did not take it personally. It also seemed to me that teachers with more experience received a more through critique than teachers with less experience. When the lesson did not go as anticipated, you may hear that the lesson needed more Kyozai-kenkyu!

Great Impressions

The Japanese Lesson Study process as a whole is remarkable and will have quite an impact on my own teaching at the university level. But there are several items that stood out as significant or something that I will want to share specifically with other math teachers of the lower grades.

- The idea to center a whole lesson around one question where the goal is to promote several different types of problem solving techniques is remarkable. To complete this in one 45-minute lesson is extraordinary. To have almost all of the class understand the lesson is just astounding. U.S. schools need to step away from teaching a problem solving technique and then practicing it on a page of problems. This process is not promoting mathematical thinking, it promotes memorization.
- The benefits of using specific diagrams and techniques that are built upon throughout the curriculum were eye opening. The double number line is a must!
- Creating a board writing plan. This was a real eye-opener! Having the entire lesson with all the student work being displayed on the blackboard was excellent for promoting conversations and generalizing.
- Student journals where they write the problem, independent problem solving, board work and self-reflections in an organized way are something that should be incorporated in math class. I was amazed that none of the lessons taught assigned homework! They were to complete their journal entry and possibly, the next day, they would work on some problems in class.

Next Steps

I am on sabbatical this year and will be sharing what I have learned with some schools in Anchorage, Alaska. Now knowing what is entailed in lesson study, I will begin by meeting with a pre-K – 8th grade private school where I have previously taught. I know they promote learning math through problem solving and believe are more open to new practices. They will also be more flexible to changing in scheduling.

Thank You

- To Dr. Takahashi and Dr. Fujii, whose dedication to this program and patience with each year's participants has made Project IMPULS a success.
- To the translators who performed an incredible job interpreting the lesson and post lesson discussions.
- To the graduate students and all those who guided us daily through the streets and made sure we did not get lost on the trains. I still hear the clicking of the hand counter making sure we no one was lost.
- To the 2015 participants for your collegiality, knowledge, vibrant discussions and friendship! May we keep in touch even though we live far apart.

Summary of reflections following IMPULS visit to Japan 2015

Pete Sides, Maths Hub Lead (South Yorkshire), Hallam Teaching School & Notre Dame High School, Sheffield, UK.

My focus, purpose and aspirations

The lesson study model of professional development is being used in a number of UK schools including my own and whilst teachers and leaders have a perceived sense of principles and practice usually from word of mouth from other colleagues and documentation researched from the internet, implementation of Lesson Study in schools is rarely directly influenced by current Japanese practice. In attending the IMPULS programme I aspired to better understand the underlying principles and ethos of Lesson Study as conducted in Japan. The reason for this was to be able to make more informed decisions with regard to adapting the Lesson Study model for use within South Yorkshire schools.

In my role as Maths Hub Lead I am in the process of designing programmes of professional development to be delivered to schools over a finite time period. My aim is to promote a reflective model of sustainable professional development that schools can utilise, to continue their developmental progress. I feel Lesson Study is particularly suited to schools' needs in this instance, as the programme of development is focused on a school wide transformation of teaching mathematics over a long period of time.

Lessons learned

a) Working together for the common good

In some sense UK schools have adopted Lesson Study in practice but there is a cultural element that may be lacking. One essence of attitude towards self-improvement as part of the professional character is not easy to define and is not unique to Japan. However although collaboration and introspective reflection is present across the teaching profession in the UK, this character of self-analysis for the collective good appears to be institutionally embedded in the Japanese culture.

b) Long term view

Another aspect is the different sense of urgency between UK (and US) colleagues and their Japanese counterparts. The Japanese curriculum and programmes of study is well embedded and well resourced. Each district choosing its own published version of Maths curricula and "textbook" which details lessons and conceptual development as well as ample practice for students. As a consequence any changes to the norm are well thought through and decided over a long period of classroom research. Lesson Study being the conduit through which hypotheses of improvement can be reflected upon without urgency.

In comparison UK teachers are often searching for quicker solutions to fundamental issues of pedagogy often without a fixed scheme of work. As a result the longer term reflective process that is prevalent in Japan is distracted by snapshots of learning and ideas.

Often UK teachers are like magpies gathering shiny new ideas and resources without always having a well-established framework within which to use these ideas. This short term view would need to be addressed if LS were to be successfully transferred to UK colleagues.

c) Accepted pedagogy

From observing the eight Maths lessons in Japan each had a very common structure which to some extent was accepted as the norm and not the focus of reflection. Teachers expected students to communicate their thoughts following a period of work on a problem and the teachers were consistent in listening to and recording their pupils' ideas. The ability of the students to work individually and explain their methods was impressive and is at a level many schools in the UK

would only aspire to. The “neriage” element of each lesson was not always as embedded but nevertheless the underlying structure of the lesson was not the focus for development.
Instead the emphasis of development was predominantly on the structure of the mathematics and processes of learning undergone by the students in understanding this mathematical structure. The pedagogical framework of the lesson was constant in most cases and as a result was a discounted variable. This caused many of the UK & US observers trouble in their own reflections as opinion about the pedagogy often distracted them from the mathematical structure.
This apparent disparity needs to be taken into account when implementing Lesson Study into UK classrooms. The variety of styles of teaching both in terms of practice and personality pose additional variables that if considered in post observation discussions could over complicate reflection. It also highlights the need for clarity of the purpose of a particular piece of research, an aspect emphasised during the visit.

d) Accepting criticism

Linked to this aspect of working towards the common good as opposed to a focus on self-development is the readiness of Japanese teachers to accept criticism. In most, if not all instances of critique the focus was on the development of practice for all. Any analysis of practice either of the planned lesson or its actual implementation sought to find best practice for the benefit of the profession, school and students. However similar depth of analysis of a lesson, particularly any judgements made by the teacher during the lesson itself would easily be taken as a personal criticism by many UK teachers. This is arguably an understandable attitude as teachers have become defensive and wary of observational judgments in recent years because of the practice of linking observation with performance management. Nevertheless this defensive attitude does not lend itself to making the most of the Lesson Study process, particularly the post lesson discussion. As a result much of the practice in the UK is limited to informal groups of teachers conducting a watered down version of school based LS.

e) Planning

A feature that struck me most during my visit was the depth to which Japanese colleagues planned their lesson. The plan not only detailed what was actioned in the period of learning but put this lesson in the context of the programme of study, the ability and pre-learning of the students (all of which may be seen in a well-planned UK lesson) and the educational philosophy & research underpinning the strategies used to bring about learning. In addition a clear discourse detailing the focus for this particular lesson within the context of the wider purpose of the research.
Great emphasis was placed on pre-empting the responses of the students to questions and problems posed. This revealed the importance of collaboration in the planning cycle and in turn could lead to some of the more significant learning for teachers if they were unable to predict all the responses of students.
This element of LS has (in my experience) not been clearly identified as an important element of the process in the UK and yet is one aspect that could easily be rectified with significant impact by making it a key feature of the process and explaining to colleagues why.

f) Pre-reading

In addition to the in depth planning of the teachers to make the most of a research lesson, was the expectation of observers to fully understand the lesson prior to observation. This placed a responsibility onto the observers to take a full and active role in the research process. This also gave worth to the effort of the planning team to create a well-documented plan. It emphasises the collective nature of the research process and raises the importance of the collaboration beyond that of the planning team to incorporate the entire professional input from all who will be involved in the post lesson discussion.

g) Post Observation Discussion

Of all the aspects of LS I observed whilst in Japan it is the post observation discussion that has the

potential to have the biggest impact on the development of colleagues if handled correctly. The formality that suits the Japanese culture so well ensures a structure and a respect that serves the importance of this element of the LS process.
How that transfers to UK mentality and culture perhaps needs to be explored further. It is clear however that the elements of a facilitator for discussion and the inclusion of a knowledgeable other add a feature that emphasise the importance of the discussion.
Key aspects I feel would need to be stressed to UK colleagues are

- Respect for the teacher and the hard work that has gone into the lesson planning
- Opportunity for all parties to contribute and share their reflections
- Focus on the purpose of the research and how this lesson supports this
- Not arriving at a definitive answer

h) Continuing development
Perhaps the last of these is a cultural difference that UK teachers may find difficult to accept but Japanese teachers may see as part of the whole evolutionary pace of LS.
"Just because perfection cannot be achieved does not mean we should not strive for it."
Is possibly an example of philosophical attitude that separates many colleagues in the UK from their Japanese counterparts?
What is clear from my visit, is that following a procedural set of steps and naming it Lesson Study does not get to the heart of what has proved to be so effective in Japan. Nor will explanations from a third party (such as myself) bridge the gap. What is required is the nurturing of an ethos that may well take many years to develop and alongside it Lesson Study will likely become something that is not Japanese Lesson Study but if the fundamental principles of collaborative and collective development are served then perhaps this should be so.

Pete Sides
July 2015

Phillip Noble

IMPULS Reflections

Phillip Noble

I should start by explaining my background and my experiences with lesson study so that my thoughts and reflections have some context. Before arriving in Japan to take part in the IMPULS programme I had what I believed to be a sound understanding of the principles of lesson study but a little less understanding of the Japanese education system. My experiences of lesson study had all been as a result of working on two projects in conjunction with the University of Nottingham, over a period of two and a half years. Both projects involved looking at unstructured problems, mainly using the Bowland assessment tasks and our aim was to investigate the process skills. As part of these projects I have delivered and observed numerous research lessons. It has at times been very challenging, due to our inexperience at delivering problem solving type lessons but also due to our lack of expertise in lesson study.
I have decided to reflect on my experiences by considering those moments that really made me think and the reflections that allowed me to consider my next steps. I do worry that I will not fully achieve this or do it justice in the given word limit.
Day one was spent at the Tokyo Gakugei University; the features of lesson study and background into the Japanese curriculum were fully explained and we began to explore them as a group. This day really challenged my thoughts and made me question the validity of the lesson studies that I had already been a part of. Although I was certain that we had made a good start and had inherited **some** of the features of lesson study, I left the university that day with a sense that in some aspects we had totally lost some of the key principles of lesson study. My daily reflective journals reveal this

battle I was having with myself. It did take a few days until I was able to rationally conclude that actually, we had made a good job of beginning lesson study but that there were clear areas for improvement. I made my focus for the rest of the programme to learn about how I would change what we already have in place. My reflections from here consider that.

The first revelation I had was about the planning of research lessons. I was interested to learn that sometimes they are planned by the individual teacher and sometimes as a planning team. This is similar to what I have experienced so far in the UK. But what was massively different was the amount of planning and more importantly the amount of thinking that went into the lesson plan. I was subconsciously aware of this before landing in Japan, especially when reading the lesson plans, however it quickly became clear that the planning part of lesson study is vital for successful research lessons where learning for teachers can take place. This was emphasised at the university but also in discussions with Japanese teachers. In one school the lesson planning process started two months before the delivery of the lesson and involved eight pre lesson meetings. The importance of detailed planning is something that I will undoubtedly keep at the forefront of my mind when I return to the UK. I feel that the significance of the planning has somewhat been lost in my school and my instant reaction is to slim line some of our plans for next year to ensure enough time is left to plan research lessons properly.

This leads onto one of my other thoughts – ones that are not fully formed at the minute. It was mentioned a few times in Japan that 'lesson study is like air.' Of course we are far from being able to say this in the UK but what was evident from the very first day was the dedication of staff involved in lesson study. It is a natural part of a teacher's career and plenty of time is given over to preparing and thinking about the process. This made me think about teachers in the UK. Unfortunately, because of the political nature of the education system there are certain features that will be almost impossible to copy from the Japanese; for example, closing schools on Wednesday afternoons for planning and research lessons. However, I do believe that most teachers would be excited by the opportunity to be involved in such a process, especially to begin with. The key, and part of my role, will be maintaining the enthusiasm and commitment of staff. On my return from Japan I have already been into a science department meeting and the excitement created by the sharing of what I had seen in Japan was instant; it is important we tap into this.

Perhaps the biggest thing to strike me in Japan was the structure and clarity of the curriculum. I left feeling extremely envious but also with a determination to be a better **'mathematics teacher.'** Unlike in the UK where the education system is a political football, the Japanese curriculum has been thought about carefully and planned deeply. It considers the learning and understanding of the students. This is something that we must strive for in the UK – and I see lesson study as being an ideal vehicle on the road to achieving this. It will provide teachers with a way to learn about how to deliver content in new ways and allow us to consider how the decisions we make when teaching, impacts students understanding. We were given copies of the Japanese textbooks – an excellent gift that I will make great use of next year. For us problem solving has been defined as solving unstructured problems with the process skills in mind – I left Japan feeling that problem solving should also be a way to develop new content and conceptual understanding. The idea of delivering new content using problem solving and teaching mathematics in a more rigorous way fills me with excitement.

I was really unsure what to expect in Japanese lessons and there were a few surprises. I was surprised by how long the students were allowed to work alone, especially in high school lessons. This is very different to lessons in the UK were pupil's work in pairs or groups quickly. The second surprise was how many different solutions were shared with the whole group – a large proportion of class time was given over to explaining students work. This wasn't a quick glance at students work either, each student was given plenty of time to fully explain their thinking to the whole group. It really gave each student a voice and allowed for deep and meaningful discussions about the maths. I

was really envious of the large boards where all the student work could be displayed – it gave a beautiful commentary of the lesson. Again we need to find a way of using this approach back in my school.

The use of problems to develop new concepts, as previously mentioned, was perhaps the best surprise. As well as allowing for great examination of the maths, the use of such problems really caught the imagination of the students and it was common for students to be excitedly shouting out and sharing ideas in the Japanese classroom. We have definitely achieved this with unstructured problem solving in my school, now I want to capture this when problem solving for conceptual understanding.

We have struggled in the UK finding out how we judge the progress of students in problem solving lessons and how we can assess what they actually understand as they leave a lesson. The use of student reflections is one that has really got me thinking and one that I do intend to share and use. We do use these already – but they were used consistently in Japan and even used to plan the next lesson. The students were at ease with this process and for it to be successfully replicated our students will need training in how to accurately record their learning.

The post lesson discussion will be key to any success we have in the UK. Teacher's time is valuable and we already have lots of commitments and meetings. For lesson study to be sustainable it will be important that the post lesson discussion is focused and meaningful. The teachers must leave feeling they have learnt something or leave with new questions that they intend to research. In Japan this was evident in almost every post lesson discussion I witnessed. This is something were we have struggled thus far. We often find our post lesson discussions are unfocused and that the discussion loses its impact. Teachers leave feeling frustrated and if this was to continue then lesson study would not be sustainable. We have found ways to be more focused in my school but this still needs more careful work and thought. I think that the person chairing the post lesson discussion will have one of the major roles in lesson study next year. It is important that this person is selected carefully and that they understand the focus of the discussion.

Having learnt so much I have returned from Japan extremely motivated and eager to put my new ideas into practice. There are three immediate opportunities for this to happen in the next academic year.

Firstly, I will be working with three other local schools, continuing the work on a project that started last year. This project will continue to look at using problem solving to develop process skills. I have already implemented changes to the schedule, reducing the amount of research lessons. My intention is to focus and spend much more time and energy on the planning of the research lesson. I believe that this will allow for a much richer process with deep learning.

Secondly, I intend to host two research lessons within the mathematics department at my school. For each I will have a three man planning team and we will plan in full detail a lesson similar to the ones seen in Japan; a problem solving lesson where the aim is to develop concepts. I am fully aware of the challenges that this will present but am excited at the prospect of planning a lesson that develops the students understanding of mathematical concepts collaboratively with other colleagues. Every member of the maths team will observe the research lesson and be part of the post lesson discussion.

Finally, I intend to spread the message of lesson study to other departments in my school. There is already interest from the science department and I intend to lead a lesson study group. This group will meet six times throughout the year and will contain staff from a range of departments. It is hoped that two research lessons will take place with the focus yet to be decided. Asides from the six scheduled meetings, more planning time will be scheduled as smaller groups. To allow for sustainability I will borrow one more idea from Japan; I propose that the research lessons will take place after school with selected student. This is an exciting prospect that will allow all members of the group to take an active role in the lesson study process.

I look forward to using everything I have learnt in Japan in continuing our work on lesson study and making it sustainable and even more effective.

Rosa Archer

IMPULS Lesson Study Immersion Programme 2015

Reflective Journal

Dr. Rosa Archer, The University of Manchester

The IMPULS Lesson Study Immersion Programme was a very enriching experience. The time spent observing lessons and post lesson discussions in Japan has given me a lot to think about and I cannot wait to bring back these ideas to Manchester. I will comment on lesson study and also on teaching and learning in general. However, in order to provide a purposeful reflection, I will focus on the area that could be transferred to my context and not on these that are outside my remit or that I cannot change.

I came to Japan thinking I understood lesson study. I have read a lot about it while in the UK but it soon become clear that I had developed my own interpretation of lesson study and acquired some misconceptions along the way. I understood the importance of having a research focus for lesson study but I feel I had underestimated the role of the "knowledgeable other" in giving the lesson an enquiry dimension. It is very clear that the Japanese teachers see themselves as researchers and engage with teacher enquiry at a deep level during the lesson study process. This is clearly evidenced by the detailed lesson plans they produce which are often accompanied by data form surveys that teachers have carried out before engaging in the process. The knowledgeable other, being and expert teacher and a researcher, has the role of facilitating the enquiry and guiding teachers in their pursuit which might involve giving them further study after the lesson. This is something I will certainly need to reconsider when conducting lesson study in the UK. Furthermore before coming to Japan I was not sure if the re-teaching of the lesson was an essential part of the experience. I have come to the conclusion that re-teaching is not a bad thing to do but it is certainly not essential; in fact the end product i.e. the lesson is not the most important part of the process; the most important ingredients of lesson study are all the conversations while planning and during post lesson discussion. I understood during the past two weeks that there is a fundamental difference between a demonstration lesson or master class and lesson study. Teachers can learn a lot from a lesson study lesson even if it has gone badly. In fact Japanese teachers use lesson study to deepen their understanding of difficult topics related to teaching and learning and not to show how well they can teach. For example they would dedicate a lesson study to difficult to teach topics, such as dividing by decimals as we saw in our last lesson.

During the whole experience I tried to understand which aspects of the process suit the Japanese culture only and would need to be modified to suit my context. The time spent in Japan was very intense but certainly not sufficient to fully comprehend such a rich and complex culture. In particular I observed that post lesson discussion take a very different format. This seems to be influenced not only by the participants but also by the scale of the lesson study. The post lesson discussion always begins with the teacher reflecting on the lesson. In all cases it is evident that the planning team worked collaboratively and is there to reflect on their work but the comments from the audience vary considerably. In some cases the comments are very harsh while in others they are limited to asking questions. I have not fully understood why, partly because of the language barrier. I think I need to continue thinking about this when I am back in the UK and adjust my lesson study model by trial and error. However it goes without saying that children deserve the best possible teaching regardless of their nationality, background or culture.

I am certainly convinced that lesson study is worth doing and that it is the best professional development method I have ever experienced. One thing that really surprised me is that I have seen colleagues working together as teams in a very effective way and I am certain lesson study had a part in cementing these teams. It was so good to see colleagues celebrating together after the lesson. They did not necessarily celebrate having just seen the perfect lesson but celebrated learning

together and developing themselves, the school and the profession in general. The main difference I observed with other professional development courses I have attended back home is that these tend to be designed to develop the individual or the school, in the best cases, while Japanese teachers work together to develop the teaching profession as a whole. I was so pleasantly surprised when Dr. Takahashi told us that lesson study is in no way linked with career progression or pay increases. Japanese teachers just do it because they feel it is important and because they want to learn. As Professor Fuji said, "lesson study is like air" for Japanese teachers. Certainly this is something we need to learn from our Japanese colleagues. It is evident that teachers are trusted to be able to do their jobs and consequently teachers trust the learners. The culture I observed in all the schools we visited is permeated by the energy, noise, and joy of teachers and students working, teaching, and learning together. I firmly believe that this can only be achieved if teachers feel trusted by the children and by the management (who sees them as researchers of their own profession) and, I suspect, also by parents.

Almost all of the lessons that we saw followed a similar format. They started with a problem that was posed to the entire class. The question was carefully designed based on the curriculum (Course of Study). Careful consideration was given to what the children already knew and what they would learn in the future. In all cases teachers tried to extend previous learning and in no occasion did we see a standalone activity being delivered. Questions were designed to be open but accessible. Almost immediately after the lessons started learners had time to work on the problem individually. While students worked on this one problem, the teacher circulated the room and took notes on the problem solving strategies of various students. This one problem, which may have taken around 10 minutes for students to solve, became the basis of the discussion and the mathematics that occurred for the duration of the one hour lesson. This was completely novel for me. I have never seen a lesson back home spent discussing only one problem. The fact that there was a lot of time to discuss only one question allowed the teachers to ask some very deep questions and encourage children to really think mathematically. The teacher used the notes that they had taken while the students had been working on the problem to make decisions on how they would facilitate the comparison and discussion of mathematics that followed. It was fascinating to watch how effectively teachers would call on students in a purposeful way to share solutions, ask clarifying questions, record ideas on the board, and keep student thinking. The focal points of the lesson are the students' ideas, and student mathematical understanding. An effective lesson was not based on the teacher's ideas and the teacher's thinking, but rather the mathematics and the ideas of the student. In doing this the teachers, at elementary level in particular, showed a depth of subject knowledge that really impressed me. I really enjoyed observing how confortable teachers were moving between different mathematical representations. The board work and many of the children's notebooks are absolute works of art and carefully capture, not a procedure or an algorithm, but genuine mathematical thinking.

I was also fascinated by how our Japanese colleagues use the textbook. I understand that textbooks take many years to write and the pedagogy behind them is very robust. Despite having such good textbooks it is not the book that does the teaching but the teachers. In the UK most schools have given up using textbooks and teachers spend hours on end writing their own resources or finding resources on line. This is very time consuming for teachers and often results in teachers using resources that are not appropriate since they have not been carefully tested, as happens in Japan. This issue with textbooks happened in the UK because it become apparent that many teachers were relying too heavily on the textbook and teaching procedurally. However I feel that having eliminated the textbook we have not eliminated the problem of procedural teaching. I feel we have a lot to learn from how our Japanese colleagues on the use textbooks. It was a very powerful experience to observe how teachers use lesson study to write books, agree on how best to use them or test if they should occasionally use a different resource. Our Japanese colleagues have the advantage that change is

introduced slowly to their curriculum and only after careful consideration. I was surprised to read in Dr. Takahashi article that the new curriculum was announced in March 2008 and only implemented in April 2011. This gave experts plenty of time to consult with teachers, do lessons study and write the books.
After having learned so much I cannot wait to get started back home. My model will be substantially revised based on what I have learned during the past two weeks and have tried to express above. I am certainly going to use some of the teaching ideas I have learned and I also hope to keep in touch with the colleagues I met during the trip from whom I also learned a lot. I will continue to be part of the lesson study international community that will benefit the profession and consequently the children.

Sandie Blakesley

Beautiful Lessons - Reflections on IMPULS Programme 2015

'The problem is not the problem. The problem is your attitude about the problem…Do you understand?' *(Captain Jack Sparrow, Pirates of the Caribbean 2003)*

I said this at the final evening with the IMPULS group for 2015. It seemed pertinent for several reasons-

It provided for me a link between what I had learned as part of the IMPULS project and what we are trying to achieve in North Yorkshire currently to support schools with the implementation of the new programmes of study for mathematics in England. What I think I gained most from the project was that in Japan, lesson study is a powerful tool to develop teaching through problem-solving. What I saw was an attitude and an approach that has the potential to solve the problem for us in UK in terms of professional development of teachers of mathematics and embedding the use of problem-solving in the classroom.

At our summer 2015 network meetings for subject leaders of mathematics, we used this quote as the theme for the day. So the quote again made a link between Japan and home. As a Local Authority, we have continued to emphasise a problem-solving approach as fundamental to enabling students to be successful in developing their mathematical thinking and reasoning. We have a new statutory curriculum and the aims of this curriculum embody problem-solving whilst the year by year programmes of study list the content. If you like, the programmes of study are the 'what' and the aims are 'how'. During my time in Japan, I realised that the new Course of Study in Japan is the 'what' and lesson study supports teachers to understand 'how' through the lens of problem-solving.

I have always liked the structure of starting with a problem, drawing out concepts/misconceptions from children's responses, exploring this in depth and taking the time through careful questioning to probe/to nudge their thinking and reasoning. It is an approach that can provide opportunities for 'productive struggle' as I think Alan Schoenfeld commented, but also for me, I think it is also about valuing children's current understanding and using this to take them forward in their learning, as well as deeper. During the lessons seen in Japan, there was no race to the next problem or next theme, but generally (not always!) a focus on developing strong conceptual understanding. One of my favourite statements has been that teaching mathematics should be like Giza not Pisa –

The great pyramids at Giza are thousands of years old. They are incredibly stable structures with a strong broad base where height is gained only slowly at first, but which thereby ensures their longevity and power to amaze us. On the other hand, that elegant tower of Pisa is very narrow and goes high very quickly. It is built on weak foundations and to stop it collapsing has to have continuous interventions. It is delicate, but it is fragile and it is fundamentally flawed. Too many mathematics lessons in England seem to have become a race to the next level of content rather than

sinking deep foundations.

During the programme, I was particularly struck by the phrase – I think it went – 'How much practise is needed for students to move from conceptual understanding to procedural fluency?' This was in response to a question on the first day from a delegate who had asked about opportunities for students to practice procedures. It seems to me that in the UK we focus primarily on developing the procedural first, and then apply to problem-solving if there's time! And unfortunately perhaps, the aims of our new curriculum are –

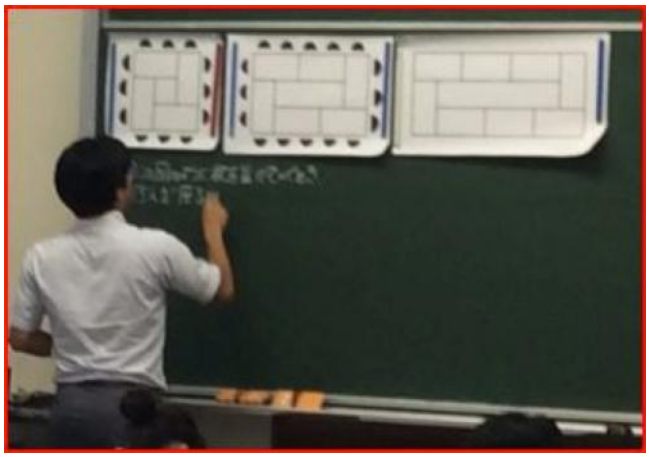
- Procedural fluency
- Reasoning
- Problem-solving

Why unfortunate? Are they not laudable aims? Yes they are, but it strikes me that they are in the wrong order and that they are the other way round in Japan. Problem-solving has been a key part of UK mathematics curricula for decades and numerous reports before Cockcroft (Mathematics Counts; HMSO 1982) and since have highlighted this as an area to be strengthened. Perhaps using lesson study to develop this maybe a possible strategy? I think what I learned through IMPULS is that lesson study is a highly effective strategy and one which would sit very well in the current climate of 'school led' developments. There is caveat – 'lesson study is like air' in Japan, it is therefore deeply rooted in a teacher's professional development and part of the distinct culture of how teachers continue to learn their craft. It takes a long time to develop cultural change in education…

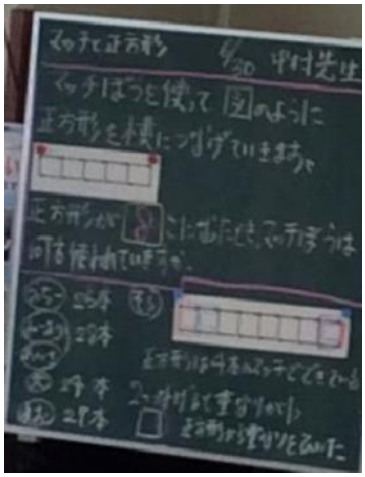
Sometimes I found the problems 'distracting', not in a negative way but because they caused me to reflect and be reminded of similar problems I have used in the past. This meant that at times I was focussing on problem-solving tasks and strategies not necessarily the lesson. This was particularly true of the lessons we saw on 'table-arrangements' (Koganei Lower Secondary School, 23rd June) and the 'eight squares' (Konagei Elementary School, 30th June).

The first of these lessons reminded particularly of problems I know as 'Pond Borders' and 'Around the Garden' which I think were from 'New York Cop and other Investigations' published by Cambridge University Press. But also 'Flower Beds' which came from the Shell Centre 'Purple Box' and was a favourite for GCSE coursework tasks in the 1990s. Actually, I think 'Pond Borders' was in the purple box too! Then there was a similar table arrangement task (Desks) from GAIM (1987), which I think may have been re-vamped for the Nuffield Foundations 'Applying Mathematical Processes' resources (http://www.nuffieldfoundation.org/applying-mathematical-processes/about-applying-mathematical-processes-amp). And of course, there is N-rich with a wealth of similar problems (http://nrich.maths.org/964)

The significance for me was that both teachers started from a simple case and built up the arrangements of matchstick squares or tables (see images). The 'eight squares' was less structured but still simple cases close together. I have to emphasise I would still rather see a problem being used like this than not at all!! The contexts were practical and engaging, just as the ones mentioned above, but the tasks I am familiar with didn't start in this way. They looked at diagram further on in the pattern or sequence and then posed the question how many would be need for…

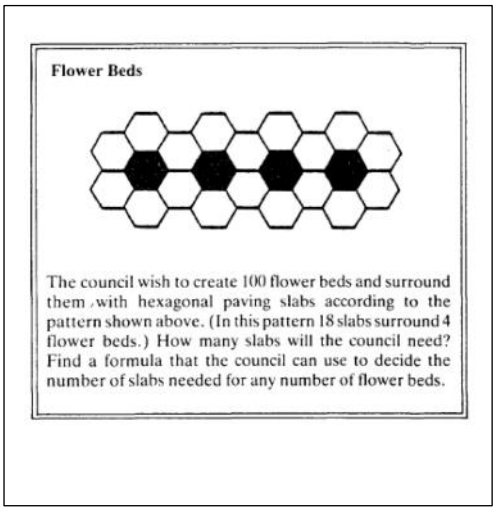


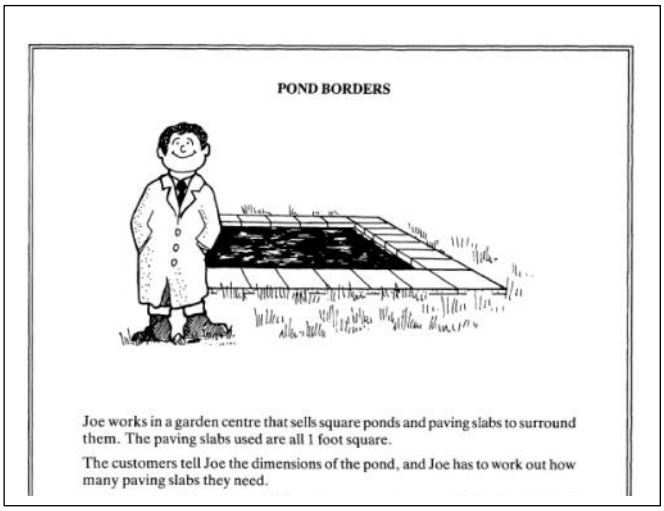
Koganei Lower Secondary School 23rd June - Tables



Koganei Elementary School

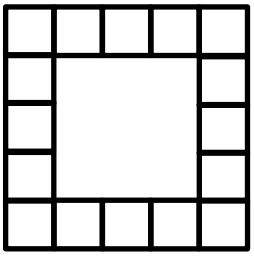
30th June – Eight Squares





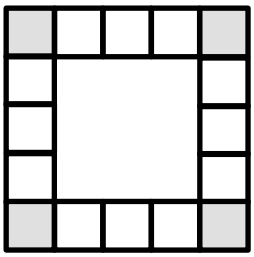
For me, there is more challenge and 'productive struggle' in these examples. I think we tended to use this approach because if you start from the simplest case, students tended to look at how to move from one diagram to the next consecutive one and then they were more likely to look for an additive relationship rather than a multiplicative one. Children as 'adders' rather than multipliers has been well documented through CSME (1988) and now through ICCAMS Project (Dietmar Kuchemann; IoE 2014). Another advantage by using a random diagram was that this approach gave us the opportunity to consider the diagram itself and say to students 'say what you see' as well as 'what is the same and what is different?'

For example, here is the border around a square pond, made up of square tiles as in the 'Pond Borders' activity above-

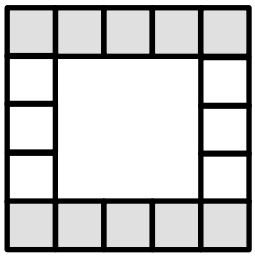


- How is this border made up?

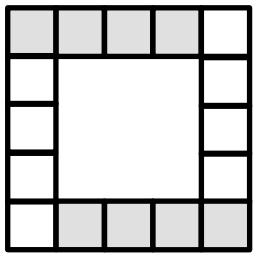
Different ways of seeing the diagram could be: -



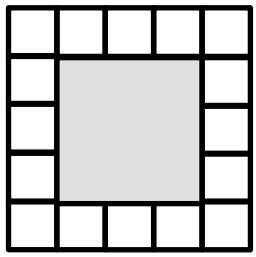
Four corners and three squares on each side:



Two opposite sides of 5 and two sides of 3 squares:



Four lots of four squares: 4 x 4



A five by five square with 3x3 square removed:

The next question is what is the same what is different here? And what if we changed the size, do all these different ways of seeing the structure still hold? Can we generalise? Are all of these expressions equivalent or not? How do we know? How could this help us solve the problem? (Interestingly, Alan considered a similar problem on our final day. If I had his presentation I would include a slide here)

I think the lessons we saw on this theme did gather students' ideas and strategies very well and there was discourse to move beyond 'show and tell'. I wondered whether there was time in one session to go beyond 'many ways to find many right answers' because the problems chosen were very rich. Sometimes during the programme the key activity wasn't rich enough as in the 'Mystery Clocks' lesson and other times teachers ran out of time or over-ran. However, getting teachers in UK to use a rich task in the first place remains a challenge with us – even if problem-solving is embedded in the statutory curriculum. We still need to balance accountability measures and real depth of understanding. I remember a chief examiner for GCSE, mathematics saying at one of our subject leader meetings just teach them to think and reason mathematically then it won't matter which examination they sit, they will be successful. The lessons discussed above made me think and remember that it is important for students to realise that there isn't just one way to find a solution and it is important to discuss alternative solutions considering which is the most efficient and most flexible beyond the initial situation. It is important to develop students' ability to think and reason mathematically and become mathematicians or mathematically proficient adults.

I found the board work in both the lessons discussed so far (and many others) absolutely fascinating and made me question the use of interactive whiteboards in the UK. In England, every classroom seems to have increasingly sophisticated technology, but how well is it used and does it support children's learning? Fifteen years ago I clung on to my chalkboard and insisted the pull-down projector screen was mounted over the chalkboard. I rarely see a chalkboard or even a dry-wipe board these days, certainly no overhead projectors and the IWB rules supreme! The quality and planning behind board work in Japan was clearly evident – there seemed to be a commitment to creating a story of the lesson for the students to follow and review as they needed. We seem to be wedded to technology in UK, which has its merits but sometimes the lesson becomes 'a ghost' because the story disappears as it is presented on different slides/screenshots and you can not necessarily see or hold several separate slides in your head at the same time. The board work did not always constitute a story but it often summarised the wealth of students' ideas that were being discussed and considered. I had an interesting response via email from my son on this point which I would like to include here –

'That thing with the boards and lessons being a story is so cool. I loved that at school, seeing loads of stuff written on the blackboard and then reflecting at the end and actually feeling good when you realise: hey I understand all that! That sounds great; I think that if teachers are planning their

lessons carefully then the blackboard is a perfect blueprint for that lesson, easily taken in by the kids too as it must leave out unknowns when everything is there ordered etc. seems a much more natural way of teaching to me when compared with characterless expensive interactive whiteboards.'

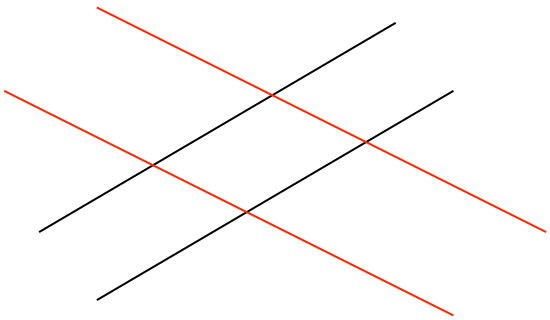
Seems to me there is an argument to really think about how we use board work in UK, what we may have lost between the chalk and the ICT revolution and what we can learn and gain from Japan.

I enjoyed the opportunity to learn more about the progression in learning/teaching certain aspects of the mathematics curriculum and how it is structured in Japan. There was been a specific focus on Geometry throughout the programme. This is an area of the curriculum, which I enjoy since it can lead into pattern which can lead into algebra; tessellation which can lead to deriving angles and properties of shapes and even back to algebra. And so much more – it can be so rich, yet it is often not explored enough in UK schools and in my view geometry is taught in a procedural way, at the moment.

The opportunity for Japanese children to discover the properties of simple shapes by drawing and construction so early compared to UK has been really fascinating. Currently in North Yorkshire, we are heavily promoting the use of a range of manipulatives to support children with understanding number, place value and calculation. Yet, we seem almost to have got to the point of 'banning' (perhaps harsh of me) compasses from primary schools! I think I will be on a mission to introduce this approach to geometry in Key Stage 2 when I get back home. I was intending to do an already planned session on geometry for our Primary Mathematics Subject Leaders' network meetings anyway, but I think I might now dig out a box of compasses...and play/explore!

What particularly struck me was starting by simply learning to draw straight lines, parallel lines and perpendiculars; using the compass to draw out regions/arcs. In England, we tend to give children the shapes and then sort/classify and discuss properties, which in fact the children haven't actually experienced for themselves – they are told what parallel means and so on. Also the opportunity to play around with overlapping parallels etc to see what shapes emerge makes the properties of say a parallelogram so easily apparent-

Ta – dah!!!!



It now seems so obvious to me! And whilst I am a big fan of nine-pin and seven-pin boards (Dave Kirkby Eigen Publications1983; now re-packaged by ATM 2015), as well as the interactive geo-board apps etc available on the web from www.mathlearningcenter.com and the wonderful n-rich website http://nrich.maths.org/2883 . I now think these resources are a next step rather than a place to start. We'll see next term!

I very much enjoyed the lesson at Sugakari School because the children clearly also enjoyed and engaged with the challenge. They needed to draw (!) on what they already knew and use this to explore ways to find an 'elegant solution'. It was a well-structured, yet open problem, accessible to all. The teacher was skilled in drawing out the children's ideas and using these to help them to think; reflect and revisit their 'solutions' rather than giving the game away. I understand the point made during the post-lesson discussion about use of manipulative resources and maybe that is something which would be considered in the next lesson – but what would be learned from a perfect lesson anyway???

And yes it was worth travelling almost half way round the world to see.

So why 'beautiful lessons'? I think the comment above makes this clear. They weren't perfect lessons but then beauty isn't necessarily perfection. They were carefully crafted lessons with a clear research point – they didn't all work but that wasn't the point. The point was what have we found out and what have we learned. The learning came through understanding what worked and what didn't and why, the focus on 'how' not 'what'. Perhaps the beauty was exploring what lies beneath not what is obvious.

I think that I learnt more about the ethos, aims and underlying principles of Japanese lesson study, its link with teacher development and continuous focus on research of learning to learn as a teacher. The paramount importance of the principle that observing a research lesson is a tool for shared learning was so clearly evidence throughout the visit. We really need this at home, rather than the current model in the UK where observation is about accountability and measuring teacher performance not developing teachers' practice. I also enjoyed the opportunity to learn and reflect on the structure for progression in learning mathematics both in Japan and experiences at home.
To end then, I am no poet but here is my attempt to sum up my experiences and thoughts about the IMPULS programme in a traditional Japanese form –

Lesson Study air,
Swirled around problem-solving –
We all breathed deeply.

Finally, thank you very much for the opportunity to be involved and to learn.
Sandie Blakesley
July 2015

Sara MacKee

Sara McKee
Project IMPULS reflective journal
Lesson Study

Before participating in Project IMPULS, I believed I had quite a good understanding of the lesson study process and the benefits of the practice of studying a lesson in depth. The immersion program allowed me to deepen this understanding, as well as address some questions I had about the planning process and post lesson discussion process. Prior to the program, I was unsure of how the planning process takes place in schools, and who participates in the planning process. I was also unsure of how to structure the post lesson discussion and ensure the focus of discussion is on the teaching and learning that occurs, and not just logistics of the lesson. This was my main focus as I observed both the lessons and the post lesson discussions.
My first observation was the amount of detail that went into the planning documents for the research lessons. I could clearly see the amount of research which informed all aspects of the lesson, such as the choice of number in a problem solving question. The sequence of learning was also apparent in the lesson planning, and this assisted in the understanding of what the student's prior knowledge was, and where their learning will go next. Going into each research lesson, I knew what to expect from the teachers, and what the anticipated responses were from the students. It was also useful to have guiding questions created by the research team to inform the basis of my observation. The planning of the whiteboard was an interesting aspect of the planning process- it was an aspect of the lesson that I wouldn't normally pay much attention to, but after observing the lesson study

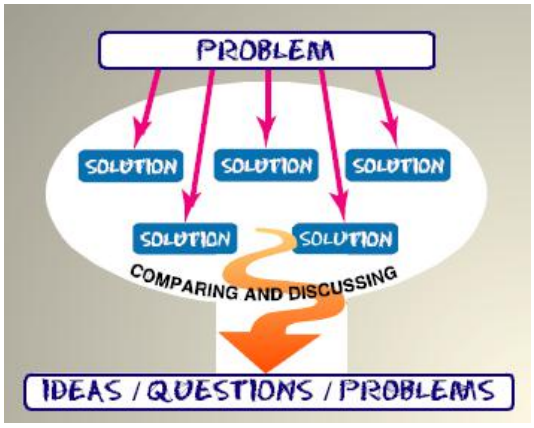
process I can see the benefits of this. It allowed the teacher to develop an understanding of the different levels of student thinking, and arrange the board accordingly.
In most of the Lesson Study research lessons, the level of collaboration was explained to us in the post lesson discussion. It was apparent that the teachers could see the benefit of working collaboratively to plan a lesson, and also the benefit of learning from each other. The teachers value their own professional growth, and also want to see their students grow in their mathematical ability. 'Kyozai-Kenkyu'- the investigation prior to the lesson shows the teachers dedication to this process. This may involve studying curriculum, textbooks and materials through research on the chosen topic, and plays a vital role in the lesson study planning process. It has made me aware of what needs to occur before a research lesson is planned.
I believe the Lesson Study process provides teachers with the following opportunities to enhance and further develop their teaching and learning:

- Opportunity to collaborate on a topic which requires attention
- A framework for accessing relevant professional reading and research
- The opportunity to learn from other colleagues through professional conversions and the input of others during the planning process
- The opportunity to learn teaching skills, such as questioning and scaffolding students thinking off others through viewing the research lesson
- The opportunity to delve deeper into a particular topic or skill which teachers normally wouldn't have the time or accessibility to do so
- A focus on looking at good problem solving tasks which promote student thinking and the idea of a 'good struggle'
- Create a culture where open classrooms are the norm, and teachers can comfortably develop their own content knowledge and pedagogical content knowledge.
- Make teachers learners as well as teachers
- View questions from a student's point of view to see the mathematics involved and the variety of ways students may approach the solving of a problem.

After viewing numerous in depth post lesson discussions, it was great to have the opportunity to conduct our own post lesson discussion amongst participants. I was interested to hear the views of my fellow participants, and I felt I learnt a great deal from this opportunity.
The Lesson Note Application for the iPad made organising my thoughts and observations of the lesson much easier than the way I normally observe lessons. It has been useful as a reference point also when looking back on lessons, and looking at my observations alongside the lesson plan documents. I am investigating the use of this application in my classroom, as a way of taking anecdotal notes, and also as a professional learning tool to use when modelling a lesson, or observing a lesson for a colleague. It allowed me to take many more notes than usual, as there was an efficient way of recording everything I observed.

Teaching and Learning in Japan

As part of Project IMPULS, we were fortunate enough to learn a great deal about teaching and learning in Japan from Professor Akihiko Takashi. Throughout the immersion program, I felt my capacity as a teacher of mathematics and facilitator of mathematics grew immensely as a result of the presentations and discussions we had prior to and after the research lessons we observed. I began to reflect on my own practice as a teacher of mathematics, and what I need to do to ensure my teaching is that of a Level 3 Mathematics teacher.
An aspect of the structure of a Japanese Maths Lesson which resonated with me was the idea of sharing responses not being 'Show and Tell'. The diagram below inspired me to really think about the way in which I structure and facilitate discussions about student's responses to a set task.



I believe the 'comparing and discussing' portion of the lesson, which then leads to ideas/questions/problems is a vital aspect of the Problem Solving process. It's not enough to just share solutions- the sharing of solutions needs to lead to a meaningful comparison which adjusts or modifies student thinking. This diagram has allowed me to think about the way I structure my problem solving lessons so they are more meaningful for the students.

Anticipating student responses is an important part of the problem solving lesson process as teachers need to be aware of how students might answer a question, so they can be prepared to structure the discussion and board work accordingly. Thinking like a student allows teachers to see the ways in which a problem will be approached, and also if the problem is a strong problem for students or needs to be modified to allow for more learning to take place. I was fascinated by the idea of each student completing the same problem, as I was wondering about how the problem would be differentiated depending on the ability of the student. It was apparent that although every student was completing the same problem, the ways in which they solved the problem allowed for them to develop their thinking at their own level. They could then learn off their peers through the discussion process, and see how they can build on their own understanding to get to that next level of thinking. The summary part of the lesson is where students can reflect on their own thinking, and what they liked about other students strategies.

Another aspect of teaching and learning in Japan which interested me was the structure of the textbooks. The format of the textbooks was explained to us in detail, and we had a chance to see how the textbooks were structured to promote the development of student thinking. The way in which problems were introduced were interesting, as were the way that 'students' responses to the question were demonstrated in the textbook. I was amazed about the depth the textbooks went into, just like the lessons, based around just one problem. Rather than many problems looked at superficially, the textbook delved deeper into the different levels of understanding and strategies that could be used to solve the problem.

I believe the main teaching and learning idea I have taken away is the use of one excellent problem, rather than 5-8 'average' problems for students to solve. I can now see the benefit in focusing on one problem in depth rather than looking at a wide range of problems at surface level. I also liked the idea of how in Japan, there is one word for teaching and learning: 'Gakushuu-Shidou.' I believe this says a great deal about how teaching and learning are viewed. I also have realized the importance of students not just learning off the teacher but from one another. We had a great discussion about where the learning occurs in a lesson and I think this process may make teachers realize that they are facilitators of learning, not the person who lectures to the students and the only source of knowledge in the room.

IMPULS has allowed me to experience a different education system for the first time in my career. It has opened my eyes and allowed me to reflect on the things that are done well in Australia and also many ideas to implement which will strengthen the teaching and learning that occurs. I have also had the opportunity to ask questions of other participants and gain a stronger understanding about the different education systems around the world.

Throughout the Project IMPULS journey, I have been reflecting on what my next steps are as a result of undertaking this program:

1. Professional learning for staff- explaining the lesson study process as I now understand it complete with photos and transcripts from my lesson note observations and lesson planning documents. Firstly at leadership team level then to all teams within the school
2. Creating the demand- constructing a team of willing participants around the school to develop their capacity in lesson study and using this team as an example for a lesson study launch
3. Sharing the role- working with a colleague who attended this program last year to ensure we are keeping the process as authentic as possible and having two leaders in the school drive the process
4. Conducting a lesson study cycle with the lesson study team as an 'open house' opportunity for teachers to observe the process and ask any questions about the process.
5. Sharing my learning through a recent network I have become a member of who are all extremely interested in the process. Further down the track, I would like to conduct a district wide lesson study with interested teachers from other schools.
6. End in mind goal: making lesson study a part of the professional learning culture at my school.

Conclusion

After participating in the Project IMPULS immersion program, I believe I have developed a much stronger understanding of not only the benefits of Lesson Study, but how to plan a research lesson and conduct a post lesson discussion. After witnessing teaching and learning in Japan, I have seen the immense benefits in problem solving based lessons and how they deepen students thinking and understanding of a topic. I have also seen the benefits of allowing students to share the way in which they solved a problem, and the confidence these students had in their mathematical explanations. Students were engaged in their learning, and active participants in their individual learning of mathematics. I was inspired by the active interest that the teachers we observed had in their own professional growth, and most importantly, the improvement of their students thinking. It has been the most beneficial professional learning experience that I have participated in, and I have already began to implement many of the concepts and ideas that I learnt from the Project IMPULS immersion program.

Sarah Seleznyov

Final report – Sarah Seleznyov, Institute of Education, UCL
IMPULS 2015

1. What have I learnt about lesson study?

Before this trip, I saw lesson study as a form of collaborative professional development and did not fully grasp how close it is to action research. In the future, I will present it to teachers as a form of action research and link it much more closely to research and development projects I already design and lead. This will mean rethinking the process of lesson study and the roles of leaders of lesson study.

I will encourage schools to have a shared research theme, perhaps drawn from a school improvement priority so that there can be a shared dialogue about research on teaching and learning from all those participating in the lesson study process. For cross-school projects, I think it will also be useful to agree a shared theme so that research can be shared by all teachers.

One half day planning session is not enough to carry out kyozai-kenkyu. Although time constraints are one of the blockers for lesson study in England, I will push for teachers to have two planning sessions: one to review the research and teaching literature, and one to produce the lesson plan and run a 'mock' lesson.

The role of the kochi was not clear to me before my visit to Japan. Now I see this role as crucial to the research-focus of the project. The lead teacher on my project will act as leader of the research group, discussion chair and kochi. Their role will be to ensure the group focuses tightly on the research question and to source relevant literature and resources for the planning group. They will also need to ensure the discussion develops threads that address the research questions and to summarise these threads for the group.

I have realised that the lesson planning format I have been using for lesson study does not sufficiently encourage teachers to anticipate student responses, nor does it push observers to focus tightly on the research question. One of the characteristics of a Level 3 teacher is the ability to anticipate how each individual student will respond to the given task. The plan will need to follow a narrative structure, as seen in some Japanese plans, with anticipated dialogue between teacher and students clearly recorded as well as teacher actions. The three questions at the end of the plan for observers will also be added to the planning template.

I was interested to hear Professor Takahashi talk about progression of skill in terms of note-taking during lesson observations. I think I have not fully appreciated the need to support teachers in developing these skills and need to build this into the lesson study professional development programmes I deliver. The use of Lesson Note can definitely support this, but the paper alternative of a *teacher/student* recording frame, as shown by the professor can also work.

2. What have I learnt about mathematics?

I have been interested to see the depth of subject expertise maths teachers develop in Japan and believe this is lacking in the English system. The three levels model[1] used in the Japanese system is one I want to share with teachers on professional development sessions:

- Level 1: The teacher can tell students the important basic ideas of mathematics such as facts, concepts and procedures;
- Level 2: The teacher can explain the meanings and reasons behind the important basic ideas of mathematics in order for students to understand them;
- 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.

The English curriculum focuses too much on the development of 'basic skills' and not the deep mathematical thinking and enjoyment of students. We spend very little time exploring concepts and too much time finding solutions, whereas the underlying concept is often very complex and requires more time to internalise and accommodate: finding the answer is not always the most important thing. In my opinion, the four assessment areas in Japanese maths (below) strike the correct balance between the development of skills and the wider value of maths to student learning and attitudes:

1. Interest, eagerness and attitude
2. Mathematical way of thinking
3. Mathematical skills
4. Knowledge and understanding

[1] Sugiyama, Y. (2008), Transl Takahashi, A. (2011)

With this in mind, I will use professional development sessions I lead to push the idea of the value of developing a mathematical way of thinking and of students enjoying maths. Starting with a story, as is common to Japanese mathematical teaching, is key to this. Supplementing a problem-solving curriculum with 'practice days' is better than what is seen in most English classrooms, namely a 'practice week' followed by one day of application of skills to a problem. We are starting in an abstract context and then trying to apply that learning to a real problem - this is fundamentally the wrong approach as working in an abstract context is more difficult than in a concrete context. The new primary National Curriculum, with its increased focus on reasoning and problem solving, provides an excellent opportunity to change our practices.

Seeing the value placed on student questions and teacher encouragement for students to say *I don't understand because…* has reinforced my own belief in the value of encouraging curiosity and using, rather than avoiding misconceptions. This is one of the principles that underpins Let's Think practice.

I have been excited to find Japanese words to describe aspects of pedagogy that I have tried to teach teachers, but which do not have an English word to describe them, namely:

- kikanshidou, which I have described as scanning the room: watching student learning to decide which solutions you want to share with the class and in what order, often annotating ona seating plan to annotate;
- toikaeshi, or 'revoicing', which I have previously not had a word to describe, but which is

crucial in Let's Think[2] lessons: for example, on hearing a key comment by a student that will move thinking on, the teacher might say C*an you say that again? What does everyone else think about that?*;

- bansho or 'boardwork': the visual displays created during the lesson to represent the sequence of students' thinking and the variety of their solutions which again is very important in Let's Think lessons and I can now ask teachers to specifically plan for, during teaching sessions.

3. What have I learnt about education systems?

The education system in England has got a lot of things right, and we should be proud of this. We do have high expectations in terms of classroom pedagogy and rightly focus on peer-to-peer as well as pupil-teacher talk, formative assessment strategies, and enjoyment and engagement. Research would suggest we are correct not to assume that experience means expertise[3] and we definitely have greater success in terms of gender equality, both at classroom, teacher and academic level.

However, we have huge problems with variability in terms of teaching quality, and at both ends of the range we destroy teachers: those with low skills are not sufficiently supported or given time to develop their practice and frequently drop out; those with high skills are pushed to breaking point through an enormous workload and frequently burn out.

The results of this system are beginning to emerge in England and will have a devastating effect on

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2 www.letsthink.org.uk

3 Hattie, J. (2003) *Teachers make a difference: What is the research evidence? Distinguishing expert teachers from novice and experienced teachers.* Australian Council for Educational Research; Hargreaves, A, Fullan, M. (2012) *Professional Capital: Transforming Teaching in Every School* Routledge; Wilkins, R., Head, M., Taylor, M., & Keaveny, B. (2004). *Supporting and Utilising the Experience of Older Teachers* Report of a research project commissioned by the General Teaching Council for England (GTC) with the support of SAGA.

learning. Already, unlike the Japanese system, we struggle to fill teacher training institutions with high quality trainees: politicians and press conspire to denigrate the teaching profession so that it is not a high status career for our most talented young people. The combined effect of the dropout and burnout described above is already having an impact, with current statistics[4] showing one in one hundred teaching posts either not filled or filled with temporary teachers.

It is important for all of us in the education profession to voice our discontent with the current status quo and to fight for teachers to have the right to a supportive professional development system, respect and a positive depiction from politicians and press, and a role in shaping the education system as it moves forward.

4. What will I do next?

I will be running several lesson study projects and professional development programmes next year. In order to ensure these draw on best practice from the Japanese model, I will:

- Review expectations about time for planning and recording of lesson observations and share this with potential leaders of lesson study;
- Edit all guidance materials for leading lesson study, in order to ensure that they better reflect the Japanese research focus;
- Share learning about the Japanese model with all potential lesson study leaders so that they understand to what degree there is fidelity to the principles of lesson study in their own projects

I also intend to prepare a presentation on the Japanese model of lesson study, which will be shared at several upcoming events:

- The Institute of Education Lesson Study Group: a group of practitioners and academics leading on lesson study in various different contexts from across the university;
- The Let's Think Forum meeting taking place in the Autumn Term (also to share maths-specific learning with maths colleagues at this event).

I intend to review the curriculum for Let's Think professional development programmes so that it includes learning about the Japanese problem solving approach to mathematics teaching and the specific pedagogical terms that are used to describe teacher practices. These will form the basis for reflections on practice with novice Let's Think teachers. I will also use the model of three levels of teaching with Let's Think practitioners, as a comparison to our own self-assessment model.

I plan to try to obtain funding for a lesson design programme for experienced Let's Think teachers. This programme will incorporate thinking about effective mathematics teaching from the Japanese model and build on lesson ideas seen on my visit as well as others in the textbooks we have been given. The format for the programme will be very similar to a lesson study process, and will include testing the new lesson on identified classes with a post-lesson discussion.

The study trip was inspirational and a deep learning experience – I cannot thank the IMPULS team enough for enabling me to benefit from this experience.

[4] http://www.bbc.co.uk/news/education-33363958

IMPULS Lesson Study Immersion Program 2015

Reflective Journal

Simon Mazumder, Altrincham Grammar School for Girls.

IMPULS Lesson Study Immersion Program in Japan 2015 was an excellent professional development opportunity, which enables colleagues to experience a deep and enriching chance to examine and investigate the complexities and detail of lesson study. Tokyo Gakugei University is a centre of excellence for lesson study with colleagues such as Professors Akhiko Takahashi and Fuji Takeshi, who could guide colleagues through the systematic procedures but more importantly the professional culture and the growth mind-set that this provides teachers in analysing with greater scrutiny their practice.

My previous experience of lesson study

I have been involved in two research projects in England, which employed Lesson Study as an action research method. The first project was a Teaching Development Agency funded project, focussed on developing Initial Teaching Trainees, teaching methods. Working in collaboration with experienced colleagues in the planning, preparation and delivery of mathematics lessons. This was a joint project with colleagues from Manchester University Department of Mathematical Education. The second project was the NCETM, Multiplicative Reasoning Project. Working with thirty schools nationally, three teams of facilitators and three writers from the Kings College London, Manchester Metropolitan University and Nottingham University respectively. The aim of this project was to develop teachers' methods and practice using proportional reasoning through problem solving. This one-year project was developed to encourage change in colleagues teaching methods from the unitary to using ratio and proportion models and methods. The method for the teaching pairs to develop this practice was using a collaborative Lesson Study approach to their planning, preparation and teaching of the prescribed lessons provided by the University writers.
I will refer to these previous experiences of lesson study to compare and contrast this with my experience of Japanese Lesson Study during the IMPULS program.

Setting the Professional Context of Japanese Lesson Study

Insightful sessions led by Akhiko Takahashi explained why there is a Lesson Study culture present in the Japanese education system. This is an account of the main features that I attained from these discussions that gave me a deeper perspective of Japanese Lesson Study and the critical features that support teacher development to improve mathematical learning outcomes. The professional view of Lesson Study was emphasised by this quote from Professor Fuji Takeshi: "Lesson Study is like air". The analogy describes Lesson Study as a critical ingredient, omni-present and necessary in the professional development culture of Japanese mathematical teaching. The observed lessons were based on problem solving; essentially the teacher presents a problem without demonstrating how to solve the problem. The structure of this is to allow students to explore many different solutions; they then compare their solutions through whole class discussion. This develops further ideas, questions and problems for the group to analysis. This teaching through problem solving allows students to develop mathematical thinking through conceptual understanding rather than

procedural understanding.[5] Two factors are critical in this methodology: the first is the need for students to develop a range of strategies for solving problems for example using diagrams, patterns or using "special cases". To add this learning culture for students to develop deep mathematical understanding requires three levels of teaching:

- Basic mathematical ideas based on facts, concepts and procedures.
- The meanings and reasons of the important basic ideas of mathematics in order for students to understand them.
- The opportunity for students to understand these basic ideas and to support their learning to become independent learners.

The Japanese continued professional development is structured around the experience gained by other colleagues. Although listening to experts for CPD does not always translate into improvement. Involvement in Lesson Study allows the practitioners to develop reflective analytical skills in a collaborative mechanism. Also with the rigour of planning, analysing, preparation, delivering the research lesson and the post lesson discussion, enables a more reflective approach to the process of developing deeper mathematical reasoning through the teaching and learning environment. Interestingly novice teachers are considered colleagues who have less than ten years teaching experience. Two key phases are identified as imperative to action continued professional development of teachers:

- Attaining knowledge for teaching maths beyond subject knowledge.
- Developing focus on particular aspects of the mathematics for cognitive development.

Many international education[6] systems highlight the need for problem solving as a key mode for developing deeper mathematical understanding for learners however this does not always occur and often there is little evidence of problem solving in the mathematics classroom[7].

The Japanese philosophy of the experience of students in the classroom is a "once in a life time experience," conveys the importance given to the elaborate planning and delivery of problem solving lessons and the need for careful collaborative planning and preparation. The purpose of Lesson Study is a place to establish shared knowledge, not necessarily to develop the perfect ultimate lesson. The Post lesson discussion gives greater knowledge shared so this informs, improves future lesson planning, construction and facilitation.
The one hundred year history of lesson study has established three types of research lesson study events:

- School based lesson study, collaborative teamwork development where all teachers are responsible for all students.
- District wide lesson study, several schools are involved but teachers still teach their own class.
- Cross-district lesson study is much bigger with a large observing audience often the research lesson could be given on a stage.

Each form of these lesson studies allows different opportunities to study student learning and so the

[5] R Skemp: instrumental Understanding.
[6] Mathematics Counts, Cockcroft Report 1982. UK.
[7] J.W.A. Young. 1908

generated discussion is very different. Panel discussions can be critical so this becomes the richness of the lesson study activity. This very critical analysis of teaching is not a reflection of the teacher and the emphasis of the collaborative planning and preparation around the agreed focus is imperative to this culture. This Collaborative Lesson Research cycle is used to ensure there is impact on students learning of mathematics, the cycle can be described as follows:

"*Like climbing a mountain, the higher you climb the more you will see!*"

In the UK the use of lesson study is usually school based and often the focus is the pedagogy rather than content and the context. For example: the focus maybe promoting student dialogue through problem solving. After my visit to Japan I think this may not be profound enough and certainly the planning and preparation in the UK does not have the same depth or detailed mathematical reasoning that I witnessed in the research planning of lessons.

<u>Observing the Research Lessons.</u>

The IMPULS group were very fortunate to experience observations all the various forms of lesson study. It is important that I was observing the practice of Lesson Study and not an analysis of the pedagogy and practice of colleagues teaching these lessons.

The main feature initially is the detail of the planning and the accompanying documentation that describes the rational and reasoning for the research lesson. This is far more detailed than I have experienced but gave a clear and precise justification for the problem solving activity and the aims and objects that this realised. Of course there was significant variation in the outcomes of these lessons but using the prescribed model, CLR cycle it became evident that this was a self improving model that over time would develop greater reflection and understanding for colleagues. I was extremely impressed with the detail and research that had been under gone to achieve the research lessons. Two things that struck me as contrasts to the UK experience was the time colleagues worked together in developing the research lesson. Often time can be an argument in the UK for why we are unable to engage in such professional activities. Next the post lesson discussion was extremely insightful and frank. Using a panel for reviewing the lesson gave a deeper systematic approach to collaborative reflection. Although discussion and reply was evident from the teacher

there was a greater degree of listening to peers comments and particularly the summation comments from the experts. I feel if I had this experience in my own career I would not have stalled at the unconscious, incompetent level for so long, that unfortunately many colleagues in the UK endure before they can start to refine and deliver mathematical lessons with good learning outcomes.
Despite the large numbers of observers students did not seem distracted by this and colleagues teaching the lessons where surprisingly collected. In the UK observation is used as a performance management tool, it is often seen by teachers as a necessary evil, especially if this relates to professional measurement and progression.
Using the Lesson-note IPAD application to record the lesson observation and take photographs of students work is excellent for reviewing the lesson, giving details of timing lesson mode, whole class etc. and the specific interactions of teacher and students. The detail obtained is extremely useful and generally a very impressive application in recording lessons accurately with evidence of progress and student work.
I mentioned earlier my involvement in a national project using lesson study, this probably was a close proximity to a district wide lesson study research lesson as I have encountered in the UK. The differences are noticeable by the consistency of the various Japanese Lesson Study types and their similarities. In our UK project there was a large variation in the approach and outcomes and I believe using CLR model would of helped achieve a more consistent approach.
Another feature is there is no dialogue between observers and students this again is a marked difference in the UK, it is common practice for observers to discuss student work directly with them during the observation. I have also seen this in lesson study situations and I am convinced this is an unnecessary distraction.
Given the detailed research rational and lesson planning, observers can use their observational focus to collect data to inform them of the events unfolding. This then positions the observer to discuss the lesson in the post lesson discussion.

Next Steps: my own development of lesson study.

I believe the CLR collaborative cycle is imperative in preparing the research lesson and this process gives the required opportunity to develop the lesson focus. Problem solving in Japanese lessons is a very detailed and fully researched method for improving mathematical understanding. I was impressed at the use of systematic variation and the holistic opportunities realised in what initially appeared to be a simple whole class problem. These problems have such heuristic possibilities that the contrast of having a carefully and intelligently developed mathematics curriculum is fundamental and in stark contrast to the open ended National Framework adopted in the UK.
Initially I would like to develop a research lesson with a group of colleagues from the IMPULS programme and other academics from the wider University community. Using some of the problem solving lesson materials observed, and the CLR cycle to emulate the process would help colleagues appreciate the complexities involved. It must be realised that as admirable the Japanese lesson study culture is, we in the UK must develop and produce our own cultural adaptation to meet our needs but without losing the focus of the research lesson and the collaborative planning and reflection needed to make this a powerful CPD opportunity that become a professional necessity.

It was a great pleasure that I was given a chance to participate in this IMPULS Lesson Study Immersion Program. It was really an amazing and wonderful experience for me. Throughout this 11 days program, I had experienced professional growth that changed my perception on what a teacher could do in a 50 minute lesson. I gained insight into how Japanese teachers practise lesson study and made use of it to improve their teaching and professional skills. Having the rare privilege to visit to nine research lessons in seven Japanese primary and secondary schools, I came to realize that there were great differences between Japanese and Malaysian mathematics lesson and I would reflect on the differences based on my observation and experience.

Task to inculcate mathematical thinking: Quantity vs quality

From what I could see in Japan research lesson, a 50-minute lesson only focuses on one question. Teacher started by posing a question. The question was open-ended and pupils could solve it with different ways. Teacher encouraged pupils to explore the problem. Teacher went around the class to check and sequence pupils' solutions. Pupils reasoned out their solution. Teacher anticipated pupils' responses and the teacher would compare the solutions as whole class discussion. This was called 'Niriage'. Through 'niriage', pupils could see different ways of solving the same problems and they could self-explain on why they solve a problem in a certain way. Pupils' mathematical thinking was inculcated through these well-planned lessons. Compared to my usual lesson with my pupils, I did quite a lot of "show and tell". I often asked pupils to try solving a few questions after every lesson but seldom encouraged pupils to discuss different solutions to a same problem. This method did not encourage mathematical thinking. Without comparison and discussion, there was little learning in pupils. Hence, I would like to change my teaching and focus more on 'niriage' in my mathematics lesson so that my students could engage themselves in coming up with alternative solutions, and actively discuss about which method is more suitable to solve the questions.

Figure 1. The teacher was doing 'Niriage' with the pupils.

Importance of generalization of the topic

Teachers often said that they have no time for trying different ways of teaching because they need to finish the syllabus. As a result of teach to test, many teachers choose to use procedural teaching and focus on 'drill and practice' (Lim & Hwa, 2007). I realized that it was not right to do that. When the teacher was able to inculcate mathematical thinking in a lesson through questioning or problem solving, pupils were able to construct their own

understanding and it might result in saving more time than procedural teaching. I had witnessed its possibility in Japan. During each of the research lesson, the teacher used problem-solving approach in a 50-minutes lesson and the pupils learned through 'niriage', making the mathematical thinking visible. Then the teacher would make a generalization of the lesson learned. From there, pupils could relate how the content of this topic is related to another. The idea of extension also enables pupils to see how this knowledge could be applied in other context. In Malaysia, we seldom focus on generalization and extension of the same lesson. This is another aspect that we should work on and lesson study is definitely a stepping stone towards this target.

Figure 2. Teacher did the generalization of the topic taught at the last part of the lesson. (On the right most blackboard)

The Role of a teacher: Facilitator vs researcher

To me, teachers used to be a facilitator of pupils' active learning in class. But lesson study gives another wonderful role to teachers as researchers to research into teaching methods used in a lesson, the flow of the lesson, choice of questions, strategy to help weak pupils and etc. Before my trip to Japan, I have never thought of looking at lesson study as a research. To me, research was something done by scholar who wish to get a master degree or PhD in university. This program has provided me a perspective that indeed the cycle of lesson study was a research into improving the quality of the lesson. Through lesson study, teachers worked in a group to plan a lesson which aimed at addressing learning problem among pupils. The teachers in Japan valued each lesson and tried her best in delivering it as what Akihiko sensei mentioned: Each lesson is a once in a life time experience for the pupils." They would never have it in a same way again. The moment I heard this, I was deeply motivated and I would remind myself this for life.

Lesson study: Individual vs team

Lesson study would not be meaningful without the lesson observation and the post-lesson discussion. The common practice was that team of teacher who planned the lesson together would observed the lesson as well as to give feedback at the post-lesson discussion. However, in Japan, the lesson observation and post-lesson discussion in a school- based lesson study involve the whole school's teachers. During the post-lesson discussion, the teacher who taught the lesson did not feel as if being judged and penalized. Instead, the teacher was humble to accept suggestion and feedback with an open heart. When being asked about why the teacher decided to change certain part of the lesson from the initial planning, the teacher would explain the rationale for doing so. The teacher could be planning the lesson individually but the decision was brought to discuss with the team. Though final decisions were made by the teacher who taught the lesson but the team took the responsibility as whole and not individual. The team makes

decision for the lesson collaboratively and they observed the lesson then gather feedback from other teachers as well as the knowledgeable others with the aim of improving the lesson. This is the power of teamwork! In Malaysia, some teachers rejected lesson study as they have the misconception that they were being watched or judged by others. This was not true and it's time for the teachers to change their perception.

Figure 3. The setting of the post-lesson discussion.

Lesson study: Role of knowledgeable others

From this program, I also learned about the importance of having an experienced final commentator to participate in lesson observation and then comment on it. They could help to pin-point certain aspects which were overlooked by the team of teachers who planned the lesson. The post-lesson discussion concluded by the knowledgeable others did give a lot of input in terms of strength and weaknesses of the lesson. When teachers are gathered together, with the final commentator reflecting on a research lesson, professional growth in teaching and learning took off.

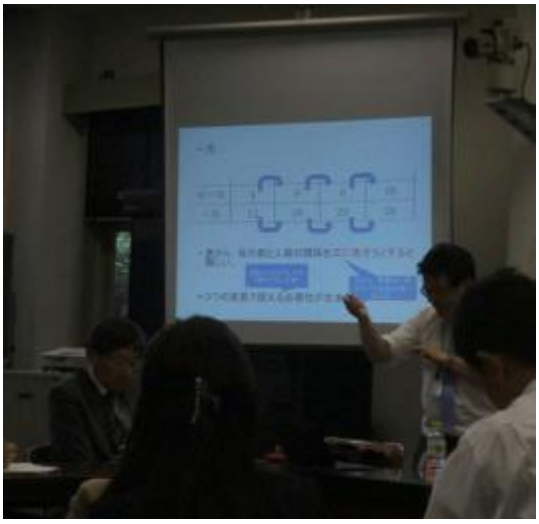

Figure 4. The knowledgeable others was giving comments in a post-lesson discussion.

School as a lovely community

It was a Oshihara Elementary school when I had the opportunity to enter the class and had lunch with the pupils, it struck me that the pupils give me a feeling that the children love their school. I had conversation with them during the lunch and they told me that they like to come to school because they have good friends and they like their teacher very much. Also in Sugekari Elementary school, I could feel the joyous atmosphere of the school. The principal, Mr. Yutaka Hase was very friendly to us and he mixed around with the pupils and teachers very well. He

was very supportive and participated actively in lesson study by forming a group with the teachers in school. Elementary schools in Japan was like a a sweet, lovely and closely knit community. Apart from that, I think that way mainly because teachers anticipated the pupils' response and pupils felt valued by the teachers. In a research lesson that I had visited, when a pupil said that he did not know anything at all, the teacher said "You are our hero today." So it gave a positive feeling for the pupil and he was keen to listen to the teachers. He was active in giving response to the teacher when he did not understand certain steps. From there, the teacher explained more and ensured that all other pupils who faced the same problem could grasp the idea. I was quite sure at the end of the lesson, he gained something. On top of that, he would love to come to school, because I felt that too. The extent that the teacher addressed the pupils learning and anticipated their response motivates pupils to learn and not feel ashamed for admitting that they did not understand. This is how the teachers make the elementary schools in Japan a marvelous place where children loved to go.

Figure 5. Lovely teachers with umbrella, shielding the pupils on rainy day.

Constraint in lesson study

Time has always been a constraint in carrying out lesson study. Teachers often said that they have no time to have lesson study because they were busy marking homework and prepare lesson; they have no time to meet up because all the teachers who taught the same grade has different time table and they could not have a meeting. This has been overcome in Japan by using two ways: (1) the school has early dismissal at 1pm every Wednesday (2) working hour officially ends at 5pm. With that, the teachers could use the free time to participate in school-based lesson study and district-level lesson study. I think this is a brilliant idea in order to make lesson study an essential form of professional development.

Lesson learned

From the lecture given by Akihiko Sensei, I learnt two important statements. The first is Lesson Study is a lifelong process and it is the accumulation of knowledge of teachers. Through lesson study, teachers get to share their thoughts and ideas on how to teach a topic or solve a problem. It is also a platform for novice and experienced teachers to learn from each other. The second statement is that every lesson is a once is a lifetime experience so we must treasure this opportunity to give them the best lesson every time we enter the class. Hence, every time when I enter a class, I must make sure that it is a well-planned lesson. I do agree too that there is no perfect lesson, as a good lesson may not work for different group of people. Hence, it is true that lesson study should be an on-going life learning process and we should be doing it on a regular basis. I would say another part that impressed me and

worth learning is writing the detailed lesson plan. For each of the research lesson, the planning was very detailed, which covers the continuity from previous lesson in the curriculum. The curriculum is also well-structured and it struck me when I get to know that there were six publishers of textbook and the approach used in teaching a topic was adapted from the lessons which has been studied in 'lesson study' by teachers.

Conclusion

Concluding my reflection, I would like to extend my appreciation and gratitude to the IMPULS team for organizing such a meaningful program, gathering educators around the world to share their experience and get to 'immerse' into the lesson study culture of Japan. A heartfelt thank you to the principals and teachers for allowing us to participate in their research lesson and the graduate students who worked hard in ensuring our comfort and making this trip a memorable one. Kanpai!

Reference

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4 External Evaluation of the Program

Evaluation Report, IMPULS Lesson Study Immersion Program

June 22 - July 2, 2015

Prepared by Jennifer Lewis, Wayne State University, USA

December 4, 2015

Overview

> "Even though I have been teaching for 20 years at a high level, I feel I have learnt so much. It has changed what I do in my everyday practice, and has given me a whole new enthusiasm for teaching." – an LSIP participant

25 participants traveled to Japan for the IMPULS Lesson Study Immersion Program (LSIP) held July 22 to July 2, 2015 to learn about the practice of lesson study in Japan. During the trip, participants observed 9 research lessons in Tokyo and Yamanashi prefecture. Simultaneous translation was provided at each school site, and participants often met with school administrators and teachers before and/or after the research lessons. In preparation for each research lesson, fully translated lesson plans were provided to participants a day or two in advance of the research lessons, often with seating charts. Lectures about the theory and practice of lesson study, the Japanese course of study, particular mathematical topics that would be the subject of research lessons, and current thinking about problem-solving in mathematics were held before visits to school sites.

This report is based on data collected from several sources: a pre-trip survey conducted in May, 2015 (raw data is provided in Appendix B to this report); a post-trip survey conducted in July, 2015 (raw data in Appendix C); participants' daily reflections collected during the trip itself; and daily observation notes from the evaluator. A follow-up study is currently underway, tracking on the longer-term impacts of the LSIP experience for this cohort and all previous cohorts as well.

The report is organized in the following way:

Executive summary

One participant's comments perhaps best sum up the LSIP experience for all 25 participants:

> Best learning experience I have had in a very long time, which seemed to come along at just the right time. It gave me the opportunity to consider in depth what I know, what I believe, and what I want as someone who has been involved in mathematics education forever. It also helped me to realize I can do things differently. It gave me new ideas and reminded me of old ones, and gave me confidence in what I value. It has been a very important learning experience for me.

1. Participants learned extraordinary amounts about the theory and practice of lesson study, the problem-solving approach to teaching mathematics, about a coherent system of mathematics education built around a rigorous and slim curriculum, and about mathematics education around the world. It would be hard to quantify the vast amount of learning that participants experienced.

2. In particular, participants' nuanced understanding of how lesson study can be productive expanded greatly through the LSIP. There was special interest and attention around the role of the knowledgeable other's post-lesson commentary, and that seemed to be the least familiar practice for participants prior to their participation in this program. All aspects, though—the lesson planning, the observation habits, the teachers' post-lesson discussions--- were considered in great detail by participants and their post-LSIP surveys revealed much greater understanding in every area of lesson study practice and theory.

3. Participants were constantly engaged in applying their learning about lesson study to their own contexts. Almost every reflection from every participant reveals consideration of applications to their own settings.

4. Participants found the research lessons to be the most vivid experience of the LSIP trip. But the lectures and presentations outside of school-site visits enabled participants to make sense of the research lessons at a higher level and better understand the research lesson plans themselves, the mathematics in those lessons, the theory of lesson study and the Japanese mathematics curriculum.

5. Participants sometimes took a critical stance of research lessons when they did not conform to their expectations about Japanese lesson study or their own prior conceptions of "good math teaching." They had fewer analytical tools for seeing the strengths of teaching in many cases.

6. In addition to the formal program of LSIP, the colleagueship with partners in a stimulating, unusual environment had its own positive effects.

7. Perfectly orchestrated logistics and a warm welcome made this experience a pleasurable one for participants. In addition to all the logistics, participants appreciated the Lesson Note app, as well as readings, and notes on the website.

Participants

The LSIP participants included 25 educators from 5 countries. This group included two participants, Professor Alan Schoenfeld and Professor Brian Doig, who had a different status. Dr. Doig had been on previous study trips to Japan; Dr. Schoenfeld contributed in a faculty-like role, providing analyses and insights in lectures and email postings. Of the 25 participants, 11 were from England, 4 from the United States, 3 from Ireland, 3 from Australia, 2 from Malaysia, and 1 from Qatar.

Prior experience with lesson study. Participants had varying degrees of experience with lesson study: 14% had never participated in lesson study at all; 29% had participated in 1-2 cycles. 57% of the participants had participated in 3 or more cycles of lesson study. Thus, about two-thirds of participants

had little to no first-hand knowledge of lesson study. Of the 18 participants who had participated in lesson study, 16 had taken part in mathematics-focused lesson study. 94% of these participants had experienced lesson study in their home country settings.

Roles in lesson study. There was great variation in the role and occupational identities of the participants in lesson study, ranging from teachers who were members of a lesson study team, to evaluator of lesson study projects, to national curriculum coordinator of mathematics wishing to introduce lesson study at the national level for professional development. The group also included a number of university faculty who conduct research on lesson study and/or use forms of lesson study for preservice and inservice teacher learning; school principals, some currently using lesson study in their schools and others considering it at this point.

Occupational identities. The participants' primary occupational identities alone varied quite a bit: 7 are classroom teachers (4 elementary school teachers and 3 high school teachers); 8 are university faculty members (2 are mathematics faculty; 6 are teacher educators at the university level); 6 are professional developers in mathematics programs for teachers; 3 work at national or regional Ministries of Education or foundations and are responsible for policy decisions for teachers' professional development; 1 is an assistant principal at a high school. Some of these occupational roles overlap; some of the teachers are teacher leaders, coaches, and facilitators of professional development; some of the professional developers are affiliated with a university; some of the policymakers are part of a regional teacher development effort. The range and depth of these different roles is significant for the LSIP curricular design; this is a theme to which we will return subsequently.

Prior understanding of lesson study's potential contribution. Participants' knowledge of the potential contributions of lesson study varied. When asked about the strengths and benefits of lesson study before the study trip, many participants mentioned the focus on student learning, the opportunities for teachers to collaborate, and the development of pedagogical content knowledge.

More details about participants and their prior knowledge and expectations can be found in Appendix B, the raw data from a pre-LSIP survey for all participants.

Participant responses to day-by-day activities

The substance of each day's activities can be found on the LSIP Basecamp site, where full lesson plans and powerpoint presentations are provided. Here we provide a very brief summary of each day's activities, with expansive excerpts from participants' reflective journals written each night of the LSIP trip. The participant excerpts are shown in smaller, indented blocks of text, so that readers can focus the participant comments or the brief summaries of activities if desired.

Day 1: Monday, June 22:
Mathematics teaching and learning in Japan,
Lesson Study in Japan,
Teaching through problem solving and *kyouzai-kenkyu*
Workshop: Japanese mathematics lessons and lesson study
Welcome Reception

The presentations from IMPULS faculty today included one on the essentials of lesson study (Lesson study: Nice-to-have or Must-have?); one on the mathematics content and curriculum strand for multiplication, division, and number line diagrams in the Japanese system; and one on "Level 3 Teaching, or Teaching through Problem-Solving." The ideas in these three sessions reverberated across the entire length of the program and followed up nicely on readings that participants had done in advance of their arrival. Participants made frequent references to ideas in these presentations and used terms from them as shorthand for large, complex ideas in mathematics education. For example, participants over the course of the 12 days, would make reference to "level 3 teaching."

For some, the overview of lesson study provided basics that they otherwise did not have:

> "[Dr. Takahashi] described the lesson study process and some mistakes that some people did it so I think I have a clear image for lesson study. "

Many of the participants were busy thinking about how they would translate what they were learning about Japanese lesson study and the approach to teaching mathematics through problem-solving into their own contexts. The following excerpt from one participant's reflective journal on Day 1 captures the line of thinking that many participants had:

> My overall focus is to consider how we can incorporate into a professional development program of sessions of the model of lesson study such that the outcome is that teachers will have an understanding and experience of the elements of lesson study. To know the principles of lesson study and explore the ethos behind its success in Japan will/may lead to an informed decision about how this can be done and if possible, in what order the separate elements can be introduced to staff and with what level of staff support and explanation.

This line of thinking was present almost every day for nearly every participant. There was a constant mental exercise for participants to apply what they were seeing in Japanese classrooms to their own contexts.

Several participants reacted to the faculty presentations by writing about how important it is for upper grade teachers to understand elementary mathematics:

> As I am involved in secondary maths continuing professional development my thoughts turned to primary education maths and how important a student's experience is at that level. In addition to teach as Dr Takahashi espoused today requires that teachers at primary level need a profound understanding of basic mathematical concepts.
>
> While I am fully convinced of using problems as an approach to teaching, the presentations today re-affirmed the importance of moving away from traditional approaches and I feel invigorated in returning to teach my undergraduate and postgraduate preservice teachers in the next academic year.

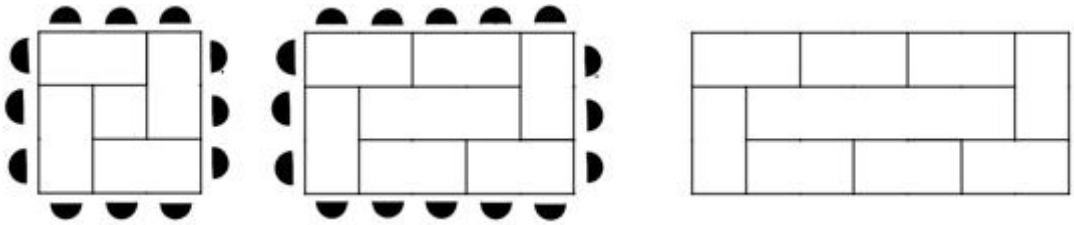
As we will see in a subsequent section of this report (Participant Learning), these presentations from IMPULS faculty on Day 1 were extremely formative, in setting frames for understanding and viewing research lessons in the field, and for thinking about the application of lesson study in their own settings moving forward. In fact, almost half the participants mentioned this day of presentations as one of the most significant for them during the entire trip, despite suffering from jet lag on the same day!

Day 2: Tuesday, June 23

Preparation for the research lesson #1 observation

Observation of Research Lesson 1, TGU attached school, Koganei Lower Secondary High School (Specially Appointed LS for Fuzoku teachers, Grade 8, Sho Shibata);

Today participants viewed a lesson where 8th grade students worked on utilizing algebraic expressions in problem-solving and mathematical exploration. The task in this lesson asks students to determine the number of tables needed for a given number of people given the following arrangement:



Some participants learned about how to observe a lesson productively:

> Today is quite a fruitful day as I learnt that there were a few things to take note of during lesson observation such as, we should not talk to the students or give them any hint during any point of time in the lesson. This is because there will be only one teacher in the class. When the teacher decided that he/she wants the students to struggle in individual work, there must be a reason behind. Hence, it's important to understand the lesson plan thoroughly and to respect any changes made by the teacher during the lesson. The helpful questions were useful in guiding the lesson observation. We need to look for concrete evidences to support our discussion during the reflection. I learnt that the time was an important element during observation. During observation, teacher should take note of the time to know how long has been spend for an activity as time is limited for a lesson. The sequential order of the event happened during a lesson must also be noted

Others noted the need for careful preparation and the importance of delving deeply into the mathematics content.

> I am glad I took a lot of time reading the plans and reflecting on it last night because today I felt well prepared.

> Before the lesson I struggled to understand why the teacher had decided to present a different arrangement of tables. I asked the question in university and again I looked out for an answer in school but I feel I have not fully resolved this, I must keep thinking about it. Many observers have criticized the teacher about it but I think the teacher was trying to keep the task as open as possible.

Often participants made comparisons to what they expected lesson study to look like, or what mathematics lessons in general should look like:

> Today I feel like actually we have made a good start on using lesson study in my school and I feel energized. It has been mentioned a few times how lesson study can take many forms, I now see my role as trying to work out which features of the Japanese model would work best in my school and what form lesson study should take - a challenge that already has me thinking! Every research lesson we have conducted has been slightly different and we have tried many different approaches, I really do think that it is important that every research lesson and lesson study shares the same core features - especially when attempting it for the first time.

> The lesson we saw today was like no lesson I have ever seen before - pupils working alone, and then the teacher scribing 6 different solutions. I found it almost mesmerizing. I did leave a little disappointed that the *neriage* did not continue - I do question if today we saw 'show and tell' due to time restrictions. I really do want to see what happens next for that class. And in the future lessons I hope to see much deeper discussions in the *neriage*.

These different participant comments reflections also point to the diversity within the group in terms of prior experience with lesson study. The first comments above shows the response of a newcomer to lesson study, the subsequent comments show increasing prior familiarity with lesson study. Comments varied greatly, in part of function of this diversity.

On this day, as well as other days, many participants commented on aspects of the post-lesson discussion. As we will see in the Participant Learning section of this report, many participants felt they especially needed to learn more about the post-lesson discussion and the role of the knowledgeable other.

> The post lesson discussion was intense and at times difficult to follow. It seems many of the questions revolved around the variables and how aware the students were aware of them and how they affected each other. I am still unsure what the students were meant to take from the lesson. It is clear the teacher would now question and probe the student responses in a different way and in this respect we learnt something new - a key feature of lesson study. This is what I currently see as essential to lesson study in my school, one of the core features and something I really need to emphasize when I start my lesson study group next year.

Day 3: Wednesday, June 24
Preparation for the research lesson observation
Research lesson 2, Sugekari Elementary School (Grade 5, Kudo)These are the aims of the research lesson plan in the words of the teacher: “In this lesson, we aim to deepen students' understanding of congruence by focusing on the constituent parts of geometric figures as we extend our study of
Congruent figures from triangles to quadrilaterals. In addition, we want to develop the disposition to both broaden and deepen their own mathematical reasoning by generalizing and extending what they have learned. For example, we want students to pose the question, ‘Can we say the same thing for quadrilaterals as we did with triangles?” on their own and investigate.’”

In the post-lesson discussion, participants were taken with the manner of the teacher, the structure of the kind of research lesson that was more in keeping with what they expected, and the discovery of a missing geometric model that they teacher would have liked to supply during the lesson. Something about today’s lesson put participants at ease. In many ways, what they saw in the research lesson more closely resembled their own country’s lessons and what they expected lesson study would look like in Japan:

> I am struck that the main focus of the goals for both of the research lessons thus far have been process goals. Even the four strands set by the Ministry of Education (Interest, Eagerness, and Attitude; Mathematical Way of Thinking, Mathematical Skills, and Knowledge and Understanding) are at least half process focused. My first response is to think that is because the Japanese have been doing Lesson Study for so long that they have moved beyond content to process. Then I catch myself and realize that is dead wrong. Process doesn't follow content! I ought to have that tattooed on my knuckles until it settles into my unconscious.
>
> I was thoroughly captured by the school, staff, and children today. Yesterday's lesson at the attached school seemed a bit sterile. It seemed more academic for academic's sake (despite me being so impressed by how much more authentic it is than our academic-school interactions). Today was real kids, with real teachers, with a real principal, all engaged in the fun, difficult work of getting better at teaching and learning math. It was a vision of what

I would love to be able to create: from the meticulous note-taking, to the raucous discussions of whether a diagonal helps define a quadrilateral, to the reflective focus on *neriage*.

The conversation about team-developed lessons v. teacher-developed lessons, and
Today, we observed a grade 5 mathematics lesson study. The teacher is a
young lady, who has a very good relationship with her students. She worked in three primary schools in the past ten years - all teachers are required to move between schools in Japan (interesting!) She shared with us her secrets of being a friend to her students: play with them, listen to them, talk with them, give individual support during the class and praise them. Compared to the first lesson we observed, today's learning environment is open and happy. The teacher is always smiling. She allowed her students talk without raising their hands first. The students could also discuss with others if they want. It would be wonderful if she has used the plastic model at the beginning of the class to orient the aim of the learning and applied the finding to solve an application problem (repair a chair).

Professor Schoenfeld shared his TRU observation framework, and also circulated on the shared website his analysis of lessons using the TRU framework. This got little visible uptake, although it would be interesting to inquire in future studies about whether participants used the TRU framework later, or what it contributed to their thinking at the time.

Day 4: Thursday, June 25

Preparation for the research lesson observation

Research Lesson 3, TGU International Secondary School (Specially Appointed LS for Fuzoku teachers)
Grade 7, Mr. Ren Kobayashi

Today the group observed a research lesson that included "problems that involve recursive relationships, as part of a unit on "observing phenomena." The specific task in the lesson had to do with Yuu taking 40g of a certain medicine every 8 hours to treat his illness, and the decreasing amount of medicine that would remain in his body as time passes.

In the post-lesson discussion, there was much discussion about the problem context, its appropriateness for mathematical modeling of the target content, and the students' ability to follow the lesson.

Participants commented on the following in their reflective journals:

Note the impact of IMPULS faculty narration of the lesson:

This morning Akihiko went through yesterday's lesson using Lesson Note. It was really useful to see his techniques especially as I am one of the observers today. It was also interesting to hear his comments on the lesson in terms of raising the level of teaching and how it may have been a different feedback if he had been the knowledgeable other. The key being there were lots of hows in the lesson rather than whys. Akihiko had noticed some students had measured 3 or 4 angles. They could see from the demonstration how to do it without, but the manipulatives would have helped them understand why.

Participants also noted features of the Japanese curriculum, and drilled down int o the content of a particular problem:

We went briefly through the lessons for Saturday and it was interesting to see how the topics progressed through the textbooks as this would be the teachers starting points. It was interesting to see the use of diagrams in the fractions/decimal progression and considering a given amount as 1 so deriving 1.5. We will also be seeing a lesson where students in grade 4 are investigating change. We tried out the start of the investigation involving the positions of the hands on a two-sided clock which is rotated. I was surprised to see this clock

investigation as part of the textbook.

> I felt quite sad about the direction that England is moving in in terms of the curriculum when looking at the Japanese textbooks. The structure and the thought behind them is remarkable.
>
> It is remarkable to me how much the Japanese trust in their textbooks and their expertise.

A continuing concern voiced by LSIP participants in the extent to which children are engaged. This was noted here, but is present in many day's journal entries by many participants:

- In all the lessons we've seen, but especially today's, I was conscious that some children were probably being left behind. Around ¾ of the room were very quiet and this was not really addressed. I'm not sure how much they learnt.

We will see again and again participants' strong focus on the final commentators for each research lesson:

- The role of the final commentator intrigues me. Do all schools have a relationship with an HEI? For every subject? This is not feasible in England, so how could this be replicated? Even a consultant or expert would be expensive. Perhaps one of the group could go back to the research (that's undertaken in the groundwork) to ensure that they are reflecting the evidence base?

Day 5: Friday, June 26

Visit to Oshihara Elementary School (observe ordinal classroom), Yamanashi Prefecture, including school lunch with pupils

Research Lesson 4, Oshihara Elementary School (School-based LS)(Grade 3, Ishikawa)

The research lesson today focused on continuously dividing remainders in division problems. The lesson plan gave extensive context for where this lesson is located in the class' study and why this particular idea is so challenging for children: "There are 4 ways to deal with the remainders: 1. **u**se the quotient and remainder as they are; 2. round up the remainder and add 1 to the quotient (quotient +1); 3. discard the remainder and use only the quotient;.4. continue to divide the reminder and find a quotient. The meaning of number 1., **"u**se the quotient and the remainder as they are" is when you solve a division problem you are answering to something like **"**so many bags can be made and so many of them are left" and "quantity of 1 person becomes so many and so many of them are left."

Again, many participants reacted to the post-lesson discussion. Some found the teachers' comments to be "tame;" others "brutal." Participants also noted some of the features of the actual lesson: boardwork (*bansho),* teacher's note-taking during the lesson, the inclusion of student ideas during the lesson. As before, participants paid a lot of attention to student engagement. The comments below are representative:

> The boardwork is really interesting – this is something we could consider a lot more in the UK. By displaying the lesson across the board, there is a lot there. The displays are also really reflective of students' work, rather than just attractive.
>
> I like the observing done by the *teacher*, noting down on a seating plan where students are at. That seems a powerful way to capture a lot.

This was a MUCH more pupil focussed lesson though, I really liked that teachers stood near a group of teachers and commented on 'this student did this' etc. brutal to show photos of students, but effective.

First lesson where they really noticeably cared about the students left behind!

Day 6: Saturday, June 27

Research Lesson 5 University of Yamanashi Attached Elementary School, Cross-district LS (Grade 5, Ms.Kasai)

In this lesson, students were working on "times as much" on a double number line. The lesson began with 4 distances displayed on the board: 4 km, 2 km, 3 km, and 1.5 km. Students were asked to see "2 times as much" between 4 km and 2 km, but were then asked to distinguish between the difference and "times as much." This was exceedingly careful work on foundational ideas about fractions, something that many participants find needed in their own contexts.

Research Lesson 6

Cross-district LS (Grade 4, Mr. Yamaguchi)

This research lesson used the "mysterious clocks" below to help students see the relationship of two quantities that change together by representing data in a table and expressing the relationship in a math sentence using symbols.

The mysterious clocks have a rule: $x + y = 15$, when the numbers on the front side of the clock (blue dots) represent x and the numbers on the back side of the clock (red dots) represent y. Students turn the page so that the clocks show different "times" and therefore different numbers for the x and y variables.

The "mysterious clock" was a mathematical tool that fascinated the group.

> Students were interested in finding out more about the "mystery clock" and I loved the collective "ooohh!" when one of the girls pointed out the result of 15 on the board. I would, however, have given students their own clocks to play with earlier in the lesson since many students seemed confused and despondent in not being able to recognize the relationship sooner. I would also have given more time to students to explore the 'square + circle = 15' relationship by themselves and
> then encouraged them to speak about these with their partners since it was an objective of the lesson to verbalize mathematics equations.

The mathematical content of these lessons and the way that students seem to accrue this knowledge was another important issue that participants commented on:

> Developing fractions as a quotient relationship is something we don't speed time on at home and I think utilizing shapes as representative fractions is a great idea to consolidate this

> idea. I'm not sure the context of this lesson was the best since distance is generally not exact (as pointed out by one of the students) so it may not have encouraged them in exploring the idea of it being exactly one and one third times as much. I did, however, think the third board explored the various multiplication/division relationships well where the same numbers were used in three different strategies on the board. This explicit linking is likely very useful for students in understanding the direct relationship between different ways of noting the same problem. I was again astounded by how students could remember what they had and hadn't learned and when they had learned it. The fact that the teacher was also able to confirm when in their learning they would have met specific topics was very surprising.

Participants were amazed at teachers' willingness and dedication to attend professional development on a Saturday:

> It's amazing how many teachers and students attended the research lesson today on a Saturday. The car park at the school is full. Again - a demonstration of how valued education is in Japan. This same value was evident in the post lesson discussion since there were so many teachers there from other schools asking in depth questions of the content taught within the lessons.

Participants continue to have strong opinions about student engagement. Many look for particular forms of student participation ("think-pair-share") or frequent turns in whole-class discussions, as reliable indicators of student engagement:

> Similar to all of the other lessons, students were never asked to or encouraged to speak to their partner and I really feel this would have benefited the majority of students in making sense of interpreting what was happening in the clock. Saying that, however, this lesson really incorporated whole class discussion where students bounced ideas back and forth over the class, with and without referencing the teacher, and this was a joy to watch. I would be concerned though about some of the students who did not verbally engage with the lesson at all.

If future groups of participants are similar, it may be useful for participants to be questioned on these assumptions about what constitutes student engagement.

Several participants noted that it was difficult to follow the lessons if they were watching remotely by video in the next room, rather than in the classroom itself.

Day 7: Sunday, June 28
Sightseeing

Day 8: Monday, June 29
Free day

Day 9: Tuesday, June 30
Preparation for the research lesson observation
Research Lesson 7, Konagei Elementary School,(Grade 4, Mr. Takeo Takahashi)
Research Lesson 8, Konagei Elementary School, Grade 6, Mr. Kishio Kako)

The Grade 4 lesson used a familiar problem to many participants: a progression of matchstick squares that grows in a linear sequence. Students were to describe the number of total matchsticks using different representations, including different ways of counting, or showing the progression in a table. Students were to find the pattern and be able to generalize.

Post Lesson Discussion

Many participants were critical of the lessons they observed, sometimes failing to notice the strengths of a lesson or the elegance of design. Participants often used their own frames of reference rather than interpret the lessons observed on using the criteria set forth by the planning team. The following comments from one participant are representative of this stance, which came up not just on this day but on other days as well:

> Cognitive Conflict
> The lesson could have supported a range of ZPDs within the classroom but the manner in which it was delivered meant that it was either too complex or too simple for many students. Missed opportunities included:
> - the failure to tackle misconceptions, by not asking those students with incorrect answers to explain their thinking and by not asking pupils with incorrect or incomplete solutions to say how they had changed their minds once they saw a correct solution
> - the failure to draw out the relative merits of the different approaches in terms of efficiency or ease of visuals eg counting one by one, using tables, different ways to group the sticks
> - the failure to explore how the different mathematical calculations ultimately represent the same numbers in different arrangements
> - the rushed 'what if I had 100?' conversation, which could have asked students to explain how they got their answer and checked who did/didn't understand
>
> c) Social Construction
> Although there was calling across the classroom by some students and several students either asked questions or came to the board, there was no social construction in the sense I understand it, which is students building on each other's ideas to develop a shared understanding across the class. This would engage as many students as possible, if not all.
> There was minimal participation across the class. Many students did not speak during the lesson. There was a gender bias, with boys much more likely to ask questions or be asked to come to the board or answer a question. There was no paired or group work.

As mentioned above, it may be useful for participants to be challenged to reconsider their assumptions about student engagement, student understanding, and expectations of coverage in a single lesson.

On this day, Professor Schoenfeld also presented his reactions to a lesson we had observed. In many ways, his observations echo those of other participants who seem to have rich analytic tools for critiquing the lesson but few analytic tools for appreciating the depth of knowledge construction, arithmetic understanding, and skill in expression and representation that were obvious in the research lessons we observed.

Participants often gained much from faculty narration of lessons. Here is an example where the post-lesson discussion prompted much thought:

> Today's session was very helpful to me. Having our own post-lesson discussion made me see clearly a fundamental difference between the American and Japanese approach. Professor Schoenfeld's comments were what helped me come to the realization that

> American educators seem so concerned with reaching every single kid in every lesson, possibly at the expense of the group, while the Japanese seem to go the other direction: focusing on the group, but missing individual kids. I'm still working on this, and it is obviously a huge generalization, but there is something going on there. Dr. Schoenfeld's notion of "affordances and constraints" seems to be at play in these choices too. I'm not saying one way is better than the other (although Dr. Schoenfeld is), just that I am noticing a difference… I did not entirely agree with Dr. Schoenfeld's critique of the lesson. I could not see how, without the algebraic skills at this age/grade, they would be able to see the connections between the different word expressions. Maybe this is unfair to Dr. Schoenfeld, and he was not thinking about the algebraic connections, but I felt that he was imposing his own values on the lesson. This goes back to Dr. Fuji's paper that spoke of the values of a teacher/system always surrounding and shaping lesson study.

Day 10: Wednesday, July 1

Preparation for the research lesson observation

Research Lesson 9, Sasahara Elementary School, District-wide Lesson Study (Grade 5)

This lesson held the participants in great sway. Participants commented on the lesson plan with its fascinating detail of past work and unit context, with a razor focus on a single math problem: What calculation do we do to find the price of 1L of juice if 1.6L is sold for 320 yen?

These comments represent the reactions of many participants:

> Wow! A whole lesson on one problem - what does it mean to divide 320 by 1.6. And it wasn't about finding the answer.

> The teacher encouraged the children to say when they were not sure or just didn't know and praised them for this honesty. This is the first time I have seen this so explicitly during the last two weeks and to be honest, when have I seen this at home? When have I actually seen a teacher encourage children to say 'I don't get it' ?

> Today's lesson was the first that really exemplified the principles of good learning, as I would understand them through a Let's Think lens. There was a good amount of pupils talk and pupils were able to write their own thoughts onto the board, so there was no 'interpretation' of children's thinking. A good balance of students were chosen to contribute, including a good balance of boys and girls. Social construction was extensive and visible eg students being asked to convince each other, students asked to say what they thought about other's explanations, voting followed by questions to elicit reasons, paired talk to clarify thinking. This meant that the lesson evolved in response to the teacher's constant assessment of student thinking. A lot of time was built into the lesson for metacognition, which also enabled the teacher to take account of student thinking. There was more focus on students who don't understand rather than on students who do understand (except for one missed opportunity at the start of the lesson where those who chose bottle A weren't asked to explain why) and an interest in multiple approaches, rather than one polished solution, e.g. the four different ways of expressing divide by 2.

This also aroused consideration of deeper questions in mathematics education, some of which are specific to this lesson and others which raise more general questions:

> There was some learning about the way in which we approach maths learning that I drew from my observation of today's lesson:
> - that we spend very little time exploring concepts and too much time finding solutions, whereas the underlying concept is often very complex and requires more time to internalize and accommodate: finding the answer is not always the most important thing
> - the use of the double numbers line to express the idea of the unit can be very beneficial to the teaching of certain concepts, but that its blanket use for all multiplication and division concepts is not in my opinion the best way
> - that teaching decimals as a linear concept (eg through number lines) is much easier to access for students, especially as they have an embedded understanding of the decimal system: fractions are much more complex (eg simple fractions, multiples of fractions, top heavy fractions, mixed fractions etc)

Day 11: Thursday, July 2
Summative Discussion of the Lesson Study Immersion Program

Dr. Fujii gave a presentation on lesson planning, which participants found extremely useful. The timing of this presentation, after participants had seen nine carefully planned lesson plans in great detail and explored them in depth, was especially helpful. Professor Takahashi also gave a presentation on lesson planning for lesson study and these two presentations together seemed to be the ideal send-off for participants about to implement new ideas in their workplaces at home.

Participants generally found the summative discussion extremely useful. Professor Schoenfeld also provided a presentation that connected the Japanese experience to classrooms in other countries. This participant's reflection represents the consensus of the group:

> Really think Alan summed up neatly what needs to be thought about after this trip. The challenge is to see can we match some of our pedagogy with the Japanese curriculum and lesson study model.

Findings: Participant learning.
Note: These findings are summarized above, in the Executive Summary section of this evaluation report.

Participants learned a huge amount about the practice and theory of lesson study. One form of documentation that attests to the vast content that participants learned is contained in their comments on the last day of the LSIP, found in Appendix A to this report. This document shows the range, depth, and sheer quantity of new knowledge and dispositions acquired by participants in ten short days, which is staggering. In addition, in a post-LSIP survey conducted in July, 2015, found in the Appendix C to this Evaluation report, provides more evidence of participants' fluency regarding the benefits of lesson study, its main components, how teachers learn in lesson study, are much more detailed, nuanced, referenced to particulars, and informed by experience and research, especially when compared with their responses on the pre-LSIP survey conducted in May, 2015, found in Appendix B to this report.

Participants were almost always engaged with thinking about how they could bring their learning about lesson study into their own contexts. Every reflective journal entry almost every day by every person contained references to applications that participants were thinking about for their own work sites.

The lectures and workshops with IMPULS faculty had great impact. In their daily reflections, participants wrote almost entirely about the research lessons they observed and very little about the lectures and presentations outside of the research lessons. Yet their understanding of the research lesson plans themselves, the mathematics in those lessons, and the theory of lesson study and the Japanese mathematics curriculum, were likely greatly enabled and enriched by those sessions. We have little concrete evidence of this since little was written about those sessions, but participant discussion of the lessons showed evidence of deeper understanding than might have been expected otherwise.

> For future years the only comment I would make is to reflect on each lesson more as a group and it would be really interesting to hear from the professors more. We had some great lectures but at the end of some lessons we were all itching to hear the professor's views and opinions.

Lectures and presentations that stood out to participants:
Almost to a person, all participants found Dr. Takahashi's presentations on the Day 1 and Day 11 (the first and last days of the program). Participants said they found themselves referring back to these lectures during the program and would use them in their work afterwards as well.

Participants often took an unusually critical stance of research lessons when they did not conform to their expectations about Japanese lesson study or their own prior conceptions of "good math teaching."
Some participants were quite consistent in this habit. Others took to heart something Professor Takahashi said on Day 9, that "different people will see the same lesson differently," and worked hard to suspend judgment.
Participants often overlooked or took for granted some of the elegance and strengths of the Japanese lessons they observed. In their reflective journals and in discussions, participants recognized the skill of Japanese students in mathematics and the way children were constructing new ideas from those collectively established earlier, but there was almost no discussion of what teachers were doing to make this happen.

Just being together in a stimulating, unusual environment has its own positive effects.

> There were countless conversations and interactions that were meaningful among this incredible group of professionals. It is difficult to pinpoint a particular moment, but most of these conversations happened over breakfast, walking to and from the university, or over a beer in the evenings. The diversity of backgrounds, experience, and professional lenses is what made so many numerous conversations possible.

> I had lots of discussions with colleagues from Nottingham. These were the most interesting because these are colleagues that are local and I will be able to work closely with them. I have made some really useful contacts and have started to work with some of these people already. Discussing what I had already put in place in terms of lesson study was a really useful reflective process for me, people on the program were really interested in what I have already done. But also listening to others opinions, about what they were planning to do, allowed me to evaluate our processes and think of ways to improve.

It was also especially useful that teams of participants formed from shared national workplaces:

> I think it's also hugely helpful that there are two people from Ireland here who are passionate about lesson study. While we work in different aspects of education in Ireland, I feel that if both of us can speak to policy makers about the strength of this approach to teacher education it will lend far more weight to try and incorporate professional

development based in teacher community as part of the Irish secondary education system. We don't see each other very often in a work sense and
even in our conversations today I feel there is huge potential for more collaboration for us in introducing lesson study in Ireland."

Participants' self-reported changes:
There were several categories of ways participants answered this:

1) LSIP corroborated and strengthened what I already know.
2) LSIP demonstrated how inadequate/superficial lesson study is in my context.
3) LSIP helped me better understand the idea of problem-solving as an approach to learning mathematical processes and content.

My students were too much dependent on teachers as source of knowledge and they were very used to be spoon-fed with knowledge without doing much thinking. They tend to accept what was told to them. Hence, after this trip, I would say it was possible to inculcate the mathematical thinking in a lesson by focusing on one question and I would like to try.

4) LSIP allowed me to see a system-wide approach to teaching mathematics.

Participants ranked what they learned from the LSIP experience.
From among 29 choices, these were the 6 top-ranked areas they selected:

1) Supporting participants to have powerful and effective lesson study experiences
2) Organizing a successful post-lesson debriefing session
3) Strategies for making students' thinking visible
4) How to support students' problem-solving ability
5) Anticipating student responses
6) Writing a useful lesson plan

For more details on this aspect, see the full data output from the post-LSIP survey, found in Appendix C to this evaluation report.

Recommendations

1. *Preserve the current LSIP offering as is, and offer it to as many participants worldwide as possible*. Few educational programs have this kind of impact. On the one hand, it seems especially fruitful for uptake of the LSIP ideas to include several educators from each country so that teams can continue to work together. On the other hand, participants greatly valued the presence of colleagues from diverse nations.

2. *Provide more time and space for more "processing" of research lessons by participants*, with additional narration from faculty. Although there is little time for this, some participants found they needed time to hear others talk about what they were seeing and how they would apply it in their own settings.

Additional, formally-planned time for sharing and reflection among the participants would also have been helpful as I processed all I was learning.

…it would be a good opportunity for the group to debrief on the lesson.

It may also be helpful to provide some kind of structure that allows participants to articulate some of the wisdom and elegance in the teaching of the research lessons, rather than discuss either where there was "room for improvement" or extolling the virtues of the lesson overall. Participants seem to lack analytic tools for describing strengths and resources of the teaching that they observed.

3. *Notify participants of opportunities to follow up on this extremely powerful experience*, through

meetings and communications following LSIP. Some of this began on the final day of LSIP. It would be useful to track on participants' follow-up activities and the longer-term impact of the program.

Please note: These recommendations would all require more funding and faculty time, so they are offered in recognition of the fact that the LSIP program is outstanding as is. These suggestions are offered in hopes that IMPULS will receive expanded funding.

Appendix A: LSIP 2015 Final Reflections, Collected July 2, 2015

LSIP 2015 Final Reflections, July 2, 2015

What opportunities for teacher learning does lesson study afford?

Jacqui: Throughout the whole process, depth, student understanding, how students understand materials, reflections on lesson decisions

Mariel: Teachers and administrators become better kid-watchers, in turn develops how we analyze student work

Tan: Involves teachers in decision-making process collaboratively when they share the responsibility and they learn through the decisions made during the lesson, which might have a huge impact on the students.

Sarah S: Difficult to separate out subject-matter knowledge from pedagogy. Real deepening of subject-matter knowledge. Supports learning in different contexts. Balances depth with breadth.

Mary: Through collaborative process of planning lessons, teachers are continually learning throughout their careers, including math research and how that impacts their classroom experience

Kalai: 3 things I noticed: in-depth collaborative experiences, understanding mathematical [something], and math processes are inculcated in order to facilitate student learning process

Kelly: Lesson study offers opportunities to change the culture of a school. In the US teachers are isolated, and have little common planning time. Lesson study forces teachers to face their understanding of the material, provides opportunities to question together, learn which colleagues can help you next time, and builds community. It also gives teachers an opportunity to learn to take feedback; critique is about improvement, it's not personal.

Sarah M: Lesson study allows teachers to look at math problems from students' point of view, and to think about what their misconceptions will be, their intuitions, etc.

Chris: Lesson study can also function as a transmitter of a school's culture, which would be especially useful in the induction phase in articulating a school's aims and values.

Pete: In UK people regard themselves "only" as teachers, but lesson study positions them more as researchers.

Aoibhinn: Teachers learn from lesson study that their own research is important, their own questions matter, and they can bring what they are learning through research and lesson study to infuse their own teaching practice.

Sandie: I'm taking back with me the idea that lesson observation can be a learning tool rather than a stick to beat people with.

Melissa: Lesson study takes the personal aspect out of feedback, drills down to the business of learning, and we stay focused about on. It's such a learning tool if you understand what it

is about.

How did your view of lesson study change from your participation in IMPULS?

Sarah S: I see that lesson study is much more connected to research than what I thought when I arrived.

Kelly: Teaching and learning can't be separated. It's an integrated process that I see in a new way. In Japanese there is a single word for teaching and learning-- *gokshu shido*, and that comes alive in lesson study.

Pete: The thing that impressed me most was that this is a long-term prospect. Just because perfection can't be achieved doesn't mean we shouldn't strive for it.

Akihiko: If you don't have a good question to start with, you won't be able to do good work.
This is the only way to become a life-long learner.

Melissa: I learned about the importance of the knowledgeable other for the post-lesson commentary, seeing how long they are, how teachers react, more than going through the motions.

Pam: Some post-lesson sessions were more intense than others, seeing the grace with which teachers could hear this criticism and hear it as the lesson and not about them personally.....would love to be able to have teachers do that.

Aoibhinn: I didn't know what the knowledgeable other was, to see that role, that they are experienced teachers and professors.

Matilde: The level of detail in lesson plans, the numerical choices, etc. Also seeing the textbooks and use of prior knowledge in a carefully sequenced way. It would be hard to build on prior knowledge that may vary as it would in the UK.

Jacqui: The principal's role in the planning, the research lesson, the post-lesson discussion. The principal's involvement gives the work value and status, elevates the importance of the work.

Akihiko: Even when you see a problematic lesson, a good final post-lesson discussion and good commentary afford serious learning opportunity. It's a whole package.

Alan: At bird's-eye level, comparing lesson study in Japan to professional development in the US: most pd in the US is focused on random topics, and it's top-down. Here, pd provides community in support of similar goals, goals are derived organically, teacher learning is taken very seriously. These features are lacking in the US context.

Matt: I've enjoyed the focus on mathematical thinking. That surprised me, and the rigor around this.

Rosa: I was struck by the work on productive struggle, and also that children's enjoyment is always so important.

Kelly: Improvement is viewed collectively, building a sense of professionalism among teachers, seeing themselves as producing a form of research instead of being fed the next idea.

Rosa: Lesson study is about developing the profession, while we look more at developing individuals.

Bridget: Planning and preparation was longer than I expected, and I fear that this would put off the teachers I work with.

How you view teaching and learning now?

Mariel: I'm very excited to take ideas back, but also frustrated that the process here is so organic, and I'm going back to a system that is compliance-based and that focuses on a million things instead of one.

Pete: In the UK we've tried to develop mathematical thinking and reasoning, but it's often an add-on. Rather than tinkering around the edges we need a whole cultural shift in the way we do things. I saw this here.

Sarah M: We got to see how students can learn more from one another, not just knowledge coming from the teacher.

Tan: In Malaysia we do a lot more show & tell, but here I see in *neriage* children start to view the concepts from what they have constructed.

Pam: To take this home, it will need a culture shift. It can't be the same, it has to fit into our culture, it can't be the same. [Jenny's thought bubble: What can you vary, what has to stay the same?]

Aoibhinn: To read so much about problem-solving and to see it in classrooms throughout a whole system, renews my faith in this prospect.

Rosa: The trust that is given to teachers here transfers to the learners as well.

Phil: I want to teach and I want my students to learn not just from rules. I've taught many students who don't understand mathematics and we need to reimagine what we do.

Aoibhinn: At home, it's thought that good teachers don't use textbooks. Here we saw a way that using textbooks is good.

Rosa: It's not the textbook that teaches, it's the teacher.

Matt: Akihiko said that here the teachers can think about how to teach, not what to teach.

Akihiko: Currently young teachers here want textbooks so say more about how to teach.

Anne: In Ireland, teachers write textbooks, but I think there should be more collaboration between teachers and researchers.

Akihiko: Almost every page in a Japanese textbook has gone through lesson study. There is a deep connection between practice and textbook in a cycle.

Anne: We have patience in Ireland, but not for problem-solving. Here I see that problem-solving is a means, not an end. I've been enlightened about problem-solving.

Mary: In the UK I've seen how we rush, but yesterday we didn't arrive at any solution because the whole emphasis in the lesson was on student understanding.

Kelly: Level 1, 2, and 3 teachers: In the US students work through 10-15 problems in a day and here we see a level of depth about mathematics working through just one problem, and this was consistent in all the lessons we saw.

Anne: In Ireland, teachers would say they don't have time for problem-solving, they focus on quantity, not quality. Here it seems focusing on one problem is more efficient.

Simon: We are describing an anxiety about not reaching a definitive solution in a lesson with students. Here we've seen evidence to calm that anxiety. We've also seen the ability to have honest critical conversations about teaching.

Akihiko: When I was a student teacher, my mentor teacher said I had to spend a whole class period on one problem. That experience was during the late 70s-90s. Some lessons are relatively easy to spend a whole hour on one problem. Algorithms can be taught in 3 minutes.

Alan: The pressure to teach to a test is real, but the solution is counterintuitive. For example, in college teaching instead of doing all odd problems 1-35, do four of them and spend the rest of the time on the real mathematical riches. At the school level, instead of mad test preparation before tests by focusing just on skills, a balanced diet of problem-solving, drill, etc. produces comparable achievement on standardized tests.
How do we build the kind of learning communities that we've seen here, that develop the knowledge base and build the integrity of the profession and enterprise that I wish for?

Pete: We have to be Level 3 *trainers*. We can't do Level 1 kind of facilitation and expect teachers to come out as Level 3. We can't bring everyone to Japan but we can create professional development that captures some of these features.

Akihiko: We have Formative Assessment Lessons to use.

Mary: Japan has had LS for a long time, but in the UK the changes have been so rapid that it's hard to build anything.

Simon: It will be interesting for English colleagues to describe the sheer use of time and how we're going to do that. That's a critical point.

JunLi: Based on my past 10 days here, I will use more group work in my own teaching. Before this I believed that whole class was enough, but I see that group work is also important. A lot of students in Australia say they're not good at math, and I'm thinking that it's because they didn't have a good math teacher. Had they been in Japanese classrooms we might have seen a different story. Developing students' mathematical thinking is useful for everyone.

Phil: to Mary and Simon-- when something is new there's lots of enthusiasm. The challenge will be to sustain it. It's hard to contemplate the long-term sustaining of this.

How will you take this back to your own context?

Monica: I'm in awe of the system (National Course of Study, shared view of professional learning, etc.) and jealous of it, and wondering how to start absent such a system.

Matilde: I have so many hats I wear at home professionally, occupationally. There are so many versions of lesson to share with people who conduct continuing professional development. I have many different definitions of lesson study in my head; how do we educate people about what authentic lesson study is?

Sarah S: Interested in learning about Japanese words for teaching:
neriage
hatsumon
revoicing
scanning the room
matsume
bansho
mondai
kadai
Having such words enables a kind of work on teaching.

Kalai: In my country, we are constrained by existing structures so this will be a challenge.

Tan: As a secondary school teacher, I can do this on my own. When teachers see the benefit, and students see benefits, school administrators will be more supportive than they were. Early release for professional development is a good idea. Start small.

Kalai: I already started with 20 teachers in a primary school.

Anne: The very fact that I'm here shows support from Ministry of Education in Ireland. We have done this model, but seeing it here...We have limited funds, and this is teacher-led so we have plans to go home, and I'll collaborate with Aoibhinn and train teachers to do this. Get teachers from their own schools involved.

Jacqui: We have problems with curriculum, but we *do* have a new problem-solving curriculum that will be a good foundation. We can do this in one small place and show what can be done.

Anne: This is meant to bring back to all support staff for all facilitators to carry this out in all school subjects.

Aoibhinn: 1. I can see doing this with my university students, doing this with preservice teachers in teacher education. 2. Policymakers need to recognize only the time that they are in contact with students. We need to make explicit that professional development is part of their contact and that lesson study needs to be one of the models in professional development. 3. My position in the media allows me to bring this to the level of public awareness, and I might be able to make parents aware of this, and then policymakers will respond.

Bridget: It can't just be individual projects, but part of a larger conversation about what professional development is.

Kelly: I'm thinking realistically and trying to keep it real: Lesson study is extracurricular right now. How do I build ongoing community: support from the university, build a better understanding of lesson so

everyone finds a spot to grab onto? But for a whole school? Maybe just getting each teacher to articulate, *What is my question?* Maybe that's the first seed that I plant.

Pam: Lots of change fatigue in the US. We have to understand the questions and we have to address those issues. It has to be accepted by the school, including by the parents.

Tan: That's universal. Teachers are resistant.

Mariel: You can't sell it to your parents unless your teachers are conversant in it. You start with one grade level and the next grade teachers see that those students can do more and differently.

Kelly: We called ourselves teacher researchers. Mariel calls her students scholars and that elevates the way they see each other and how others see them.

Mary: I'm a new teacher educator, having been a teacher for a long time. My university situation allows me to start the process there. Working with preservice teachers will allow them to educate more experienced teachers when they get to schools. We can also work with mentors. Mentors and student teachers can plan more collaboratively, and that may permit more focus on the mathematics.

What are the next steps?

Alan: I want to clone Akihiko.

Anne or Aoibhinn: What opportunities: Bring Kampai to Ireland! Seriously, the idea of working hard, and playing hard--team work is really valued, celebrate as a community.

Akihiko: We're celebrating the hard effort, not that the lesson was perfect etc.

Melissa: We did bring back kampai, but we have to do it directly after the lesson. But also want to bring back the idea of building community in classrooms.

Rosa: Practical next steps: I'd like to try a public research lesson.

Mariel: I taught a public research lesson, and I taught the unit in that classroom for the two weeks before. It built a lot of trust with my faculty.

Aoibhinn: Professor Fujii suggested we host a meeting of lesson in the UK. We should bring our Japanese hosts to launch it.

Jacqui: We have a Professional Learning Day every end of October, with over 100 teachers attending. We might have a research lesson day: start with a speaker, have everyone attend two research lessons, and then take part in the post-lesson discussion.

Akihiko: The team we observed yesterday had 8 meetings for planning and they were sometimes rocky, and getting through that is cause for celebration.
I encourage each of you to go through a round of lesson study for yourselves. This isn't easy work. It’s a lot easier to talk at students than listen to their ideas.

Alan: How do we extend this community in time and space to continue to support the work?

Akihiko: Basecamp will continue through end of December. IMPULS facebook page can continue.

Alan: Project NExT is another site for math pd people.

Jenny: We can stay connected virtually, and also try to meet up at conferences like WALS, etc.

Appendix B: Raw Data Output, Pre-LSIP Survey May, 2015

1. 1. How many years have you been involved in lesson study to date?

#	Answer		Response	%
1	None. (Please skip to question 6.)		3	14%
2	1-2		6	29%
3	3 or more		12	57%
	Total		21	100%

Statistic	Value
Min Value	1
Max Value	3
Mean	2.43
Variance	0.56
Standard Deviation	0.75
Total Responses	21

2. 2. In what content area(s) did you experience lesson study? (Mathematics, music, language arts, etc.?)

Text Response
Mathematics
Maths
mathematics, English
Mathematics
mathematics
Mathematics
Mathematics
mathematics
Supporting schools across a range of subjects.
Mathematics
Mathematics
MATHEMATICS; LANGUAGUE ARTS; SOCIAL STUDIES
mathematics
Mathematics
Mathematics y7-20 ages
mathematics
Mathematics
Mathematices

Statistic	Value
Total Responses	18

3. 3. How many times have you observed and participated in lesson study?

#	Answer		Response	%
1	At least one cycle as a participant		3	19%
2	1-3 cycles as a participant		2	13%
3	4 or more cycles as a participant		11	69%
	Total		16	100%

Statistic	Value
Min Value	1
Max Value	3
Mean	2.50
Variance	0.67
Standard Deviation	0.82
Total Responses	16

4. 4. Did you experience lesson study your home country or in another country? Select all that apply.

#	Answer		Response	%
1	In my home country		16	94%
2	In another country		3	18%

Statistic	Value
Min Value	1
Max Value	2
Total Responses	17

5. 5. Please describe your experiences with lesson study to date.

Text Response

- I had contributed partially in Professor Lim Research University Project “Improving Mathematics and Science Teachers’ Teaching Quality and Student Learning Performance in Low- Performing Primary Schools Through Lesson Study Collaboration” since 2012, by getting involve in workshops and conferences. - I had attended an open classroom by Dr. Akihiko Takahashi at SKJ (C) Pai Chai as observer on 2nd February 2012. - I had attended the APEC Khon Kaen International Symposium and International Conference on Educational Research: Challenging Education for Future Change on 8-10 September 2012, in Khon Kaen University as second presenter to Professor Dr. Lim Chap Sam, representative from Malaysia. - I had taught a research lesson on Grade 10 on the topic of Statistics. The first lesson was taught on 16th June 2012. The same lesson was taught again on 18th June 2012. The lesson aimed to promote emergency preparedness among secondary pupils. - I had attended a one day workshop organized by Professor Dr. Lim Chap Sam entitled: “Open classroom: Effective Mathematics Teaching Through Problem Solving.”, at SJK(C) Choong Cheng, Tanjung Dawai, Kedah, on 5th October 2013. - I had participated and won Third Prize in State level Innovative Teacher Award Competition 2013, secondary school category, organized by Penang State Education Department, Ministry of Education Malaysia and Ministry of Science, Technology and Innovation. The innovation is based on the research lesson and producing one chapter of ‘Dbook’ entitled “Statistic Lesson Integrating Tsunami and Earthquake” - Based on the research lesson, an academic paper entitled, “Preparing Secondary Pupils for Disaster Awareness through a Statistics Lesson” is produced and presented in Fifth International Conference on Science and Mathematics Education (CoSMEd) 2013 at SEAMEO RECSAM Penang, Malaysia, on 11-14 November 2013. - The paper was published as a chapter in the book entitled “Learning Science and Mathematics in the Classroom: Case Studies of Successful Practices/ edited by John Leach, Nur Jahan Ahmad, Suhaidah Tahir” published by SEAMEO RECSAM, in year 2014.

Leadin on impact evaluation of lesson study projects, designing professional development programmes for schools wanting to use lesson study with a particular focus on developing teachers as leaders of lesson study.

Outside expert collaborator with planning team teacher of lesson (professional training of teachers) observer of LS training of African teachers in Japan (JICA funded) researchers conducting research into LS with schools

I have had 2 experiences of lesson study so far. Both have been projects offered by the University of Nottingham. The first was the Bowland Project and this was followed by the LeMaps project. Both projects were specifically looking at using lesson study to look at teaching problem solving lessons.

I have attended the Chicago Lesson Study conference once. At the conference, I watched two lessons and the debrief for each.

I have studied lesson study within a graduate-level course in teacher learning. I have participated in a lesson study conference in Chicago where I observed two research lessons. I have led four lesson study cycles in mathematics with the entire math department of a local high school and middle school. I have also read quite a bit of the current literature on lesson study.

As Maths leader and consultant promoting "Lesson Study" as a Professional Development tool, NOT as a research tool. This version of LS is more informal and not as maybe the LS that we will be experiencing through the IMPULS programme.

As a former mathematics teacher in secondary school, I wanted to introduce lesson study to schools as part of a national curriculum reform in Ireland. For my PhD I engaged with two schools who participated in iterative cycles of lesson study over the course of one academic year. My role was initially as a facilitator of the lesson study and I subsequently participated in cycles as a maths teacher member of the group. I have since been promoting lesson study as a model of professional development for teachers and will incorporate lesson study as part of my pre-service teacher modules in September.

I have worked at the Teacher Development Trust, a charity set up to improve teacher learning, for two years. For that time I have been working with NTEN, a network of schools that is working to improve teacher development. A large part of our work and support is around implementing Lesson Study in these schools. The schools are a mixture of Primary and Secondary schools, and they have all used Lesson Study in slightly different ways. As part of my role, I have worked with schools and teachers; designed resources and tools and lead workshops to support them; gained expertise from Prof. Pete Dudley and much of the research on Lesson Study (that's in English); networked with other organisations, universities and schools using Lesson Study and learnt from their experiences.

2012: 2 Primary Maths lesson study- participant 2013: Secondary Maths lesson study- participant 2014:

2 Primary Maths lesson study- participant 2014: 1 Primary English lesson study- observer

My experience of lesson study was in the context of trying to introduce it to Ireland as National Coordinator. Please see my paper "Introducing Lesson Study in Promoting a new Mathematics Curriculum in Irish Post-Primary Schools," which appeared in International Journal for Lesson and Learning Studies (vol. 3, issue 3)

*Highlighted Lessons indicate the research lessons I taught Lesson Study Experiences and Lesson Study Collaborations Watertown City School District, MA, 2003 Lesson Study Conference 2002 (Stamford, CT). Toward a Common Understanding: Implementing Lesson Study Effectively. Presented collaboratively by Global Education Resources, Greenwich Japanese Schools, Regional Alliance @ TERC, and Research for Better Schools. Title of Research Lesson Collaboration: Lesson Study; Subtraction Gr. 3 B. Researcher/Presenter, Institute for Child Study (ICS) at The Ontario Institute for Studies in Education (OISE), University of Toronto, 2005-2008. Titles of Lessons: *Lesson Study: Geometry- An Exploration of Visualization and Representing Three-Dimensional Objects; Gr. 4 Exploring Fractions Through Lesson Study: "The Altered Whole"; Gr. 5-6 A Community of Teachers Approaches to the Teaching of Multiplication of Fractions Through the Process of Lesson Study; Gr. 5-6 Lesson Study: A New Algorithm for Dividing; Gr. 4 C. Invited Discussant: Port Hope High School Lesson Study; Public Lesson, 2008 D. Grant Writer- Collaborative Partnership Grant- University of Toronto, 2006; coauthored with Dr. Joan Moss (OISE); Richard Messina, Dr. Elizabeth Morley (Lab School Principal). 3. Researcher/Facilitator, The Ensworth School, 2009-present Titles of Lesson: *Exploring the Language Implications of 'Difference' in Subtraction; Grade 3 Examining the Impact of Organizational Focus on Natural Approaches to Problem Solving, "A Sharing Problem"; Grade 2 Brain Training and the Effects on Spelling and Reading with First and Fourth Grade Students; Grade 1 and 4 Building Number Sense & Operational Understanding through Storytelling; Grade P1 PAPERS and PRESENTATIONS Advancing theories of teaching, learning and professional development through analyses of iterative cycles of Lesson Study : A Design Experiment; PME-NA 2007; Lake Tahoe, Nevada, Poster Presentation Richard Messina, Institute of Child Study University of Toronto; Kelly Goorevich, Institute of Child Study University of Toronto; Elizabeth Morley, Institute of Child Study University of Toronto; Joan Moss, OISE/University of Toronto Ontario Teachers' Federation and the Ontario Association of Deans of Education conference, "The Teacher as Creator", January 27, 2007, Toronto, ON; Beyond Professional Development: Japanese Lesson Study as "Profession Development", The Integration of Individual, Community and Inter-community Growth. OISE- Institute of Child Study (ICS) Parents' Association Annual General Meeting; "Japanese Lesson Study as Professional Development"- Research Night- 2007/2008

Through reading and research, through National Strategies training (2009); sessions led by colleagues in maths team for NumbersCount teachers; MaST delegates; Y34 cpd course. Promoting teacher learning communities and related training. Informally, through planning and coaching sessions with teachers and feedback sessions. Working collaboratviely as part of a maths team to deliver agreed lessons and then reviewing together (no observations) to review/adapt.

I have worked on lesson study for the past 4 years at the University of Manchester. I have used Lesson Study as a professional Development tool for Beginning Teachers as well as more experienced colleagues. In particular I have lead a research project that researched the impact of lesson study on the development of reflective practice for beginning teachers. I have also been involved with the Bowland lesson study project and attended a public lesson in Dagenham in the summer 2013. I have also been involved with the LeMaps project and have recently attended a seminar titled "What can we learn from Japan about professional development for mathematics teachers?" at King's College on Monday 1st December.

I have been involved in lesson study on several projects led by different Universities. There was a considerable variation between each however the core focus of the LS was consistent. This has led me to realise the different styles can be used in a variety of contexts.

I involved in Lesson Study process for the past four years till today. I completing my PHD research thesis in investigating the changes in mathematics teaching after Lesson study process.I am in the chapter five till to date.

I have taken part in a lesson study cycle, but am now more in a position of supervision. More recently I have led the team of mathematics teachers and consultants who have written and delivered lessons for the new curriculum. We have found lesson study a useful tool for studying the necessary changes in pedagogy focused on specific concepts in mathematics.

I participated in one cycle and observed 3 cycles

6. 6. What do you think are the strengths/ benefits of using lesson study in your local context(s) (e.g., district, school, university setting)?

Text Response
lesson planning; professional knowledge; cooperation
In my school, lesson study can helps to improve the teachers teaching both in pedagogical content and knowledge content. This is because when teachers sit down together and discuss about a lesson, an experienced teacher can share his/her experience to the novice teacher and comment on the lesson plan before the teaching. After the observation on the teaching, Novice teacher and experienced teacher can do reflection together and this is a crucial part as all teachers commented on the process and we all learn together on the strength and weaknesses of the lesson. The weaknesses will then be improved in the next retaught lesson. This cycles continue over time and the both novice teacher and experienced teacher can improve their knowledge.
It draws on notions of teachers' tacit knowledge being an untapped professional development resource and builds capacity within the school. It gives teachers time to focus on students' needs and reflect on their own practice.
strengths are structured problem solving lessons, collaboration between teachers, use of bansho, anticipated student responses, school leadership involvement benefits include greater sense, and understanding of curriculum goals, task design issues, in the main, are establishing a LS culture within a school and district
The chance to work closely with colleagues is one of the main strengths of lesson study that I have encountered so far. In the current climate teachers rarely get chance to work collaboratively, but lesson study has provided a vehicle for this to happen, consistently and regularly. Lesson study has also helped my school make massive strides in our understanding and our delivery of problem solving lessons. So much so that we now have some really strong expertise in this area. It is also highly beneficial to be part of a process that allows you to think deeply about lessons and to consider carefully the needs of the learners. Finally, the deep reflection that lesson study demands has had a massive impact on day to day teaching.
I believe the formation of a lesson study group, either within a single school or among teachers across schools within the same area, would allow for the development of promising instructional practices, shared understandings of content and pedagogy, sustained collegial conversations, and a record of practice that can be preserved and shared. I think the sum of all of these components could yield improvement in the teaching and learning of mathematics among the participating teachers and their students.
Breaking down the isolation that is typical of K-12 teachers. Opening up our classrooms to each other. Focusing on student learning and instruction within a responsive instructional design model.
The structure and principles behind lesson study are its strengths.This can provide a methodology through which teachers can be encourage to focus more in depth on their lesson design and reflection outside the usual constraints of time in a busy teachers work week.
Irish secondary teachers are currently not incentivised or acknowledged for participating in professional development and yet there is an obvious need for teacher learning supports, particularly with multiple curriculum reforms occuring nationally. Lesson study can provide teachers with a simple but powerful structure within which they can develop teacher community, focus on their classroom practices, engage with new syllabi, and enhance both their content and pedagogical content knowledge.
Lesson Study is a teacher driven approach that is really focussed on pupil learning. It therefore is one of the approaches to teacher development that has the largest impact on pupil outcomes. As a charity that is trying to support pupils to succeed and teachers to thrive, Lesson Study is a crucial medium for supporting schools and teacher development. The particular strength of our organisation is that we have national reach across a wide range of schools.
- Improvement in student learning - Improvement in student justification - Teachers more aware of student answers and reasons behind them
1. Increasing collaboration among teachers 2.Increasing Peer Observation which is lacking in Ireland 3. Promoting pedagogical content knowledge 4. Observing students' work and seeing misconceptions first hand 5. Trying new methodologies
Lesson Study brings professionals together to draw upon the experise of the community. It changes the

culture of education in that it encourages teachers to rely upon one another to deepen their own learning through research and communication. Lesson Study creates a culture of openness, questioning, and learning among its participants. It provides an opportunity for schools to connect with one another as well as with universities and pre-service teacher training. It is THE model of professional development and its affect can be seen in all disciplines. In my experience, it has linked research and teaching/learning for participants.

Supports teachers in developing their professional practice together. Focusses on classrooms not procedures/systems Makes lesson observations meaningful learning experiences rather than judgmental/performance managment related structures imposed by managment. Provides opportunities for reflection; review; research and recognition Has the potential to deepen and enhance school - to -school support.

Following the events described above and after having analysed data form the research project (recordings of lesson and post lesson discussions saw ell as interviews with student teachers and teachers) I have become more and more aware of the potential of lesson study to help develop the teaching profession. The main strength being the collaborative nature of lesson study. I also think that lessons study allows student teachers to develop reflective practice.

An opportunity to really understand what is affecting the learning. This is a change of focus from what we normally experience in the UK when others enter our classroom.

I have realised the opportunity LS offers colleagues to collaborate and reflect leads to a continuous professional development cycle, centre around the professional self development.

Strengths and benefits are improving lesson planning, classroom teaching practices, strengthen collegiality collaborations among teachers, improved student learning outcome and performed a quality classroom lesson.

Besides the outcomes of better lessons, the strengths would be creating a collaborative group of teachers/professors who were creating all lessons independently prior.

There has recently been a rapid change in the expectations for teaching mathematics but these changes are not always obvious to all. We can put on training sessions, but lesson study offers us the opportunity for professional learning in the actual classroom setting and in collaboration with others. Teaching in London with many schools who have intakes well below the national average and high levels of disadvantage students it is essential we prepare our teachers to deliver mathematics that will allow these students the life skills and qualifications they need to progress.

our students have difficulty with understanding concepts and problem solving , i think lesson study help them to understand the concepts very well and to be problem solver.

7. 7. In your mind, what are the essential features of lesson study?

Text Response

practical aim; cyclic process; cooperative way

Lesson study involve 4 steps in which planning a lesson, teaching observation, reflection and reteach the lesson again to other class. Lesson study start from planning a lesson through written lesson plan by a group of teachers, deciding on what topic and which class to be taught and what are the activity to be taken place. Then in step 2, one teacher teaching and other teacher would be observing and evaluate. Step 3, teachers do reflection on the lesson taught and do critical reflection especially, to analyze the strength and weaknesses of the lesson and suggest improvement measure for the next lesson. The lesson is then reteach in Step 4 to another class and the cycles of lesson study continues till the teacher think that it is time to switch to another topic.

- a collaborative approach, not hierarchical - a non-judgemental ethos - time and space to think deeply about teaching and learning - improvements in practice emerge from cycles of action and reflection

collaborative planning task selection bansho neriage post-lesson debriefing/discusssion

That participants have the time to carefully plan the lesson, this is when lesson study has worked best for me. When time has been short and lessons have been planned in less detail the impact of lesson study has been diminished. That there is an outside contributor to the process that can see things from a different point of view - such as from the University. This person is invaluable during both the planning and post lesson discussion. That everybody talking part in the lesson study cycle is committed and is aware of lesson study being a collaborative process.

identifying a "troubling" topic researching content and pedagogy planning the lesson implementing the

lesson reflecting and refining the lesson (with additional implementation and reflection cycles possible) recording and sharing what was learned through the process
Collaboration on goals and exploration of other approaches Discussion on rationales of instructional choices Detailed lesson design Observation focused on student learning Thorough discussion of evidence of learning/effectiveness Deep teacher learning
Collaborative planning on a clear focus for improvement Observation of learners and learning Reflection and improvement
I think it important that teachers begin lesson study with an overall goal for their teaching and that the planning process is a collaborative one. I feel it important that, where possible, members of the lesson study group are present in the classroom to observe the research lesson and think it essential that ample time is given for reflection of that lesson. I think it essential that teachers develop ownership of their lesson study group and that it not continue to be externally driven (although that may be initially necessary).
- Absolute focus on pupil learning (rather than observing teacher practice). - Not a 'top down' approach - all teachers contribute and benefit, and it is driven by a particular area of pupil need (rather than teacher practice/external inspection grading etc.) - Collaborative
- Collaboration - Planning of the lesson - Identifying possible student responses - Post lesson discussion
Each part of lesson study has beneficial merits from: (a) planning the lesson (b) peer observation (c) writing the lesson plan (d) documenting findings based on data collected
In my mind, the planning stages are the most essential components of the lesson study. The research and reading, and the discussions among participants about anticipated student responses, the exact language of questions, as well as the choice of experiences and manipulatives are rich. I have found that I have learned to questions my own choices when working alone in a similar way as I would among lesson study participants. While the lesson is enlightening and rewarding, after the planning sessions, the debriefing of the lessons are very rewarding. It is a rare opportunity to have many eyes on a lesson and on its students. The various perspectives on the lesson are a critical feature of the study.
Shared learning environment built on trust and collaboration Opportunity for high quality professional inquiry Careful joint planning and design of lessons with a key research question to explore. Meaningful lesson observation with peers In depth discussion, reflection and exploration of lessons and learners responses Opportunity to work with expertise (koshi)
To my experience the main feature is the collaborative nature of lesson study. For student teachers reteaching the lesson after reflection is also an important aspect of professional development.
Collaborative planning. Joint responsibility. Observing effects on learning and understanding. Discussion of impact.
The opportunity to really focus on the learning and cognitive movement of students experience.
'An essence to improve classroom teaching practices as well as enhancing skills in lesson planning and lesson observations to improve student learning outcome'.
From readings the features are 1) Finding a focus; 2) Planning the research lesson; 3) Planning the study 4) Teaching lesson, observing, gathering data; 5) Debreiving, analyzing and revising lesson; 6) Repeating the cycle and 7) Documenting and disseminating study findings. These all seem very important features and I belive they are all essential.
Lesson study must be collaborative and have a clear and worthwhile focus.
learn concepts through especial problem solving write lesson plans as a team discussing the lessons before and after lesson

8. 8. What do you think are the challenges to using lesson study in your local context(s)?

Text Response
specialist leading teachers; open culture of teaching; teaching research time
Time and administrative support. Teachers are not willing to commit time to stay back after school for meeting to plan a lesson. Admin of the school are not doing their role to plan the time table ahead. Teachers teaching same subject in a same grade clash with their time table and they could not do lesson observation or discussion together during school hours. Teachers are also burden with a lot of paper work and hence, some of them has misunderstood that lesson study is another paper work that burdening them.They had negative perception towards lesson study and thought that lesson study was too time consuming.
- difficulties getting sustained release time for tech hear, especially given the recent tightening of school budgets - enabling senior leaders in schools to distinguish between lesson study as a professional development process and lesson observation as an evaluation process
cost of time release for lesson observation
The amount of time that teachers need outside of normal teaching hours can be a challenge - especially if a school is reluctant to release a teacher for observations and meeting. In these circumstances, when teachers are forced to plan at short notice etc then lesson study has less impact and is less useful as a learning experience. That some senior leaders need to be convinced of the impact of lesson study and are concerned about how you measure the impact on students. Some teachers are not willing to take part in observations - observations are linked with judgements., Some colleagues need convincing that lesson study is a learning experience.
lack of common curriculum materials (across traditional public schools and public school academies) emerging and/or superficial understanding of content expectations limited experience working collaboratively in this way the social and professional risk of opening classroom practice to others time and resources for the thoughtful and sustained execution of lesson study
Time How different the lesson study model is from what teachers have experienced and are taught
Colleagues see as the process being over burdensome particularly in respect to time without apparent or clear benefits in their mind
In the Irish context, there is currently no specific time contractually allotted for professional development since teachers are acknowledged only for their class time. With this in mind, it is difficult for teachers to justify investing so much time in planning and reflecting on one specific lesson without being familiar with the overall benefit of lesson study. In Ireland, teachers are also unfamiliar with collaborating with their peers and colleagues and it can be a challenge to introduce this culture into schools and mathematics departments.
- Teachers are used to being observed for judgemental reasons - introducing Lesson Study as a developmental peer observation can be challenging. - Schools are used to accountability and want to see immediate, measurable impact from the time spent on Lesson Study. - Finding the time for peer observations is tricky, too. - Teachers are used to top down, irrelevant CPD. It is hard for staff to buy in to something that is so different to what they are used to. - Focussing on a real pupil need (rather than a teacher practice, or a school issue) is something that is really hard for some staff.
- Logistics- organising for a number of people to be available to attend planning and the actual research lesson
There are many challenges Insulation and isolation of Irish teachers Time to conduct it Will it improve examination performance? Confronting traditional practices of teaching mathematics
Finding time to engage the planning stages in a timely way is challenging. Also, accessing research to inform our ideas can also be challenging at times.
Time for teachers to be released to work together (and related costs) Challenging current systems of cpd and support in schools
In my local context I have experienced two challenges: 1) allowing teachers enough time to prepare the lesson and for discussion. Teachers in the UK are under a lot of pressure and it has been difficult to persuade senior management to allow enough time to do it properly 2) in my local context teachers are constantly under scrutiny, being observed to manage performance so they might find it stressful if observed while teaching
Time - making teachers available to work with each other.
Initially engaging colleagues to participate in LS cycle, time and logistics if working with different

schools.
Challenges in time factor. Over workload of teachers increase in other task apart from classroom teaching.
Finding a group of educators who have the extra time to work on Lesson Study.
Other priorities for teacher time. Not easy to measure immediate impact and hence value for schools, their students and their teachers.
The textbook teacher's attitudes

9. 9. Please describe how your current organizational contexts use lesson study for educational improvement.

Text Response

want to start but do not know how to do
My school has been introduced to lesson study in one of our Teachers' Professional Development. However, there was no effort for teachers to continue in doing it as it involved time for teachers to discuss on lesson time. All the teachers teaching the same subject has different time table and they could not carry out lesson observation together as their lesson clash. However, I have tried once with the teacher in school on lesson study in Mathematics with the guidance from professor from Universiti Sains Malaysia and two teachers are willing to participate in the lesson observation and give their comments after the lesson. Yet, I would say that my school has not fully implement lesson study in our school and there is big room for improvement.
- focus on impact for target pupils and tools designed to measure such impact - development of more effective teaching skills and leadership skills in relation to lesson study, with impact evaluation tools associated with these two aspects - integration of lesson study as a tool for research and development projects in schools
they do not any LS is done via research funds of University researchers participants all report benefits to their teaching
Currently my school only uses lesson study within my mathematics department and it is used solely to develop the teaching and understanding of problem solving lessons.
My current organizational context does not yet use lesson study.
We work with local K-12 teachers and run lesson study cycles
As a Maths Hub lead LS is not employed but is planned to be introduced into schools to follow up developmental programmes as a way for these schools to sustain the developments they have begun
As co-coordinator of an undergraduate programme for BSc students choosing to become mathematics and science teachers, lesson study is incorporated into the degree programme as a way of familiarising these pre-service teachers with collaboration and with the importance of focusing on pedagogy. As lecturer on a graduate programme for pre-service teachers, I incorporate lesson study as a way for these students to share and build on each others' ideas in teaching mathematics in a time of curriculum reform.
We currently support a wide number of schools of different sizes and ages to implement Lesson Study. We offer workshops, tools and resources, and also visit and work with schools.
It was trialed in 2014 in two different year levels to improve student learning
We have conducted it in Ireland twice as pilot studies and put on 2 National Conferences showcasing the work.
Lesson study is a volutary program at my school. It is because of our studies that we have been able to convice our administration for the need of a mathematics coach for grades k-5. Through the participation of our Curriculum Alignment Directions in Lesson Study, we have begun to firm up the content scope and sequence within the k-5 program at our school as well as begin to develop a common mathematical language. We are currently trying to welcome preservice teachers and thier professors at a local university into our cohort. We are hoping that Lesson Study deepens our relationship with local universities as well as opens the door for more teaching interns.
We currently use LS on training courses for teachers, as descried above. We have also in the past used Dylan Wiliam Teacher Learning Communities resources to support schools in developing TLCs, which have similar ethos/aims as lesson study n terms of teachers working together on mutally agreed research activities.
I have used Lesson Study as a professional Development tool for Beginning Teachers
None
Although currently only used in Mathematics, the expectation is all colleagues complete a least one cycle per academic year. Over the last 5 years generally colleagues complete 3 cycles per year. LS is now being

introduced in other curriculum areas.

Implement Lesson Study process an innovations to improve professional development skills among teachers and educators.

We do not currently use lesson study.

I work across 36 academies including primary and secondary. There are several models of lesson study being carried out mainly in secondary academies. The lesson study cycles are excellent professional learning for the teachers involved, but my emphasis has been on using lesson study to support teachers in the new style pedagogy needed to deliver key concepts to mastery.

I start to give teachers workshops about the importance of problem solving then work with them step by step to write lesson plan using (lesson study) after that help them to teach students by this way and let them see the improvement in students's learning

10. 10. Please describe how you hope to use lesson study for educational improvement in your current organizational contexts after this trip.

Text Response

observe then consider how to use it in practice

With the support and approval from school administrator, I would lead, influence and encourage the teachers to form lesson study group for each of the subjects in school, starting from mathematics. I would assist the lesson study group with the knowledge that I gained and actively participate as observer to other lesson study group. As the time factor can be overcome if the school plan the time table in such a way that all the time table for Mathematics teacher are similar in some days of a week so that the teachers teaching the same subject can have discussion during school hours to plan lesson and if their time table allows, lesson observation can be carry out in one of the classes they taught as every teacher's time table do not clash with each other.

I hope to be able to consider whether and to what degree the lesson study model has been adapted to the English education system context and whether these advantages are right for this context or whether a stricter adherence to the Japanese model would be beneficial. I will present my findings to the group of academics working with lesson study across the Institute of Educationa nd it will inform my role in organising the London Lesson Study conference in October.

applying for Education department support as well as Federal funds. The IMPULS experience will add strength to claims that LS team of researchers (there are two of us in IMPULS) have the requisite expertise.

Firstly to continue developing the teaching and understanding of problem solving in my school but also at schools across our alliance. In my role as lead practitioner I have the opportunity to work with colleagues across a number of schools To use what I learn to encourage more participants to take part in lesson study. My aim is to make lesson study sustainable over a long period of time at my school. To attempt to use lesson study looking at other areas of mathematics teaching - not just problem solving. Looking at how lesson study can be used with teachers who are at different points in their careers and who have different needs. To promote lesson study as a fantastic way to develop teachers across the whole school and not just in the maths team. To attempt to encourage the use of lesson study in other subject areas.

I am only beginning to imagine what might come of this experience, but I am considering the establishment of two lesson study groups. The first would be among teachers at the school in which I work. The second would be a group of teachers from across schools (both traditional public schools and public school academies) who express interest in such an endeavor. Both groups would be focused on improving mathematics instruction at the elementary school level.

After the trip, I hope that my understanding of the entire cycle is deepened and I will be better prepared to help the teachers that I work with improve their teaching.

I hope to be able to instigate the methodology in a way that maximises benefit and promotes the continuation of LS instead of being seen as a luxury to which a school cannot afford the time to engage in.

After this trip I plan to further communicate the benefits of lesson study to a national audience using my media profile (as a tv and radio presenter) and with the national educational bodies with whom I collaborate (the National Council for Curriculum and Assessment & The Department of Education and Skills). Collaborating with my colleagues in other Irish universities, I plan to speak about my experiences in Japan and further develop more research papers incorporating lesson study. I will also

use this trip to develop and enhance pre-service maths teacher modules incorporating lesson study.
After this trip, we hope to develop these resources and advice and better support our schools. We also hope to engage more fully with more schools that are already engaged in Lesson Study and contribute to the community that is growing in the UK in the most useful way possible. It is hard to get the balance between growing Lesson Study and ensuring fidelity.
I would like to have a stronger understanding of how to organise a research lesson, including planning the lesson and the post lesson discussion
After this trip we hope to try and expand lesson study nationally.
My goals upon my return from IMPULS are: 1) to build a stronger foundation of Lesson Study within the lower school community by sharing the lessons and experiences gained from IMPULS. 2) to support expansion of Lesson Study to the broader Ensworth community (middle and high school teachers and administrators). 3) to support dissemination to other independent schools, to the Nashville Metropolitan Public School District, and to Vanderbilt University's Peabody School through "Lesson Study open-houses" and workshops when we will welcome colleagues to immerse themselves in our Lesson Study. to lead to discourse beyond the specifics of the mathematics by influencing lesson structure and questioning in other subject areas; sciences, music, humanities, foreign language, and the arts.
Would hope to raise more awareness about lesson study and its impact through local authority team; headteacher networks; subject leader networks.In our work with schools to also encourage lesson study as a tool for teachers to use to develop together. Encourage teaching school alliances and those who will increasingly take a bigger role in school support to develop lesson study in ther work with schools causing concern, but also as a way to further develop successful schools.
I hope to understand lessons study better in order to adapt the model to beginning teachers and to the local culture. Following the trip I inter to disseminate my understanding through my work with beginning teachers and by facilitating professional development for etchers in the locality.
Create lesson study groups across a number of schools.
This is an obtuse question, depends on the reflective experience. I hope to experience the variation of LS and use this in the different contexts we professionally wish to research.
Promote Lesson Study process among the teacher trainers (Lecturers) and in-service teachers in the schools around the district and state. Promote Lesson Study more broader through Ministry of Education throughout nation.
I am hoping to 1) use lesson study in the university setting to make better and more focused lessons and 2) to work with other elementary and secondary schools to help them create lesson study groups.
I would like to continue to use lesson study to support teachers with the challenges of delivering the new curriculum in mathematics especially around problem solving and reasoning and set up a site where teachers can publish their research to share ideas and discoveries with others as well as inspiring others to try the process themselves.
I am sure i will learn more about lesson study during the trip so i will be more confident about my knowledge and more professional . I hope to be able to transfer my knowledge to my colleagues and teachers

11. 11. To what extent do you expect to learn about each of the following during the immersion trip to Japan?

#	Question	Not at all	A little	Some	Quite a bit	A lot	Total Responses	Mean
1	a. Mathematics content	0	4	5	4	8	21	3.76
2	b. How to support students' problem-solving ability	0	0	2	6	13	21	4.52
3	c. Evaluating lessons on the basis of the written plans	0	0	3	7	11	21	4.38
4	d. How lesson study is conducted in another country	0	1	0	0	20	21	4.86
5	e. How lesson study is conducted in different educational contexts (e.g., schools, districts, etc.)	0	1	1	2	17	21	4.67
6	f. Collecting data on student thinking to inform instruction	0	0	2	7	12	21	4.48
7	g. Strategies for making students' thinking visible	0	0	2	5	14	21	4.57
8	h. Analyzing/studying curriculum materials	0	1	4	9	7	21	4.05
9	i. Ways to build connections among educators at multiple levels of the education system	0	0	5	7	9	21	4.19
10	j. Anticipating student responses	0	0	3	6	12	21	4.43
11	k. Writing a useful lesson plan	0	0	3	7	11	21	4.38
12	l. Supporting participants to have powerful and effective lesson study experiences	0	0	1	5	15	21	4.67
13	m. Organizational/structural supports for lesson study	0	0	1	6	14	21	4.62
14	n. Students' mathematical reasoning	0	0	2	10	9	21	4.33
15	o. Differentiating/ offering support for struggling learners	0	1	7	5	8	21	3.95
16	p. Cultural influences on mathematics teaching and learning	0	2	1	5	13	21	4.38
17	q. Organizing a successful post-lesson debriefing session	0	0	1	2	18	21	4.81
18	r. A typical school day at a Japanese elementary	0	2	1	9	9	21	4.19

	school							
19	s. Developing mathematics units and lessons	0	1	4	6	10	21	4.19
20	t. Strategies for working effectively in a lesson study group	0	0	1	3	17	21	4.76
21	u. My own country's approaches to mathematics instruction	0	3	5	6	7	21	3.81
22	v. Analyzing written student work/ responses	0	0	4	8	9	21	4.24
23	w. Analyzing and interpreting verbal student comments	0	0	5	6	10	21	4.24
24	x. How to build students' mathematical habits of mind and practices (such as in the Common Core State Standards)	0	0	4	6	11	21	4.33
25	y. How to build a classroom learning community	0	1	5	4	11	21	4.19
26	z. Knowledge about the Japanese educational system in general	0	1	3	7	10	21	4.24
27	aa. How to lead lesson study	0	1	1	1	18	21	4.71
28	bb. How teachers learn from participation in lesson study	0	1	1	3	16	21	4.62
29	cc. What other IMPULS participants are doing with lesson study	0	0	0	7	14	21	4.67

12. 12. Please select and rank in order of importance the five items from the previous question that you believe will be most professionally useful for you within the next year. (Drag and drop your top five.)

#	Answer	
1	a. Mathematics content	1
2	b. How to support students' problem-solving ability	8
3	c. Evaluating lessons on the basis of the written plans	3
4	d. How lesson study is conducted in another country	4
5	e. How lesson study is conducted in different educational contexts (e.g., schools, districts, etc.)	4
6	f. Collecting data on student thinking to inform instruction	6
7	g. Strategies for making students' thinking visible	10
8	h. Analyzing/studying curriculum materials	1
9	i. Ways to build connections among educators at multiple levels of the education system	4
10	j. Anticipating student responses	2
11	k. Writing a useful lesson plan	5
12	l. Supporting participants to have powerful and effective lesson study experiences	12
13	m. Organizational/structural supports for lesson study	7
14	n. Students' mathematical reasoning	3
15	o. Differentiating/ offering support for struggling learners	2
16	p. Cultural influences on mathematics teaching and learning	2
17	q. Organizing a successful post-lesson debriefing session	8
18	r. A typical school day at a Japanese elementary school	0
19	s. Developing mathematics units and lessons	0
20	t. Strategies for working effectively in a lesson study group	6
21	u. My own country's approaches to mathematics instruction	0
22	v. Analyzing written student work/ responses	1
23	w. Analyzing and interpreting verbal student comments	0
24	x. How to build students' mathematical habits of mind and practices (such as in the Common Core State Standards)	2
25	y. How to build a classroom learning community	1
26	z. Knowledge about the Japanese educational system in general	0
27	aa. How to lead lesson study	8
28	bb. How teachers learn from participation in lesson study	2
29	cc. What other IMPULS participants are doing with lesson study	3

13. Anything else you'd like to add?

Text Response
no
The differences between other country versions of Lesson Study and the degree to which these variants have fidelity with JLS is an extremely important aspect of how, or whether, lesson study in its broad sense, will benefit students to the extent that it does in Japan. We always differentiate between lesson study and Lesson Study (Japanese version). Fidelity, as Robert Felner points out, is a key factor in implementation success.
My participation in the IMPULS programme will add weight and merit to my promotion of this valuable model of professional development in Ireland and I am very much looking forward to learning more as a maths teacher, as a maths teacher educator, and as a researcher.
I have much to learn and am very excited to get started. So grateful for this opportunity.
All these descriptors and statements could easily be prioritised depending on context.
How Lesson Study improved and help teachers to develop their teaching methods in the classroom lesson.

1. In looking over all the research lessons during the immersion program, name one that was especially meaningful to you, and why:

Text Response
The one that I observed on 26 June, because I was able to get close enough to the children to get a real feel for their understanding of what was being taught.
For me, I think it was June 24th at Sugekari Elementary School. While watching the lesson, I had thought that the lesson was so good. I loved how the students, who were only grade 5 were using and investigating conditions for congruence. I thought a lot of learning was taking place, with students building on previous knowledge. However, during the post-lesson discussion I realised I hadn't fully understood the depth in which lessons were analysed. The focus on the lack of use of the manipulative was something I had noticed, but dismissed. It made me realise that I often only superficially observe lessons, and don't pay attention to the real learning that is taking place.
The Grade 3 lesson in Showa City Oshihara Elementary School on the 26 June 2015 at 1:50 p.m to 2:35 p.m. The lesson was about Let's Think about Division (Division with remainders) taught by teacher Yuji Ishikawa. This lesson was really meaningful for me since it was the taught for the lowest grade of students Grade 3. Next, was the topic taught division in more detail on how to divide the remainders. It was something very different and interesting when the similar content lesson is not practiced in my country's mathematics lesson. The lesson was on exploring how to deal with a remainder which can continue to be divided (eg into a fraction of a whole). The students seems to be merged into critical thinking skills to solve the two problems given to them on the board. It was seen to be very challenging for the Grade 3 students.
Research Lesson 8 July 1st: Sasahara Elementary School The reasons why I picked this lesson is manifold: 1. The teacher's capacity to use problem solving as a means to teaching mathematics was extraordinary 2. The students could clearly be seen to be active participants in their own learning 3. The students were clearly responsible for their own learning 4.The students constructed their own self criticism per se 5. The classroom environment highlighted cooperation between students and their readiness to venture an answer, ask a question and accept ideas from other students 6. The teacher seamlessly knitted in Assessment for Learning
Just one? Oh dear! Thats too difficult!! Lesson 2 24/06/2015 at Sugekari Elementary School - approach to teaching geometry through problem-solving and use of practical approach. The children were engaged and interested in solving the problem - how many pieces of information do you need to draw the given quadrilateral? They were well-prepared and could relate the lesson to prior exexperiences and learning. There was a high level of trust in the classroom, children willing to take chances, make mistakes, narrow down the range of information required. They were willing to contribute to the flow of the learning. But the content and execution also led me to consider how we teach geometry in UK primary schools and how ths could be improved/re-invigorated so that children learn from constructing straight lines, arcs etc and develop a 'feel' for shape in a practical and investigative way.
The final lesson, because it was the pedagogy was most like examples of teaching seen in the UK, as a result the focus of reflection was more on the Maths and less on the pedagogical structure of the lesson.
The last lesson was particularly significant for me since I was in charge of writing the report and therefore I was allowed to see the children work closely. The topic of dividing by decimals is also a very difficult one so I was interested to see how the Japanese teacher approach it.
The Sasahara Elementary School lesson (Division with a Decimal) on July 1 was especially meaningful because it was a lesson responsive to the questions and inquiries of students. The lesson began with the characterizing presentation of the problem and conversation intended to understand and clarify the problem. The students began to talk to one another. Suddenly I felt as though I were in a familiar environment. IT became clear that these students were comfortable discussing ideas and the pacing of the lesson helped keep the conversations focused and purposeful. The teacher circulated the room randomly asking students for their ideas and it beamed clear that students knew there would not be any 'hiding' or sitting invisibly in this classroom. My favorite moment was when the third child to share his thinking said, "I don't know," and with a smile in his voice, the teacher told that student that his comment would be the star of the day. Undoubtedly, this reinforced the idea that confusion is not only acceptable, but also that there is power in expressing and articulating points of confusion. Further, as the lesson developed, student learning was advanced because the simple answer, "I don't know" was not acceptable. Students were asked to elaborate on what exactly was not understood. In this environment,

student learn to THINK and find ways to support one another through collaborative confusion and idea sharing. I loved the fact that several students who appeared to understand how to use the double underline and represent the equation also came to discover the limits of their understanding because they were forced to explain their thinking. Several student realized that, while they could represent the equation, they did not fully understand what the numbers in the equation represented and 'why it worked' to find a solution. They moved themselves into the 'I don't know' category. It was clear that this was a knowledge building community in which students felt safe and trust in the idea that all ideas and theories are improvable.

The lesson which was most meaningful to me was the matchstick pattern lesson. Patterns and Algebra is an area in which teachers are not that confident, and it is an area in which I have a particular interest in. I found this lesson inspiring, as it showed me that students are capable at a young age to develop their thinking and explain how they solved the problem. I was interested to see if there was a strong emphasis on the link between the number sentence the students were creating and the diagram, which I find is something that isn't usually covered in detail however is important for students to understand when constructing and analysing algebraic equations. The way in which the teacher went about this was great- he even made the emphasis on the difference between 1+3n and 3n+1 and related this to the matchstick diagram

The final lesson we saw is the one that stands out for me. To see a whole lesson devoted to why we divide and not to actually think about the actual procedure of division was something that you would never see in the UK. It really made me think about my own practice and how I want to become a better maths teacher. I want to start teaching maths in a more rigorous way that allows my students to really deepen their understanding of mathematical concepts. On top of this the teacher's manner with the class was amazing, every student's response was valued and every student felt confident to share ideas and thoughts. In that respect this lesson was the one that most reflected an English classroom.

I like the first research lesson, although the content seemed simple the depth of systematic variation was incredible deep, as described in the planning.

23/06/2015. The lesson on creating algebraic expressions through people sat around tables. The thoroughness of the lesson plan and the Kyozaikenkyu where the teacher considered so many variations in the possible solutions. Then observing the teacher during the kikanshido phase. Both of these elements differ greatly to the normal process in the UK.

I really enjoyed the final research lesson held as a district lesson study. This lesson was particularly meaningful to me since it dealt with a topic (dividing by a decimal) which, in my experience, would be taught in a very procedural way. This lesson objective was not for students to learn how to divide by a decimal, but rather convince them that this could be done. This is a step in the learning trajectory of students that is often ignored and it was wonderful to see how this lesson unfurled with the majority of students wanting to find out the answer. This lesson also stood out since students were not afraid to say "I don't know" or "I'm not sure" and were praised by their teacher for these authentic declarations. The teacher made students feel important and relevant within the lesson when they were not sure what they should do. In addition, the teachers' interaction with the students and constant surveying of the room in making students' thinking explicit was a valuable pedagogical skill to see.

The lesson that was most meaningful to me was the final lesson that I observed on 1st July 2015 at Sasahara Elementary School. It was a grade 5 lesson, where the focus of the lesson was that 'Students will understand the meaning of (Whole Number) ÷ (Decimals) and be able to explain why division is an appropriate calculation. The emphasis on 'explain' was particularly apparent and it was this aspect that became the dominant goal of the lesson. One reason why this lesson was meaningful to me was because it was using the double number line (a new concept to me) which I has already seen one teacher use effectively in a 'times as much' lesson a few days earlier. The other reason was that the whole emphasis of the lesson was not on finding a solution but on ensuring that all the students understood why they were using division in order to solve the problem. It was interesting that despite dealing with division by a whole number with relative ease, once the divisor became a decimal number, the grade 5 students suddenly found that this problem was largely inaccessible for them. This did not necessarily put the students off, they were happy to admit that they could not divide by a decimal and it was reassuring to see how they felt so secure in admitting this to the teacher. This was the response the teacher wanted as he wanted to develop the reason why through mathematical discussion with the students, so he changed the classroom setting into an informal setting by inviting them to move their chairs so they were all sat at the front of the room and not behind their desks. The teacher encouraged the students to speak mathematically to their peers when they were explaining and despite the fact that by the end of the lesson the problem had not been solved the students had taken part in a mathematics rich lesson. I just

wish I could have seen the follow up lesson, I wondered if the students would have gone away and researched how to solve the problem before the next lesson, I would hope that they did.

The most meaningful research lesson was the second lesson. It showed me how an admistration and staff can work together to create a powerful lesson study environment. The principal and the math department head were very active in the planning and encouragement of the lesson.

June 30 in Konagei elementary school The teacher has a lot of communications with the whole class and 6 different ways were presented on the board. However, I found that the girl in front of me was not able to follow the class. She just copied the blackboard notes and obviously her note making was slower than the class pace. She finished her note making at the last minute. I doubt whether her learning really occurred in her note making. I do prefer individual work and whole class discussion in my own teaching, but this lesson observation really shocked me. I need to include more group discussions and care for all students in my class in future. Don't be cheated by active students' responses.

The most meaningful research lesson to me, was the Research Open House at University of Yamanashi Model Elementary School. The lesson was conducted by Miss Kasai, Sayuri on times as much with fractions. This research lesson emphasized on division using fraction, which began with partitive division as introduction then focused on quotitive division. From my knowledge, there was no such emphasis on times as much in my country mathematics syllabus, and my understanding on division was often restricted to only procedural understanding for partitive division at Grade 5 level. However, through this lesson, I was impressed that Miss Kasai would teach from a point of view of pupil in which she kept on asking pupils are they sure that a number can be divided by decimal? This question raised the interest of the pupils to think and to find out whether it was really possible. Pupil themselves could see the relationship between numbers as the teacher as asked a very engaging questions to them even before the lesson start, which is: What makes 38(the number of the day)? A warming up question before the lesson begin , which was related to what pupils will learn on that day, indeed would help pupils to prepare themselves in learning. The use of double number line was another point that I found it meaningful and useful. The double number line was a powerful tool to help pupil in thinking and relating the set of numbers. In the lesson, pupils started to come out and draw the double line diagram to help them to figure out the times as much. This was the moment in which involvement of pupil was clearly seen as they were eager to participate in this activity of solving the problem. The use of double line is good to justify the pupils' thinking and to convince others that they were thinking in a correct way. At primary level, perhaps using only double number line would be helpful for pupils to learn solving quotitive division.

The June 24 research lesson at Sugekari Elementary School really opened up the Lesson Study process for me. The lesson on the day before (our first) was at an attached school, and the whole process felt a bit sterile and a little staged (not as in fake, but as in performance). At Sugekari, I was thoroughly captured by the school, staff, and children. The experience felt more authentic and familiar to me: real kids, with real teachers, with a real principal, all engaged in the fun, difficult work of getting better at teaching and learning math. It was a vision of what I would love to be able to create: from the meticulous note-taking, to the raucous discussions of whether a diagonal helps define a quadrilateral, to the reflective focus on neriage. The lesson at Oshihara Elementary School on June 26 was also especially meaningful, for very similar reasons.

I will name two so that they can be compared. 1) June 27, grade 5, Kasai – sensei and 2) July 1, grade 5, ? – sensei. The first was focused on times as much with a fraction while the 2nd was focused on division of whole number by decimal both focused on the meaning. Both of these lessons were larger (cross-district and district wide and the topics were (I think) difficult ones for students to grasp. Both used the double number line as a model for understanding the problem. These two lessons were both excellent, but showed the fine line that is walked by the instructor in introducing a topic and working with the students to a solution that is understood by a majority of the class. I viewed both of these lessons as the teacher being the orchestra leader and the students were the players of the instruments. The first lesson was amazing with the teacher beautifully calling student by student until the double number line model came to fruition. The teacher focused on the double number line model exclusively and had different students add to the model until understanding emerged. The teacher was careful to call on many students and constantly check for class understanding. I believe it was successful for a majority of the class. The second lesson also went well, but the double number line model was a bit more difficult in that the students needed to model a division problem with a decimal rather than multiplication by a fraction. I think that the combination of the teacher allowing more models to be shown by the students beyond the double number line and the problem about understanding the meaning of division by a decimal maybe was too much to overcome in one lesson.

2. In looking over all the post-lesson discussions during the immersion program, name one that was especially meaningful to you, and why:

Text Response

The discussion on 26 June was the one I enjoyed the most. I think this one was very well translated so I felt better able to follow the flow of the conversation. I liked that fact that for the first time, there was a female taking a leadership role (chair) and that it felt as if she was supporting the teacher by stressing the fact that they all, as a research group, bore responsibility for the lesson.

The most informative post lesson discussion for me was at Showa City Oshihara Elementary School, Friday 26th June. In the post lesson discussion, much was made of the fact that the teacher had used origami paper to exemplify division with remainders. This was seen as a vital error: origami paper cut in half is useless! Students rightly answered the question 'If you divide 9 pieces of origami paper between two people, how many pieces will each person have' with the answer 4, and one left over. When one boy suggested the origami paper was cut in half, the class gasped! However, this was not the biggest oversight in the lesson. The post-lesson discussion also concentrated on the teacher's decision to move away fro the textbook examples and to look at a problem which focussed on grouping rather than sharing. Professor Fujii in his summary at the end said that if a teacher was to veer off the well-researched and planned curriculum, there had better be a very good reason! The level of detail that Professor Fujii went into here was incredible. He had sourced questions about remainders that had student responses to show how the choice of question affected how students thought about remainders. It was added an extra dimension to the discussion: something that would not happen in lesson discussions here in the UK.

The post-lesson discussions of Grade 5 mathematics lesson taught by Ms Kido in Sugekari Elementary school was really meaningful for me since it was the first post-lesson discussion I had joined in since the Immersion programmed started. The lesson was on the topic of drawing congruent and finding the diagonal shapes. The teacher Ms Kido was very confident when the post lesson discussion as well as in the classroom teaching. The post-lesson discussion was conducted among the teachers and with us the LSIP participants. We have been given chances to discussed on the lesson with the teacher Ms Kido. Many comments and suggestions were shared together in the lesson. Later, Many questions were posted to her as Prof. Akihiko translated to Ms. Kido and the participants.Pioneer interesting and fruitful experiences were gained in this post-lesson discussion.

Research Lesson number 3: Tokyo Gakugei University International School This was especially interesting to me as the Professor at the end summed up so succinctly the could have improved the lesson and offered concrete work: 1. Students look at the phenomenon and do the calculations 2. Students should then move on to the table but what is the purpose of the table: for students to see what is and isn't changing...this is at the heart of a functional relationship 3.He illustrated how a table could have been used by the teacher to make more explicit what was happening as opposed to relying on the students' work at he board 4. He then offered a problem from an old textbook regarding a tree growing half its height every year..this would have achieved the same goal and been less convoluted than the phenomena with taking pills!

Again a difficult question! Possibly the first one as I did not know what to expect and so that gave me a better idea of how what I had read about might look in practice, and therefore a baseline. The interactions and formal structure was fascinating at all such occasions - the level of discussion and the clear focus on the research point. the discussions were always very specific and though sometimes quite harsh, it never felt as thought this was a critique of the individual teacher practice.

Research Lesson 4 Oshihara Elementary School & Research Lesson 2 Sugekari Elementary school. I feel that both these discussions were more meaningful as they were school based LS and the participants had a greater "buy in" to the outcomes and lessons learned as they would more directly impact on their day to day practice at their respective schools.

Again the last discussion was very useful since I had a better understanding of what the children were doing. I also found it very useful to be able to discuss the lesson with fellow LSIP participants and try and understand what would work and what would not work in a different culture. It was very interesting to see how much how perceptions of lesson study had changed in two weeks.

Each post lesson discussion held a great deal of value, but I found the post lesson discussion at Oshihara Elementary School to be especially meaningful because we were able to hear ideas from the Mathematics

Representative from Yamanashi Prefecture, from Dr. Nakamara, and from Dr. Fuji. I found the diversity of commentary to be quite comprehensive and the ideas discussed caused me to be quite reflective. The point the discussant from the Yamanashi Prefecture (name?) made about being more selective when choosing the 'manipulative' was important. While seemingly obvious after the fact, a piece of Oregami paper cannot be used once it is divided and this discussant highlighted the foundational confusion this may have caused some of the students. This comment resonated with me because too often teachers in the states select 'general' nonspecific representations for children to use to solve problems (beads, counters, etc.) and they don't stop to consider how these choices limit student idea development and understanding. This was an excellent lesson, but the fact that students were expected to cut Oregami paper rendering it useless was a hurdle for some students that impeded their ability to think through a lesson. Dr. Yamanashi emphasized the fact that a lesson cannot be taught because we want to, but rather because we need to research it to make sure its appropriate. This approach is different than many of the lesson study cycles I've been a part of. We have not taught lessons in context, but rather because they interest us. His points about presenting a Research Lesson within the context of student learning requires teachers to think about what to do next based on what the children experienced in the research lesson. He also highlighted the tendency and frequency of interactions between teacher and one student (10 interactions) and emphasized the importance of the teacher looking at all students. In EVERY lesson taught, I found that teachers called on boys disproportionately so I found this comment quite valuable. And Finally, this discussant emphasized the importance of writing a friend's ideas during the lesson as a way to teach children to consider the perspective and ideas of others. Dr. Fuji continued the discussion of the importance of copying a friend's idea, but emphasized the significance in being sure students UNDERSTAND the idea copied. He also discussed the fact that in this lesson, the partitive and quotative significance didn't matter within the context of the problems because in both situation the mathematician can divide on. Personally, this comment was a great reminder about the need to give a mathematically specific situation about the need to chose better if you are trying to have students make the distinction between the types of division so that the students can enjoy the mathematics and use their natural reasoning process to solve problems. I found that in this post lesson discussion, the three voices following the committee and faculty discussion truly deepened my thinking and understanding of the mathematics, instructional decision making, as well as future considerations that are easily extended into other ideas and subjects.

The post lesson discussion that I found most meaningful was the Congruent Quadrilaterals lesson. I thoroughly enjoyed this lesson, and I was amazed in how much they discussed the 'forgotten' aspect of the manipulative to show students what the quadrilateral looked like. It was also clearly apparent that the teachers in this school enjoyed teaching maths, and were looking to further develop their own professional understanding

The post lesson discussion at the end of the second lesson was the most valuable to me. There was a large amount of time spent discussing the fact the teacher forgot to use a manipulative to show the students quadrilaterals. The fact that Japanese teachers are really able to focus on details such as this, the details that have the most impact on students understanding, is a reflection of the planning that goes into research lessons. This was a common theme in the post lesson discussions that I observed and something that I want to capture back in the UK. To have the best post lesson discussion the planning has to be thorough and detailed.

The quadrilateral lesson, I concurred with AH's criticism.

24/06/2015 - Sugekari Elementary School. It was here that I realised that general pedagogy and relationships with students isn't sufficient. There also has to be a clear focus on developing mathematical thinking. To my untrained eyes the lesson had appeared good. However the reaction of the knowledgeable others helped me realise that I've been looking at the wrong things!

The post-lesson discussion in Yamanoshi school was particularly meaningful since it seemed to demonstrate the most sense of community between the teachers who had planned the lesson. The discussion was robust and dealt with many mathematical issues within the lesson (let's think about division!), but I most enjoyed the fact that the conducting teachers' colleagues defended him when external observers questioned some of the activity within the lesson.

This is difficult as I felt all the post-lesson discussions were meaningful. Can I choose two? Firstly I will address the post lesson discussion at Sugekari Elementary School on Wednesday 24th June 2015 (Congruent shapes). The post lesson discussion started with time given to all the observers to write their own thoughts on 'what went well' and 'even better if' in different colours which were then displayed at the front so that everyone could see. The merits of the lesson were discussed, such as the students were engaged from the start of the lesson, prior knowledge was addressed, the whole lesson was covered

in the set time, it was a good strategy not to show the right angle to the pupils and the teachers use of the red pen to highlight measurements on the diagrams. This initially gave the teacher some good feedback. Then the other column was addressed which was mainly concerned with the question, why after having included the use of a geometrical tool to illustrate the problem in the lesson plan it had not been used in the lesson? The teacher admitted that 'she had forgot', this really impressed me as it showed that was not frightened to admit her mistake in front of other colleagues and such a big audience as the LSIP team. The school principal had made it clear to us before the lesson that the planning was a team effort and that no one person had ownership of the lesson. This really encompassed the idea of lesson study. The school principal and the 'knowledgeable other' addressed the fact that the students may not have internalized the problem at the beginning of the lesson but overall they praised the teacher and sais well done at the end of their reflections. it was noted that the teacher had just 10 years teaching experience so she was forgiven for forgetting an important aspect of the lesson as she was still relatively inexperienced and also this was her first academic year at this school. Secondly, I'd also like to reflect on the post, post lesson discussion that we had amongst the LSIP group on the final lesson observation. Discussing the merits of whether to divide by 1.6 or 1.5 was very interesting and hearing Professor Fuji talk about how much thought goes into choosing specific numbers to use in problem solving really brought home the impact of the mathematical thinking that needs to be involved and addressed when writing mathematical problem solving activities.

The discussion following the lesson on sequences (the medicine lesson) was especially meaningful because it showed how important the knowledgeable other can be. His thoughtful comments placed the lesson in context of the current curriculum and historically--going back to the 1950s. That type of detailed knowledge of curriculum and mathematics is rare in America.

June 23 in Tokyo Gakugei attached secondary school There are 8 teachers involved in the post-lesson discussion. All of them actively engaged in the discussion. Students' work and their learning reflections at the end of each class were collected as a part of evidences of their comments. They not only indicated some problems existed in the teacher's instruction, but also gave their specific suggestions for improving the teaching. The lecture from outside experts was well prepared. Besides of talking about the pros and the cons of the lesson and giving alternative teaching ideas, he also took Japanese students' performance in TIMSS 2011 as an example to illustrate that the task discussed in the lesson was really difficult for Grade 8 students. His talk brought some new ideas and new solutions to the same issues discussed by school teachers.

The most meaningful post-lesson for me was the one at Showa City Oshihara Elementary School. The lesson was taught by Mr. Yuji Ishikawa. The post-lesson was attended by three final commentators and what impressed me was that the three final commentator could comment on three different aspects of the lessons. From this lesson, I also learned about the importance of having an experienced final commentator to participate in lesson observation and then comment on it. They could help to pin-point certain team overlooked by the team of teachers who plan the lesson. The post lesson discussion did give lots of input from the flow of the lesson to the expression written on the board. Only when teachers gathered together and with the final commentator reflecting on a research lesson, it was the point where learning and teaching professional development could happen.

The post-lesson discussion at Oshihara Elementary School was the pinnacle for me. The quality of the lesson debrief was significantly different. There seemed to be much more talk about specific examples of student responses, certainly owing in part to the strategic placement of the teachers at the table. Professor Fujii's comments were qualitatively different as well. You could tell why he's so good at what he does. He was really focused on the students, with specific examples (and even a few illustrative pictures!), and he brought a sharp focus on the math (for example, writing 4x2 rather than 2x4). I also noticed, more so than during the other debriefings, the use of the phrase "I wonder..." It is helpful to frame the mindset of the speaker and ease the possible sting of the comments, in the US context. Today, though, it struck me that it might make the list of must-haves for Lesson Study in any context.

The post lesson discussions in general were very interesting and a challenge for me was listening to the original speakers in Japanese and hearing the English translations simultaneously. I thought at first that maybe it was the translators voice making me sleepy, but in retrospect it was probably more of having two sound inputs and trying to focus just on the English for an hour! Gives me great respect for our translators! The discussion that the meaningful was June 24th at the Sugekari Elementary School. The discussion was on the geometry lesson of creating congruent quadrilaterals. I thought the discussion was good because the questions were critical and the teacher generally had thoughtful answers for each question. The item that stood out was that the teacher did not use the manipulative in her lesson which was obviously something that the group thought she should use to show the necessity of

locating the 4 vertices. From her comments it seemed that she did not truly grasp the benefits of the manipulative and I am thinking that it was for this reason that it was forgotten as part of the lesson. I will not forget the other teacher from her group bringing this topic up again at the dinner/party with the group later that night.

3. In looking over all the lectures during the immersion program, name one that was especially meaningful to you, and why:

Text Response

The lectures on the first and last days were the most meaningful as they explored aspects of lesson study with which I was unfamiliar or about which I had questions.

For me, the lecture on the final day brought everything we had done together and really focused my thoughts on what I planned to do on my return. We had time to reflect, which meant we had clear goals for when we returned home.

The last day lecture by Prof. Akihiko on how to Japanese teachers practices Lesson Study among their schools and district were very meaningful for me . In other, Prof. Fuji's talk on the textbook review was also very useful for us.

The Lectures on day 1; Reasons: 1.These lectures highlighted for me what is misunderstood by Problem Solving in Ireland and perhaps further abroad. Problem solving is a means through which mathematics is taught. 2. The distinction between different level of teachers (although I as aware of this from Sugiyama) was brought home to me and how Kyouzai-Kenkyu plays such a role in this development. Level 3 can only be attained by doing something for yourself and working with your colleagues to do so. 3. How Professional Development is organised for teachers who are at different levels

EASY!!! Day 1 - Lesson Study: Nice to have or Must have? I have gone back to this over and over again, both during the immersion programme and since. It is such a rich source of ideas; information; so many opportunities to reflect on so many things at different levels.It set the scene for lesson study programme; it explored problem-solving in a clear and engaging, yet thought-provoking way. This will be used by me and my team in many ways over the next academic year and beyong! I have already used parts of the presentation and in fact slide 3 - Emphasis on Problem-Solving. I photographed and sent to my maths team and they used it as a starter at our termly networks for primary mathematics leaders. I also included the slide 10/42 at networks when I got home as the quote is relevant to what is currently going on in mathematics education in UK at th moment. And again I have used slides from this for a very short presentation to the entire North Yorkshire School Improvement team (80 people) as a 'taster' for a session at the beginning of the new school year in September. And actually, having opened up the presentation again just now - its distracted me again!!!

There was no specific "lecture" that stood out but the elements that were most useful to me were when we got an insight into Akihiko's thinking. When he gave us the benefit of his wisdom this raised my understanding the most.

All lectures were very informative. I really liked to reflect on how much my understanding of lesson study had developed during the last day.

I found the summative lecture by Dr. Takahashi, "To Plan Lessons for Lesson Study" to be quite meaningful as it helped me draw together my ideas about all that I had seen and begin to formulate articulations about this experience, my Lesson Study learning, and next steps. I also like that on the same day, Alan shared his TRU lecture because these ideas are central in my experience and helped me to take what seemed very Japanese and infuse it with a culture of teaching that felt quite familiar. Alan's lecture helped to bring the authentic Lesson Study process into focus with a more global lense on a powerful learning environment that extends beyond a mathematics classroom. Of course, Alan gave me much to think about in his brilliant Alan way. Great paired lecture. It is so easy to forget how to be proud of the good things we do when we are immersed in an environment so different from where we come from. I felt quite down on our American educational system on many days. Listening to Alan helped me remember our strengths and made it possible for me to absorb the summative ideas presented by Dr. Takahashi.

The lecture which was most meaningful to me was Akihiko's lecture which included data from the TIMMS test which showed the amount of content taught at the particular time in the year, correlated with the percentage correct on the TIMMs test. This showed me how although content may not have been taught to students, they have developed thinking skills which they can apply to solve questions which

are unfamiliar to them. It resonated with me, as it proved how useful and beneficial it is to encourage students to explain they thinking, and also listen to the thinking and explanation of others.

The lectures during day one about lesson study followed by the talk about the Japanese curriculum were the two that immediately got me to reflect and think. Firstly, the lecture about lesson study really made me challenge my thoughts about lesson study and question the merits of what we had already put into place in my school. This is something I needed to go through and by thinking deeply I realised that we have made good progress. Being in Japan was my chance to learn about what features are left to incorporate in our lesson studies and what features needed refinement and improvement. The lecture about the curriculum left me really envious. While we will never achieve such a coherent curriculum in the UK for a long time, I did leave knowing that I could make a difference in my school and that I could share what I had learnt. I have already had discussions with colleagues about changes I would like to make to our year 7 curriculum.

The in depth discussion about CLR cycle.

The first session! This quote says it all.... "Ten pages of mathematics understood are better than a hundred memorized and not understood, and one page actually worked out independently is better than ten pages clearly but passively understood" (J.W.A. Young, 1908).

I very much enjoyed the lectures on the first day which introduced how teaching mathematics was approached and thought of in Japan. While I had heard of the 'levels of teaching', this was the first time I connected it with practice due to Pr Takahashi's explanation of the theories and the culture of teaching and professional development. I also very much enjoyed seeing how textbooks were constructed to encourage learning through problem solving and enjoyed identifying the various strategies students might use in attempting to solve these problems.

I found the first day of the programme very interesting (despite trying to stop myself from falling asleep due to jet lag!!!) as it gave us a really thorough and excellent introduction to Japanese Lesson Study, how it has developed over a long period of time and how it is seen as essential professional development by Japanese mathematics teachers. I really enjoyed the lecture by Professor Takahashi on 'Teaching Through Problem Solving - Level 3 Teaching' as this is an area close to my heart. As a new teacher educator I want my trainee teachers to be able to develop these essential teaching and learning skills so that they can become outstanding classroom practitioners who will foster the development of understanding mathematics and making connections between topics through their teaching. I also want them to recognise that when they teach it is a once in a lifetime opportunity for the students in that classroom at a particular time so they must ensure that the learning experience is worthwhile. I also thoroughly enjoyed looking at and doing some of the Japanese problem solving activities myself during this session.

All of the prebriefings were very helpful. I wanted to learn more about the lesson study meeetings where the teachers develope the lessons. We didn't get a chance to see any of those, but the final lecutres that tried to present a summary of these meetings were helpful.

Talk: Lesson Study: Nice-to-have, or Must-have? This lecture introduced the aim of lesson study, how to teach mathematics through problem solving, three levels of mathematics teaching and how lesson study could be helpful to help teachers achieve the third level of teaching and so on. The talk improves my knowledge of Japan mathematics education and lesson study.

The lecture on the first day was the one especially meaningful to me. The lecture with the scope on Lesson Study: Nice-to-have or must-have. I think it was a good start and to introduce the participants to the current practice of lesson study in Japan. I gained some insight to the Japanese Lesson Study and would be ready to learn more through lesson observation. From this lecture, I learnt two important statement. The first is Lesson Study is a lifelong process and it is the accumulation of knowledge of teachers. Through lesson study, teachers get to share their thought and ideas on how to teach a topic or solve a problem. This is also a platform for novice teachers and experienced teachers to learn from each other. The second statement is that every lesson is a once is a life time experience so we must treasure this opportunity to give them the best lesson every time we enter the class. Hence, every time when I enter a class, I must make sure that it is a well-planned lesson. I do agree too that there is no perfect lesson, as a good lesson may not work for different group of people. Hence, it's true that lesson study should be an on-going life learning process that we should be doing in weekly basis.

The lectures as bookends were all very helpful. I found myself wanting more of that, interspersed throughout the program. While not a full lecture unto itself, in both the pre-reading and the first-day lectures, I loved the response to the idea of re-teaching. The students must always get the best possible first lesson, and they should never have to re-sit through a lesson they've already had. Dr. Takahashi wrote on the board: everything is once in a lifetime. When thinking about classroom teaching, this

conveys both the beauty and urgency of sharing learning time with young people.
I think lectures on reviewing the lessons prior to watching them where we were allowed to explore on our own and practice finding student responces were the most meaningful. Then when we watched the lesson, the student responses were more meaningful. To me, any process where we can participate in the lesson study experience is meaningful. Lectures can be viewed later or watched on the computer, but hands on experience always seems more meaningful.

4. Was there a conversation among participants during the immersion program that stands out to you? (This might have been an informal conversation, outside the official program.) Please describe, and provide reasons that this stood out for you:

Text Response
Conversations with Jun Li about Shanghai maths were very enlightening for me.
I work closely with Matt Woodford in Nottingham as part of the Maths Hubs programme in the UK. We had a discussion about how we believe we have just been 'playing' at lesson study in the UK. We discussed at length how the Japanese curriculum is well researched and builds every concept carefully through carefully chosen examples. This means that when immersed in lesson study in Japan, there is a whole framework that links all the learning together. So, in post-lesson discussions, participans are able to refer to prior learning when discussing examples that have been chosen. Matt and I compared this to practice in the UK where what students has learnt is quite arbitrary! Therefore, what can post-lesson discussions really tell us about except that one lesson at that particular time?
Yes, many times the informal conversations between me and the participants during the immersion program were stands out for me. For example, most of the conversations were done after the lesson observations. In formal post lesson was carried out among us. We probably share our thoughts on the lesson taught. Mainly on the teachers' teaching practices and students' participation in the classroom. Apart from that, most the challenging problems posed in the lesson were our topic of discussion too.
Yes many conversations but the one that struck me most was how familiar students were with what they had learned and when they had learned it. For example in Grade 3 (Research Lesson 4) the students could remember what they had learned in Grade 2 as prior knowledge for this lesson. We were all struck that we observed this happening over and over again. In Ireland by and large students would not remember what they had previously learned never mind in what Grade.
Not really. I enjoyed talking to colleagues from other countries about the education systems, their experiences of lesson study and different models. I was sometimes surprised by some of my UK colleagues in terms of 'Maths Hubs' and what they do and do not know, but enjoyed their enthusiasm for what they believe they are trying to do.It was intersting to talk to such a range of people from the wide spectrum of mathematics education and educators - university professors; graduate students; teachers; PGCE courseleaders; government/local authority advisers/koshi !!! Ok - I was shocked when a couple of maths hub leads said 'who is Dylan Wiliam?'
My disagreement in "our" post observation discussion with others in the dispute about 1.5 & 1.6 This was the first time we properly focussed in on the Maths but the discussion was not handled formally enough and as a result I went away dissatisfied that my opinion had not been properly heard.
Yes on the last day we spent a long time discussing if the choice of numbers (320 and 1.6) were appropriate. This highlighted to me how much our perceptions of lesson study were changed. However all conversations with colleagues were very rich and important for my own development.
There were countless conversations and interactions that were meaningful among this incredible group of professionals. It is difficult to pinpoint a particular moment, but most of these conversations happened over breakfast, walking to and from the university, or over a beer

in the evenings. The diversity of backgrounds, experience, and professional lense is what made so many numerous conversations possible. One conversation stands out to me and it was after the Research Lesson Konagei Elementary School. While walking to Hotel Mets with Monica, Hana, and Kalai, and Tan Phei Ling, we engaged in a discussion the difference between eastern and western education… The individual vs. the collective. We discussed this difference as it presents in each of our countries and it helped me form the following ideas. and questions. In the US, the mathematical learning and discussion could not be the sole consideration in the planning of the lesson. Does the Japanese teacher scaffold a lesson? Where were the resources for the struggling students? What is the role of the teacher for ALL the students? I understand that teaching 40 students in a lower division class cannot be about the traditional western student/teacher relationship. I believe this may be part of the cultivation of the group as teachers. I am not disregarding the learning that develops through presenting ideas and considering the ideas of others, but perhaps broadening the number of 'colleagues' in a class enables the Japanese teacher to support students through cultivating a culture of authority among students? How does this impact the students who cannot participate in ideas sharing? Example, the boy biting his feet. How is he viewed by his classmates in terms of what he has to offer? It is clear that the teacher is able to make next step instructional decisions, but is he also basing these decisions on the needs of the individual students? This appears to be a critical cultural difference in the teaching of mathematics between eastern and western education.

A discussion which stood out for me was one that I had with a few other participants regarding how often we all incorporate problem solving lessons into our teaching and learning programs. We all said how we could see the benefit of using this for all lessons, and how one great question is better than many average questions.

I had lots of discussions with colleagues from Nottingham. These were the most interesting because these are colleagues that are local and I will be able to work closely with them. I have made some really useful contacts and have started to work with some of these people already. Discussing what I had already put in place in terms of lesson study was a really useful reflective process for me, people on the programme were really interested in what I have already done. But also listening to others opinions, about what they were planning to do, allowed me to evaluate our processes and think of ways to improve.

The lesson about quadrilaterals, there was a debate about using manipulative in the introduction which later came up in the review.

Not one particular one that sticks out. I developed my thinking with a number of others slowly and gradually as the two weeks progressed!

I can't say that any one conversation stood out but I found it so beneficial and helpful to discuss mathematics education around the world with this international group. I felt I have learned so much about how mathematics is taught in other countries, not just Japan, and this will help in developing my own vision for mathematics teaching. It was mostly in informal conversations where these were discussed.

There were many! The main ideas that we talked about were: 1. The amount of time that goes into the planning stage of the research lesson. 2. The emphasis on understanding how to solve the problem rather then on what the actual solution to a problem is. 3. The double number line 4. The collaboration between professionals from all sectors of mathematics education.

Our attempt at a post-lesson discussion stood out the most. It showed me how focused the Japanese discussions were (and ours was not).

Alan's TRU framework is a new tool for me. Especially its "equitable access to content" and "agency, authority, and identity" dimensions made me consider mathematics teaching issue further from students' perspective.

During the lesson observation in Showa city Oshihara Elementary School, I had a chance to sit together with Prof. Akihiko and hence we manage to have a short conversation before the post-lesson discussion starts. The discussion with Prof. Akihiko was quite eye opening as he said that it was he was not sure if the lesson as good as he commented that the teacher needs more kyozai kenkyu as the research content of this lesson was not very meaningful as the question itself, asking if the remainder could be divided into half or not is not very meaningful, instead it should be asking if the remainder could be divisible against the people. He pointed out that the context of cutting the origami paper did not fit with the pupil, it/s not meaningful to the pupil as some pupils were whispering on the reason why must you cut the paper into half... It was such a nice paper that you cut it. Hence, perhaps the teacher could explain more

on the need to cut it into half, is it meaningful to cut into half, what does it mean when it was not cut into half? Can the paper be cut into half? Is there anything that can be cut into half when we want to divide equally? Or is there anything that we could not cut into half? These questions would help the pupils to contextualize the need of cutting things into half and the rationale for doing this so that pupils were convinced to do so. Otherwise, many pupils tend to want to leave the remainder as it is. To me, the lesson was quite well-planned and smoothly carried out. I would never thought that the lesson could be review from this aspect and I was convinced that with a more experienced teacher that you can always gain more insight though we were observing the same lesson at the same time.

I had multiple informal conversations with colleagues, mostly from England, about initiatives to improve mathematics instruction in their locations. What stood out to me across these conversations is the same consistency of inconsistency that we face in Detroit (and really throughout the US). Like Japan, England has more national-level initiatives, but they were not characterized as systematic and sustained. Implementing Lesson Study seems a powerful way to confront this, but the historical, cultural, and structural impediments outside of Japan are daunting. I would have liked to have more formal opportunities to share specifics of implementation plans (past and future) with other participants.

I had a conversation during lunch time with a few participants from the UK in which a few interesting topics were discussed. One was that that the countries standards/curriculum produces and keeps teachers at level 1. Second was creating time within the schools schedules to create time to prepare/conduct lesson study. The schools were not being supported by upper levels of their organization to make these changes. I realized that this was similar in the US, but that in most cases the schools in my area do not provide meaningful teacher development to help teachers grow out of being level 1. It seems that it is up to individual teachers to grow and not a sense community growth as in Japan. This is a cultural change that needs to happen, possibly school by school, in order to succeed at lesson study.

5. Please comment on the schedule/timetable of the program. Was there enough time for preparation and review? Other issues that would help in planning future programs?

Text Response
Yes
The only one thing I would have liked was dedicated time to discuss our lesson write up with our colleagues. This has been difficult since we returned home. Everything else was very good, I thought.
The time-table or the schedule of the program was good and well planned instead. The time allocated for the preparation was enough whereas the review needs more time. Other issues that would help in planning future programs, I felt to reduced the number of the lesson observations might helped on understanding the limited lesson observations in more in-depth from the view of participants observers.
The schedule/timetable was arduous given Jet lag but it had to be this way to get the most out of a programme that required travelling half way around the world to access. I have no issues at all with the timetable but would feel the following would help in the future: When one is assigned to observe a Lesson the other participants sit down in the chairs that are allocated to them and listen and follow Tad and Makota's translations. I found that during my observation (and this was not just confined to me) practically all participants were standing and moving between desks which made it difficult for those who were meant to be observing.
I thought the programme was extremely well thought out and planned. It was very professional and with clear focus. I had plenty of time to do preparation and review. I enjoyed having 'work' to do in the evenings, probably because I havent had such an opportunity to completely immerse myself in my own interests and learning. No family, no team, no phone calls - just two weeks to have time to myself to really think and reflect on what I am learning, what I have learnt in the past and reflect on my own practice, my own experiences as well as think about where next? Personally, I would have preferred a different day to myself, rather than the Monday - but in some ways this was good because it limited my choice of what to do with this day because museums and galleries were closed on Monday. Any other day, it would have been more difficult to make a choice!!
The schedule was overall excellent and in particular our opportunity to see so many lessons. I would have liked to have less time preparing for the lesson on some occasions and more time open discussion between delegates. This could for example have been built into a morning to discuss the previous day or an informal gathering at the end of a day - the hotel would have benefited from a lounge/bar area that delegates could meet informally in the evening.
Maybe the programme could have been condensed a little, two weeks away form one's family is such a long time! During some of the lectures I would have liked to have more time to do the mathematics with colleagues instead of listening to the speakers interpretation of the task. I would have also like some of the lectures to be more of a two way process.
I thought the prelesson lectures and discussions were very valuable. One of the post lession discussions that was most interesting was the one we held privately at Sasahara Elementary School in the school library. Combing through the mathematical concepts, the details of the student comments, and our own questions was a nice change to the post lesson debriefs when we only listen without an opportunity to discuss the questions in our heads. I enjoyed considering the ideas of others and I was able to note many new ideas that I had missed on my own. Interestingly to me, is the fact that through both formal and informal conversations with LSIP participants, we have found a common struggle in the job of educating children. First would be a lack of deep mathematical understanding among many of the professionals who teach lower divisions. Second is a culture cultivated in our countries in which students and families expect more individualized attention build in to our lessons. Third, the teaching in our countries does not focus on the problem solving in the same way, so that students are not as skilled at facing an unfamiliar question. Consequently, students have difficulty finding the entry point and collecting the prior knowledge necessary to begin a problem. Much of the responsibility in this third point lies in the culture of teaching, professional mentoring, and note taking. These are some of the issues that I have been struggling with this past week, but within the community of respect and trust built among the LSIP participants, we have been able to engage many informal (and today) formal conversations, which help us unravel a bit of the challenges we all face. Through the similarities, a need has been established for

ongoing discussions, which I hope will lead to an ongoing network of support and idea sharing. It is incredible to find a group of colleagues who can engage the discussion of a 45 minute lesson for 3 hours. I believe we would have benefitted from more of these discussions on our own. Perhaps after the post lesson discussions, Project LSIP could schedule time for the group to meet and engage their own questions and observations. My group's lesson observation was the last lesson of the entire program. We did not have time to discuss our observations as a group. I think that meeting as a group to discuss lesson observations and our learning as a group would be beneficial. I think meeting as an entire LSIP group or in our teams after each lesson would have been beneficial as our international perspectives on the mathematics, the process of Lesson Study, and the cultural differences we have with authentic Japanese Lesson Study would have been enhanced and supported with more time to discuss as we did on June 30. Also, this may have helped enrich a conversation about next steps for Lesson Study in our own situations.

The schedule of this program was fantastic- we got to see many lessons and also have some time before hand to discuss the lessons and what we would be seeing. It would have been beneficial to have more time after the lessons to debrief and discuss, and I got a lot out of the post lesson discussion which we participated in ourselves.

In my opinion the programme allowed ample time to prepare and reflect. For future years the only comment I would make is to reflect on each lesson more as a group and it would be really interesting to hear from the professors more. We had some great lectures but at the end of some lessons we were all itching to hear the professor's views and opinions. This would have been a real worthwhile addition to the programme.

Great timing, perhaps a fur the Weekend? I would of liked more discussion time at review.

Yes - good. The lesson plans were given well in advance so timings worked well.

It would have been helpful to have had a little more time in the evenings to reflect and to write up these reflections. It might be an idea to incorporate some of this time before leaving the university to allow participants time to begin their reflections.

The only suggestion I would have is that the beginning of the schedule seemed to be heavier than towards the end. Perhaps if the program had started on Tuesday rather than Monday or just half a day on Monday, it would have given a little more time to settle in, as being at work in the UK until Friday and then travelling Saturday and Sunday meant that Monday was quite a difficult day for many of us. Another issue I have, is that I felt the two lesson observation on the Saturday with so many people present and having to use a video link and not being able to see the work the children were doing was slightly counterproductive. I feel that observing just one lesson may have been more beneficial.

I feel like there was enough time to prep and review for each lesson, but I would like to observe a planning meeting.

a very good plan.

To me, the schedule was perfectly fine and I did not encounter any issue on that. Well done.

The schedule and timetable were demanding but not overwhelming. There were sufficient breaks across the program and within each day to keep me from overload. I think we spent enough time in preparation for each research lesson (individually and as a group), but I would have appreciated and benefitted from more time spent in review as a group after each research lesson. It would have been good to hear from Professors Takahashi and Fujii about their impressions of the lesson and especially the post-lesson discussion. As I mentioned in question six, I believe additional, formally-planned time for sharing and reflection among the participants would also have been helpful as I processed all I was learning.

I think the schedule/timetable was fine in terms of enough time for us to prepare and review. My only suggestion was that there were some times where we had time between the lesson and post lesson discussion. During that time, it would be a good opportunity for the group to debrief on the lesson. If there is time available, it would be fun to try to tweak a mathematical question from a text to make it "lesson study worthy".

6. In your mind, what are the essential features of lesson study?

Text Response

Collaborative planning and shared responsibility Linking planning to research - kyokai kyenzuu A lesson with a research question and a post-lesson tightly focused around this research theme An oberved lesosn where the observers remain neutral and do not interact with pupils nor interfere with the flow of

the lesson in any way

Kyozai Kenkyu (not done at home in such depth) The collaborative team planning Planning over a long period of time Considered pupil responses The knowledgable other's summary, when possible, as this takes the conversation to a deeper level.

According to me, the essential features of Lesson study is the planning of the lesson and the post-lesson discussions. The planning needs more collaborative minds to come out with a compact lesson plan. The post lesson discussion with participant teachers are very meaningful on planning the future lesson or re-teach the lesson again.

1. Need a question to start with..identify an issue students are struggling with. This must be very clear and focused 2.Kyouzai-Kenku is where all the groundwork is done....put yourself in the students' position and identify all the possible methods they may come up with to solve the problem. Order these from least to most sophisticated and consider the advantage or otherwise of every move made in the classroom. 3. Design the Unit and Lesson within it. Include the rationale for all decision making e.g. Students do X because 4. Keep in mind this is not an ideal less plan but a research proposal: hence the well formed question posed in step 1 5.Post-Lesson discussion solidifies the ideas to overcome the issue and the both the moderator is essential to continuously summing up but the Professor has the insights from Research to refine what should be done to overcome the initial issue 6.Identify next steps....teaching is learning for life.

I think being clear about what the 'issue' or research point will be about and how it relates to the needs of the school/ teachers/children. An absolute focus on improving learning - both for the children and the teachers. Doing the pre-planning research in depth so that the planning is based on good knowledge and is evidence based. Joint or collaborative planning and importantly the discussion which allow particpants to share knowledge and ideas. Being clear about the roles of observers and the teacher who delivers the lesson on behalf of the 'team'. The professional level of discussion afterward and how this is structured. The involvment of 'knowledgeable others'.

Clear common purpose Collaborative planning Objective observation Personal & collaborative reflection But a feature is also the flexibility of the process within a framework to account for different adaptations from school LS to district wide LS

. Team work . Developing the way difficult topics are taught and therefore developing the profession (as opposed to the individual) . Teacher enquiry dimension of lesson study

A good lesson: Encourages profound thinking and deeper investigation The teacher is learning to think and question her way through teaching A student is learning to think and question her way through her learning and teaching as well. The flow of a lesson must include: Grasping; Investigating; Deepening; Summarizing 1) Every lesson begins with a question- Question supports a research theme 2) Kyozai Kyenyu The research of the lesson- placement in the Unit; positioning of the lesson- RATIONALE= RESEARCH Researching the mathematics to deepen teacher understanding= richer student learning Collaborate with colleagues to discuss the question and anticipate student responses Make model/manipulative decisions Collaborate further Revise Repeat 3) BANSHO is one of the features of LS I came to learn more about. How a lesson is storyboarded deeply impacts how students make sense of the ideas shared. Students learn to Bansho their notebooks as well. 4) Nariage- (perhaps the most important feature?) This student discussion and idea sharing is at the heart of every good lesson- students explaining their thinking- being pressed by classmates and teacher to elaborate- having a change to articulate questions and confusions- collaborative learning development. 5) Some lessons had a student summarize the learning before ending the lesson. This was an important job and hopefully every student has the opportunity to do so. 6) The notebook reflection was a great way for students to sum up their own ideas or questions. The directive here should be strong.

- Collaborative Planning - Research informing planning - Identifying anticipated responses - Discussing and comparing/contrasting student responses - Reflecting on learning

There are clearly many features that are key to lesson study but I really only want to mention one here. I do feel we have made good progress with most features in my school, better than I originally thought, but there is one that stands out as needing careful revision; the planning stage. I was interested to learn how deeply the lessons are planned in Japan and this in turn allowed for meaningful post lesson discussions and learning for all the participants to take place. At times we have lost that in my school, and research lessons are planned in a rush. I have already changed the programme for next year to allow proper planning time to take place.

Collaboration and the CLR cycle.

1. A coherent and well thought out curriculum. 2. Lessons planned with a focus on Kyozaikenkyu. 3. Post lesson discussions with knowledgeable others steeped in the experience of the UK National Curriculum.

I believe the essential features of lesson study are: * Collaborative planning between teachers around one specific lesson as part of a series of lessons. This planning should also hinge on shared goals for this group. * Teaching of a research lesson by one member of the group where other members of the group observe (and others may be invited) * A collaborative post-lesson discussion held immediately after the lesson including the core group of planning teachers (and other invited observers)

Lesson Study brings together a team of like minded mathematics educators to research and plan effective lessons so as to develop deep understanding of mathematical ideas in the classroom so as to support students to think mathematically. It is a tool for developing the professional development of all teachers through collaboration with their colleagues. It enables teachers to think about and improve both their subject knowledge and the pedagogy of their subject. Teachers become aware of all areas of the curriculum and not just the particular year group that they are teaching at a certain time in their career. It makes teachers become reflective on their own practice and enables them to observe teachers from different levels of expertise, different schools and different districts. Lesson Study is a mechanism for continually improving teaching and learning. It is a continuum which is constantly being developed by those mathematics educators who are willing to participate.

A supportive system and administrators Time Access to curricular resources Knowledgeable Others

cooperation, research, professional development

The lesson study should consist of teachers where planning and teaching the lesson. The essential feature includes deciding on a objective of the lesson, planning for the lesson, observing the lesson, post lesson discussion and then reteach to another class or continue with another topic of interest. In lesson study it requires collaboration and sharing of knowledge. 1. collaboration between teachers in planning out the lesson. It could be combination of novice and experienced teachers. In lesson study, there was no hierarchy and every teachers were treated in the same way. The teachers worked together as a team and make decision as a team. The team took the responsibility of lesson and the class and not individual teacher responsible for a class. 2. sharing of knowledge. Teachers in a lesson study group are ready to contribute their knowledge and idea in deciding on the objective and flow of the lesson. The choice of number for the task was also very important, depending on the aim of the lesson and the targeted group of pupils.

The essential features of lesson study are: identification of a research/teaching question; collaborative planning of a research lesson to address the question, including kyozaikenkyu and planning for an effective class discussion (neriage); implementation of the research lesson, with multiple observers; analysis of the impact of the research lesson on the students, through observation of their comments and their written work during the lesson; and a post-lesson discussion, which includes participation from a knowledgeable other.

All four parts of the lesson study cycle are essential (Study curriculum and formulate goal, plan, conduct research lesson, reflect). During the LSIP Program, we learned the importance of kyozaikenkyu (study or research of teaching materials) and how detrimental the lack of kyozaikenkyu can be to the research lesson. We also learned how important the question is not only to the goals of the lesson, but that just a small change in one number in the question can change the whole dynamics of the class responses. An example from this year was seen in the last lesson that we watched on July 1 where the question of whether a 1.6 L bottle with the price of 320 yen was a better buy than a 2 L bottle with 420 yen. Why 1.6? Why would other decimal number not be as good of a choice? The creation of the lesson plan included the anticipated student responses and how the teacher should react to each one. I saw how critical this was with the Clock Lesson. The teaching of the lessons by the Japanese teachers still has me in awe and I would be extremely happy to see this level of classroom focus by students and orchestration in handling student responses in the US. Post lesson discussion was less harsh than I had anticipated from listening to other LSIP participants. I was glad to see that newer teachers had less harsh comments than those who had been teaching many, many years.

7. Please describe how your current organizational contexts use lesson study for educational improvement.

Text Response
Design and lead programmes for lesson study for individual schools or alliances of schools. About to start a London Lesson Study Network Group for interested teachers. Promote lesson study on other programmes as an effective model of profesisonal development.
Currently, in the UK, lesson study is a big thing. However, the interpretation varies from one institution to another. Many places just use it as a tool for collaborative planning of lessons, to create the 'perfect lesson'. In our hubs, we have tried to use a model of authentic Japanese lesson study to improve the teaching of problem solving in the LeMaPS project run by Nottingham University.
My current organizational contexts use lesson study for educational improvement was to delegate and share the context of lesson study among the teacher trainers and trainee teachers. The teachers training institutes could deliberate the model of lesson study as a 'role model' to improve classroom teaching practices as well as to improve the professional development skills among the teachers in school.
Initially Lesson Study was introduced to a group of Project Schools in Ireland (24 which became 23 schools due to an amalgamation of schools) in the academic year 2008-2009. It was introduced amidst the introduction of new syllabuses and reformed examinations at both lower and upper Secondary school and lessons were learned (see paper written by me in the International Journal for Learning and Lesson Studies vol.3, issue 3) It was reintroduced for a second time to these schools in 2012-2013 and had more success (findings under analysis). Teachers presented their work at a National Conference Maths Counts 2013 (www.projectmaths.ie/for-teachers/conferences/) Building on what appeared fruitful from its second introduction, Lesson Study was introduced national during the academic year 2014-2015. This was completely voluntary for teachers to engage in and forty schools and one hundred and fifty teachers became involved. Again a second conference Maths Counts 2015 was held to share this work with teachers nationally(www.projectmaths.ie/for-teachers/conferences/) The beginnings are small yet the ground looks fertile to continue this work. However, at the moment it is only school based with some schools coming together with isolated teachers. A caveat here is that it is not being led in an active way by school principals.
We have used a lesson-study type approach with teachers who we have paired up to plan and deliver lessons between schools. We have used a similar apporoach with teachers who trained as NumbersCount specialist teachers and those we have supported in their training as specialists (MaST programme with Sheffield Hallam Univ). This approach has given teachers involved valued opportunites to build a trustin relationship with one or two other teachers and then be willing to be observed by their peers and reflect on the impact of the lesson on children as well as on their own practice. We will continue to encourage lesson-study through all our courses and networks and begin to build it into our work in schools.
LS is "used" in a variety of schools in South Yorkshire and is generally more akin to the informal elements of school based LS only. Many of the participants do not have a clear understanding of the principles behind LS and are "going through the motions" rather than making the most of the process.
Currently I use lesson study as a professional development tool with in beginning (in service) teachers. Following the experience in japan I have decided to make lesson study a more prominent part of the course and to involve experienced teachers.
Lesson Study is a voluntary process at my school. 22 teachers and administrators at the school have participated in the program since its inception. The program has developed tremendously and has changed the culture of collaboration among the lower school's faculty. In addition to deepening our understanding of the mathematics we teach, Lesson study has helped to redefine our methods of questioning and instructional decision making across various disciplines, including foreign language, humanities, and the arts. We have identified the improvement of math instruction as a major goal and the Lesson Study work has been tremendously helpful in this work toward.
At my school, we have undertaken numerous lesson study research lessons in mathematics in some year levels as a form of teacher professional development, and also to improve student learning.
At present lesson study is used solely in the mathematics department. We have used it in conjunction with other schools and with the University of Nottingham. We have been focusing on developing the teachers toolkit in delivering problems solving lessons – focusing on the process skills, not conceptual understanding. We have mainly been using the Bowland tasks to do this.
We use LS as an action research tool, currently three cycles an academic year.

Little at the minute! I've taken part in a couple of studies around the LeMaPS material, but this has sat uncomfortably with me. The material is around teaching isolated lessons on problem solving, not part of a coherent development of concpets.
Currently, lesson study is incorporated into two modules for undergraudate and postgraduate pre-service teachers in building their mathematical knowledge for teaching but also in familiarising them with the model so they can continue practicising lesson study as in-service teachers.
At present the Initial Teacher Education department at the School of Education, University of Birmingham is starting to investigate Lesson study as the University has a secondary (high) school opening this September 2015 and it is hoping to incorporate lesson study into its teaching and learning policy. Obviously the school has an anticipated high profile as it is the first of its kind in the UK, it will be called the Universe of Birmingham School and will be striving to make an impact through outstanding teaching and learning. Hopefully lesson study will play a big part in this.
We use it strictly as a professional development tool for in-service teachers.
some schools are interested in introducing lesson study in near future
Currently my school did not actively starting any lesson study group as the school admin did not make it compulsory for teachers and teacher were overloaded with paperwork. Teachers were only exposed to introductory workshop about lesson study and most of them did not perceive it positively as they commented that it would only added pressure and workload to them. Hence, it was only on voluntary basis that a teacher and myself, we collaborate with a professor from a university to conduct a cycle of lesson study in my school.
In my current context, lesson study is not used at all. However, there are a few initiatives, led by Dr. Jennifer Lewis at Wayne State University, that are beginning to introduce and implement Lesson Study in districts near the one in which I teach. I have been a participant/observer in two of these initiatives.
I do not think that anyone in Alaska currently uses lesson study.

8. What do you think are the strengths/ benefits of using using lesson study in your local context(s) (e.g., district, school, university setting)?

Text Response
Empowers teachers, develops practice, improves learning
We are in the early stages of a new curriculum in the UK. I think Lesson Study is a great opportunity to look carefully at what is taught in detail, concentrating on the didactics, rather than only concentrating on pedagogy, which seems to be what we currently do. The process of planning over a long period of tie will be really useful for teachers to really home in on the detail of what we teach in mathematics lessons.
The strengths and benefits of using lesson study in my local contexts is to become a 'role model' for other teachers' training institutes in the country. Improving teaching skills in the classroom context as well as improving professional development model through lesson study process could benefits more in my local contexts. Identifying students' problem particularly in solving problems in the classroom is one of the major strengths of lesson study. A compact lesson plan could be planned through th collaborations of many teachers' idea and mind.
The strengths and benefits for those involved in schools are enormous: 1. It is strengthening teachers capacities as authors of their own work 2. Encouraging students as active and responsible learners 3. Developing teachers' desire for collaboration 4. Stimulating teacher initiatives to begin to understand how to teach mathematics through problem-solving 5. Cultivating constructive self and peer criticism 6. Building maths departments and teams in schools
I think it could be seen as a powerful professional development tool for schools working with schools. Our government is committed to sector-led school improvement and what they mean is schools working with schools, without Local Authority or University expertise. SO in this changing environment, if schools supporting others schools understand Lesson Study and are committed to its implementation, it may be a way forward in this evolving new system...However, who will be the 'knowledgeable others'??
To develop an ethos of teachers & professionals as "reflective practitioners" and eventually as "reflective researchers" . In the UK teachers, academics, educationalists and consultants see themselves as in different professions and LS could start to develop a common culture where the lines become blurred. This will in turn develop greater collaborative opportunities for the common good rather than the disparate way profession currently appears to work.
Develop a culture for team work using a professional development tool that is supportive as opposed to evaluative.
Lesson Study is the key to improving instruction, increasing professional responsibility, and in developing teachers into the professionals we need them to be. When teachers take their moment and teach their lesson, the entire community wraps around the teacher for his/her benefit. This rigorous process requires the teacher of the lesson to research, plan,write, articulate, defend, explore choices, think like a student, listen to difficult critique, consider the ideas of others, respond to questions, and still rise further. This is a challenging process with great benefits for those willing to put in the work and be a little bit brave. The teacher and community both benefit. Additionally, and most obviously, I think that, for those involved, a proper mathematics lesson study highlights the depth of understanding required to teach mathematics to children. Even after one research experience, it becomes clear to participants that it is impossible to make sound teaching decisions unless a deep understanding is supporting each instructional decision. Realizing one's lack of depth in their own subject area (particularly in US lower school mathematics education) can be unnerving, but is an essential step in improving. Lesson Study offers this eye openning experience as well as a sense of community and support in which to grow.
- Opportunity to collaborate on a topic which requires attention - A framework for accessing relevant professional reading and research - The opportunity to learn from other colleagues through professional conversions and the input of others during the planning process - The opportunity to learn teaching skills, such as questioning and scaffolding students thinking off others through viewing the research lesson - The opportunity to delve deeper into a particular topic or skill which teachers normally wouldn't have the time or accessibility to do so - A focus on looking at good problem solving tasks which promote student thinking and the idea of a 'good struggle' - Create a culture where open classrooms are the norm, and teachers can comfortably develop their own content knowledge and pedagogical content knowledge. - Make teachers learners as well as teachers - View questions from a student's point of view to see the

mathematics involved and the variety of ways students may approach the solving of a problem.

Mainly the chance to work collaboratively, something that only happened rarely before we introduced lesson study. The chance to plan with other teachers and observe regular research lessons is, in my opinion, the best form of CPD. It has allowed us to really think about our practice with regards to problem solving, an aspect of teaching that we had little expertise in at the start of this process. It has allowed us to generate enthusiasm within the department for teaching problem solving lessons.

Developing reflective practice in an improvement model.

It will get our thinking back on to developing mathematical thinking, and provide a catalyst for creating a coherent and well thought through curriculum.

The benefit of pre-service teachers engaging in lesson study is that they become aware of the importance of shared knowledge between their colleagues and of the various ways and importance of anticipating student thinking in learning and teaching mathematics. I feel this is also beneficial since these pre-service teachers will then be able to introduce lesson study to their respective schools in future and build this collaborative practice from the ground up.

In my role as a teacher educator, I see using lesson study as a means of developing and improving the way trainee teachers plan effective lessons that will have a positive effect on teaching and learning. This should also help to improve the lesson planning of school based mentors through working in collaboration with the university which should then have a knock on effect within their departments. I appreciate that in some schools this may not happen but as I know many of our mentors are ex University of Birmingham students I can see that they will appreciate the strengths of using lesson study to enhance teaching and learning.

The encouragement of collaboration in an otherwise-isolated structure.

develop teachers' professional knowledge through collaboration

In my school it will definitely benefits the professional development of the teachers. The teacher will have chance to sit down together and exchange their opinion on how to teach a certain topic identified. During the process of discussion, teacher would expose to different possibility of teaching the same topic, teachers would also contribute on how to inculcate mathematical thinking among the pupils through the research lesson, which was very rarely done in our country context.

There would be many advantages to using Lesson Study within the Detroit Public Schools. The first might be a cultural shift to a stance that respects and empowers teachers as a source of both knowledge and change. If teachers within Detroit, in both traditional and charter public schools, have been disenfranchised from their professional curiosity and development, Lesson Study would begin to place them back in the center of knowledge-making and improvement efforts. Beyond this foundational and big-picture shift, Lesson Study would provide an on-the-ground, real time process in which teachers could craft meaningful questions, enact deeply-considered instructional responses, analyze the impact on students, and reflect among a community of educators. Each of these steps would help build capacity and agency within Detroit teachers, toward the end of improving student outcomes.

I think the strengths of lesson study here in Alaska is that we are isolated by location from other states and thus we share more within our state. We are also somewhat flexible to allow for some of the changes necessary to conduct lesson study. I think lesson study would be beneficial to allow teachers to really learn the Common Core Standards for the US in mathematics. An additional benefit is for the teachers to have a deeper understanding of the mathematical concepts themselves as this is an area, I believe, is lacking in our elementary teachers. I would like to see more level 2 and level 3 teachers in our area and I believe lesson study would be helpful in this endeavor.

9. What do you think are the challenges to using lesson study in your local context(s)?

Text Response
Time for release for teachers to participate, especially given the current climate of excessive workload and accountability. The need for schools to show imporvement over very short timeframes. The performance management system and conflist between lesson study and lesosn observation.
Time is the biggest issue. Unless people can see the benefits straight away, they will be reluctant to invest the time (unless they are directed). Also, I think people in the UK are programmed to observe teachers in lessons. The switch may take some time. Then there is how teachers will take the feedback...
The main challenges of using lesson study in my local contexts were the time constraints to implement the process of lesson study. Another challenge was the collaborations of different participants of various field together in one lesson.
Challenges: 1. Time 2. Traditional approaches to teaching and learning 3. Rift between their beliefs and their practices 4. Insulation and isolation of teachers 5. Effects of Lesson Study on examination performance: Will it improve them?
We have lots of small primary schools more than half our schools have less than 100 pupils (national average is 250). Schools are remote and isolated - so getting people together can be a challenge. Cost of releasing staff to work together. Convincing schools to engage and drive this for themselves and finding the opportunities to do this. Although we have managed to make this work on a small scale and I am thinking that our big primary schools tend to be in areas of high deprivation, they have more money and more need to develop and keep staff. So maybe ...
Greatest obstacle to overcome is peoples' attitudes to change although the most common obstacle teachers and leaders will quote is there isn't enough time.
I am concerned that lesson study might become a quick fix, something that teachers don't understand deeply but do as a tick box exercise and therefore loose the potential for reflection and development.
Time- Lesson Study is voluntary at our school and we do not have a Wedensday early release program (or any day of the week). Our administration is very supportive of LS participants and works to find coverage for our planning sessions, but TIME is the factor. Teachers coach after school and run tutorials before school. We do not have a common office space and time together to discuss mathematics or lessons is challenging. Culture- Authentic Lesson Study would be quite difficult in the States, even in an independent school. Teachers have contract hours and the school fills that time with supervision duties, extracurriculars, pointless faculty meetings, and what is left is very little time for planning and assessment. Most teachers I work with arrive at 7:30 and stay until 5-5:30. Teachers take home piles of work and stay up late assessing and planning with their home time (after dinner and driving and bedtime for children). SO.... asking teachers to give more time consistently or even TAKE THE LEAD on a Lesson is very difficult. The most successful LS program I have been part of was at the University of Toronto's Lab School (OISE) where we had a Wednesday release day each week. That was LS Day EVERY WEEK and we developed an authentic program and held time asside EVERY WEEK for our important work. This is what is required.
- Time - Teacher coverage
The main challenge is sustainability, something I mentioned in Japan on the final day. In the UK we have a constantly changing curriculum with lots of external pressures. We often have new things to trial and incorporate into our teaching, and are typically rewriting a curriculum year to year. Teacher's time is already very tight and we need to find a way to make lesson study sustainable. At the start lesson study will be successful due to the initial excitement it will create. I believe our job is to find ways of sustaining that excitement and enthusiasm and keeping it on the agenda for the long term.
The main challenge is time and opportunity for colleagues to plan, prepare for LS.
The absence of a well thought through curriculum means we may lack the focus on what Lesson Study is for. Time (the obvious complaint!) will provide a challenge.
Currently, there is no acknowledgement or incentivisation for teachers to participate in professional development in Ireland. Lesson study takes time and teachers should feel rewarded in some way for their investment of time in developing their practice. There is not yet a culture of continued professional development in teacher education and this is a huge challenge to introducing lesson study to schools.
Unfortunately, in the UK in recent years there has been a huge emphasis on external examination results and school league tables which has resulted in many mathematics teachers 'teaching to the test,

with little regard for understanding'. The new mathematics National Curriculum (2014) has placed a much bigger emphasis on developing fluency, reasoning and understanding which I hope will change the ethos of rushing through topics to pass the examination. There is a big culture shift required to get all teachers on board.

The lack of time. The lack of systemic buy-in. The emphasis on process versus product.

culture differences

Time factor and commitment from teachers were the two major challenges. In my school, averagely, each teacher has 26 to 27 periods of teaching during school hours, 40 minutes of each lesson. Every teacher will have another one to two non-academic tasks assigned to them. Some teachers were given other extra work. On top of that, every teacher would take up some task during the school level event such as sport day, green run, school fund raising and Prize giving ceremony. Every teacher must also take up at least two extra co-curriculums as teacher advisor. Hence, to them, lesson study would be another work to take up their time, especially it requires a few meetings to discuss and make decision collaboratively. Hence, unless it is made top-down, meaning made compulsory by the ministry or school admin, otherwise, teachers would prefer to use the time left to focus on marking books and to prepare exam papers and lesson for their own class. Misconception on lesson observation as the teacher who taught the lesson would think that other teachers were coming to criticize them for the lesson that they observed and hence, the teacher feel uncomfortable to be observed by other teacher.

There are major challenges to implementation of Lesson Study within Detroit. It is an educational system in disarray. In general, professional development within mathematics within the Detroit Public Schools has not been responsive to teachers' questions and sustained over time. The institutional factors, teachers' understanding of mathematics, and culture of collaboration that support Lesson Study in Japan are absent. There is currently a dire funding context and an adversarial role between district administration and the teacher union which impede the allocation of time and resources necessary for the collaborative planning, implementation, and reflection which Lesson Study would require.

I am honestly not sure, but based on discussions with other participants my anticipation is finding teachers willing to donate time to this process and also being able to arrange schedules so that everyone could attend the research lesson and reflect on it. For these reasons, I will first contact some local private schools and the Japanese immersion school that are a bit more flexible in their ability to find solutions to these challenges.

10. Please describe how you hope to use lesson study for educational improvement in your current organizational contexts after this trip.

Text Response

See 7 above

In Maths Hubs: To use as a tool in continuing professional development. We have moved away from one day courses, to coursed over time. Now, when teachers collaborate to try things fro their courses, i would like them to use the lesson study model over a prolonged period of time. In school: I am introducing it over the whole school as part of our practitioner enquiry model. Instead of written research, teachers can be involved with a research lesson instead. Hopefully this will encourage collaboration within departments, and open up a meaningful dialogue into their everyday practice.

I hope that I could deliberate well the bigger scope and context of lesson study process to improve my current organizational educational contexts after this trip. I could share the inputs from Japan LSIP program through an in-house training. I would like to share and implement the entire idea among the teachers' training institutes in the country through proper channels.

I hope to build on the work that was done nationally last year by recruiting and training practising teachers in Lesson Study. They will be employed to convene/organise interested teachers either within their own school or across schools to participate in Lesson Study. University College Galway, and University College Dublin are now interested in collaborating with me on this venture to offer credits to teachers involved and hopefully act as moderators/advisors at post-lesson discussions where possible.

Share the experiences and learning with the whole school improvement team. Approach the new improvement partnerships for funding to set up some lesson study projects with identified schools. Promote lesson study at all subject leader networks and run sessions with gap tasks, so that they can go away trial and feedback through networks. Link to local maths hub to look at ways to develop lesson study. Work with Nottingham University - two days planned for end of August.

I am currently in the process of starting a programme of development in 30-50 primary schools and LS elements will be built into the programme so that at the end schools will be encouraged to continue their development through a LS style process. At the same time I will be encouraging particular schools (primary & secondary) to undergo a more formal Japanese style LS process that demonstrates to a wider community the true nature and potential of LS

After having learned so much I cannot wait to get started back home. My model will be substantially revised based on what I have learned during the past two weeks and have tried to express above. I am certainly going to use some of the teaching ideas I have learned and I also hope to keep in touch with the colleagues I met during the trip from whom I also learned a lot. I will continue to be part of the lesson study international community that will benefit the profession and consequently the children.

1) to build a stronger foundation of Lesson Study within the lower school community by sharing the lessons and experiences gained from LSIP (faculty meetings, informational workshops, board meetings, parent education night)　2) to support expansion of Lesson Study to the broader Ensworth community (middle and high school teachers and administrators).　3) to support dissemination to other independent schools, to the Nashville Metropolitan Public School District, and to Vanderbilt University's Peabody School through "Lesson Study open-houses" and workshops when we will welcome colleagues to immerse themselves in our Lesson Study.　4) to lead to discourse beyond the specifics of the mathematics by influencing lesson structure and questioning in other subject areas; sciences, music, humanities, foreign language, and the arts.　5) to work with mathematics education researchers who may help participants access appropriate reserach materials and mathematics articles to deepen the understanding of the mathematics being taught.　6) EVERY lesson begins with a good question. Refocus our teaching so that it holds problem solving at its core. Keep student idea development and discourse at the heart of the instruction. Use student thinking to direct the next lesson. Enourage teachers to spend more time learning about the mathematics so that they may know enough to facilitate rather than teach procedural math because they lack true understanding.

1. Professional learning for staff- explaining the lesson study process as I now understand it complete with photos and excepts from my lesson note observations and lesson planning documents. Firstly at leadership team level then to all teams within the school　2. Creating the demand- constructing a team of willing participants around the school to develop their capacity in lesson study and using this team as an example for a lesson study launch　3. Sharing the role- working with a colleague who attended this program last year to ensure we are keeping the process as authentic as possible and having two leaders in the school drive the process 4. Conducting a lesson study cycle with the lesson study team as an 'open house' opportunity for teachers to observe the process and ask any questions about the process.　5. End in mind goal: making lesson study a part of the culture of my school

There are three ways I will do this; Firstly, I will be working with three other local schools, continuing the work on a project that started last year. This project will continue to look at using problem solving to develop process skills. I have already implemented changes to the schedule, reducing the amount of research lessons. My intention is to focus and spend much more on the planning of the research lesson. Secondly I intend to host two research lessons within the mathematics department at my school. For each I will have a three man planning team and we will plan in full detail a lesson similar to the ones seen in Japan; a problem solving lesson where the aim is to develop concepts. I am fully aware of the challenges that this will present but am excited at the prospect of planning a lesson that develops the students understanding of mathematical concepts. Every member of the maths team will observe the research lesson and be part of the post lesson discussion.　Finally, I intend to spread the message of lesson study to other departments in my school. There is already interest from the science department and I intend to run a lesson study group. This group will meet six times throughout the year and will contain staff from a range of departments. It is hoped that two research lessons will take place with the focus yet to be decided. Asides from the six scheduled meetings, more planning meetings will be allowed and to allow for sustainability I will borrow one more idea from Japan. I propose that the research lessons will take place after school with selected students; this is an exciting prospect that will allow all members of the group to take an active role in the lesson study process.

We will be using school based LS on our regional and national projects, especially on long term CPD programmes.

Develop with a number of primary schools (that are part of the Singapore textbook trial) as they have a coherent curriculum.　Develop within my school, then seek to share the experience we've gone through.

As mentioned above, I will be introducing lesson study in two new modules for pre-service teachers. I also plan to begin working with the Masters programme available to in-service teacher to develop a module on lesson study which practising teachers can then introduce to their schools.　I also plan to work with

my Irish colleagues in developing a national roll-out of lesson study to ensure that it remains authentic and valuable as a model of teacher collaboration and education.
As stated before, I hope to use lesson study to improve both the lesson planning skills of my trainee teachers and their subject knowledge. One particular area that I wish to focus on is anticipation of pupil responses as this is a weakness of trainee teachers. They regularly fail to recognise when misconceptions have been raised by the students they teach, and as a result miss perfect opportunities to discuss mathematics in their lessons. In addition, I am hoping to present with another LSIP 2015 participant at the next Association of Mathematics Educators and Teachers Conference in October 2015, about our experience of the LSIP trip to Japan. This conference is for UK based mathematics educators and teachers so from this we should be able to engage more likeminded professionals in the benefits of lesson study.
I will focus more on the LOCAL context. Facilitating the growth of local experts (in the local curriculum) will be a new point of attention.
I will do my best to help the schools that are interested in using lesson study in their daily work
Since I am not part of the school admin or the ministry staff, what I could do is from my own, I would gather a few colleagues and start a small lesson study group. We would plan to carry out a research lesson and an open class to invite schools in the same district to observe the research lesson. By doing that, I hope that the teachers would be able to see the benefits of lesson study. However, all these was still in a planning stage and hope that action would be taken as soon as we get agreement from three to four mathematics teachers in my school.
I am hoping to use Lesson Study in three ways following my experience this summer. The first is to establish an informal lesson study group, comprised of teachers from schools across Detroit. These are teachers with whom I have a professional connection, and who I think would be interested in thinking deeply about mathematics instruction along with me. Secondly, I would like to begin a Lesson Study cycle with teachers at Bennett Elementary school, perhaps with a more formal recognition by the district of this as a professional development experience. Finally, I would like to continue to participate in the evolving Lesson Study work that Dr. Lewis and Christopher Nazelli are implementing in Southeastern Michigan.
My perspective is a bit different than the other participants in that I am not affiliated with any public school or department of education. In the next school year (Aug – May, 2015-16) I plan to visit with at least two different elementary schools in Anchorage, AK to explain and promote Lesson Study. Secondly, I plan to give a talk on Lesson Study at a state math and science conference. Last, when I return to my university in the fall of 2016, I will try to bring lesson study to a small group of interested individuals who teach mathematics.

11. How much did you learn about each of the following during the immersion trip to Japan?

#	Question	Not at all	A little	Some	Quite a bit	A lot	Total Responses	Mean
1	a. Mathematics content	0	4	4	7	4	19	3.58
2	b. How to support students' problem-solving ability	0	0	7	3	9	19	4.11
3	c. Evaluating lessons on the basis of the written plans	0	2	3	5	9	19	4.11
4	d. How lesson study is conducted in another country	0	0	0	1	18	19	4.95
5	e. How lesson study is conducted in different educational contexts (e.g., schools, districts, etc.)	0	0	0	5	14	19	4.74
6	f. Collecting data on student thinking to inform instruction	1	0	3	9	6	19	4.00
7	g. Strategies for making students' thinking visible	0	0	3	6	10	19	4.37
8	h. Analyzing/studying curriculum materials	0	1	3	8	7	19	4.11
9	i. Ways to build connections among educators at multiple levels of the education system	0	0	3	9	7	19	4.21
10	j. Anticipating student responses	0	0	5	6	8	19	4.16
11	k. Writing a useful lesson plan	0	0	7	1	11	19	4.21
12	l. Supporting participants to have powerful and effective lesson study experiences	0	0	5	3	11	19	4.32
13	m. Organizational/structural supports for lesson study	0	0	1	7	11	19	4.53
14	n. Students' mathematical reasoning	0	1	6	4	8	19	4.00
15	o. Differentiating/ offering support for struggling learners	5	5	3	4	2	19	2.63
16	p. Cultural influences on mathematics teaching and learning	0	0	3	6	10	19	4.37
17	q. Organizing a successful post-lesson debriefing session	0	0	1	5	13	19	4.63
18	r. A typical school day at a Japanese elementary school	0	1	4	4	10	19	4.21
19	s. Developing	0	3	3	9	4	19	3.74

	mathematics units and lessons							
20	t. Strategies for working effectively in a lesson study group	0	1	3	4	11	19	4.32
21	u. My own country's approaches to mathematics instruction	0	1	6	8	4	19	3.79
22	v. Analyzing written student work/ responses	0	4	8	4	3	19	3.32
23	w. Analyzing and interpreting verbal student comments	1	5	4	5	4	19	3.32
24	x. How to build students' mathematical habits of mind and practices (such as in the Common Core State Standards)	0	1	6	7	5	19	3.84
25	y. How to build a classroom learning community	0	2	6	7	4	19	3.68
26	z. Knowledge about the Japanese educational system in general	0	2	1	5	11	19	4.32
27	aa. How to lead lesson study	0	1	2	5	11	19	4.37
28	bb. How teachers learn from participation in lesson study	0	0	2	6	11	19	4.47
29	cc. What other LSIP participants are doing with lesson study	0	0	4	7	8	19	4.21

12. Please select and rank in order of importance the five items from the previous question that you believe will be most professionally useful for you within the next year. (Drag and drop your top five.)

#	Answer	
1	a. Mathematics content	3
2	b. How to support students' problem-solving ability	7
3	c. Evaluating lessons on the basis of the written plans	0
4	d. How lesson study is conducted in another country	6
5	e. How lesson study is conducted in different educational contexts (e.g., schools, districts, etc.)	2
6	f. Collecting data on student thinking to inform instruction	5
7	g. Strategies for making students' thinking visible	8
8	h. Analyzing/studying curriculum materials	4
9	i. Ways to build connections among educators at multiple levels of the education system	3
10	j. Anticipating student responses	7
11	k. Writing a useful lesson plan	7
12	l. Supporting participants to have powerful and effective lesson study experiences	10
13	m. Organizational/structural supports for lesson study	3
14	n. Students' mathematical reasoning	3
15	o. Differentiating/ offering support for struggling learners	1
16	p. Cultural influences on mathematics teaching and learning	2
17	q. Organizing a successful post-lesson debriefing session	8
18	r. A typical school day at a Japanese elementary school	0
19	s. Developing mathematics units and lessons	1
20	t. Strategies for working effectively in a lesson study group	4
21	u. My own country's approaches to mathematics instruction	0
22	v. Analyzing written student work/ responses	1
23	w. Analyzing and interpreting verbal student comments	0
24	x. How to build students' mathematical habits of mind and practices (such as in the Common Core State Standards)	0
25	y. How to build a classroom learning community	1
26	z. Knowledge about the Japanese educational system in general	1
27	aa. How to lead lesson study	5
28	bb. How teachers learn from participation in lesson study	3
29	cc. What other LSIP participants are doing with lesson study	1

13. How did your views about teaching and learning mathematics change as a result of this trip, if at all?

Text Response
My views were further embedded - I had time to tjhink about my beliefs and explore them more fully.
That what we do in the UK is very superficial, and perhaps does not support student learning as much as we think it does. That every detail is important and that careful consideration is needed to avoid pupil misconceptions. That students need to have time to struggle with concepts.
Teaching maths through problem solving.
Develop a new approach to teaching geometry in primary schools - re-introduce pencil ruler and compasses and exploring how lines, angles and arcs interact to produce shapes and geometrical relationships. Re-affirmed my belief in problem-solving as the way to develop mathematical thinking and develop leaners as mathematicians not training them to pass tests. I have been chipping away at this since I was handed the Cockcroft Report as a new PGCE students in 1983 - so I have been chipping away for a long long time!!
My views did not "change" per se but it was useful and interesting to observe and hear about T&L of Maths across the world through meeting such a wide variety of participants.
Not much but I was able to reflect on how to make such views more visible to students
I learned how much I need to learn. I also learned that my teaching will be far more powerful when I keep it problem centered, focused on one INTENTIONAL situation and problem, and engage my colleagues with greater frequency in conversations about student learning and number selection. Board writing and notebook Bansho are central in the learning process. Students can draw on past lessons and learnings when they have ideas 'storyboarded' in their notebooks.
My views were confirmed and extended in seeing the benefit of using problem solving as a way of developing student thinking
It has changed me massively. But I will comment on the main two. Firstly, problem solving that leads to conceptual understanding. This is brand new to me and something that I will use next year. It will take careful thought and planning, it will be a huge challenge. Secondly, being a 'mathematics' teacher. Due to lots of factors I have lost the rigour that maths demands, as have many of my colleagues. I have returned from Japan eager to get back to thinking carefully about the maths.
Problem solving is a particular interest and certain I attained some new ideas to develop a heuristic approach.
Need a better balance between general pedagogy and developing mathematical thinking.
I don't feel they changed but were challenged and solidified through the lectures and discussions and through observing so many mathematics lessons. I feel that problem based learning is a powerful approach to teaching and learning mathematics once students' thinking is made explicit and once there is a classroom community where students feel they can share their thinking.
I have always had the view that teaching and learning cannot be separated, I feel that this trip has cemented this view as the Japanese have just one word to represent teaching and learning.
The strong emphasis on problem solving impressed me. The similar structure of all of the lessons helped me see how they have operationalized it. I will try to incorporate that into the lessons that our lesson study groups design.
I will use more group work in my future teaching
I see that it was possible to let pupil explore mathematics themselves or in pairs by engaging them with thought-provoking task and questions. Before coming to this program, I used to thought that practice make perfect and I used to do show-and-tell a lot in my lesson, then continue with practice in next lesson. The most that I did was to ask pupils to solve problems in group and explaining their answers to the class as reinforcement at the end of the topic. After this trip, I realized that the quantity of mathematics questions solved by pupil was not a factor of mastery, the mathematical thinking and mathematical skills that pupils gained in a lesson was very much valuable compared to quantity of task given. Pupils would gain more through mathematical discussion or "Niriage". That's the point where pupils starts to learn more than what they knew as they could explore many other possible solutions. Niriage rarely happened in my classroom, or I would say within my schools. My students were too much dependant on teachers as source of knowledge and they were very used to be spoon-fed with knowledge without doing much thinking. They tend to accept what was told to them. Hence, after this trip, I would say it was possible to inculcate the mathematical thinking in a lesson by focusing on one question and I would like to try.

My experience during Project LSIP has not changed my view of the teaching and learning of mathematics, but it has given me an experience of a system-wide approach to implementing and improving teaching through problem solving. I have a deeper understanding and appreciation of the pursuit of thinking profoundly about planning and instruction, as well as viewing lessons and learning from the student's perspective. The challenges to implementation in my context became underscored, but my determination to implement Lesson Study strengthened as well.
It taught me what the ideal process can look like!! Learning does not have to be teaching rote processes followed by a lot of homework for student understanding. Narrow scope and depth of understanding is more important than breadth of topics. The challenge will to convince others that the time put into the process is worth it in the end.

14. Please comment on the transportation arrangements arrangements and hotel facilities, to help in planning for future programs.

Text Response
All excellent
All were excellent. It would have been nice to have a communal area in the hotel so we could discuss the day into the evening. Unless people were outgoing enough to talk to others, some may have spent many evenings alone.
All the transportation arrangements and hotel facilities were superb and no comments to posed about it, A wonderful hospitality services were given to us. We were well taken care along the program.
None
Great! Fantastic! The hotel was very easy to find, the room was lovely and well-equipped and the staff were incredibly helpful. The hotel was in a good area with lots of places to eat/shop. I arrived at Narita Airport and because I had printed off the details of where I was going it was very easy for the information staff at the airport to give me the right ticket and instructions of how to get to Kokubunji. Travelling to and from schools was also well-organised.
Apart from the opportunity for delegates to meet informally at the hotel, I would suggest any other changes.
Absolutely perfect thank you
Tokyo transportation was easy- please let participants know they need to take rapid trains to Kokubunji on Sundays as the local trains do not go all the way. The SUICA card was easy to use and there was a very GENEROUS stipend on the card. Thank you. Hotel Mets was very comfortable and clean- good breakfast and helpful staff Hotel Fuji was incredible. Clean, comfortable, delicious food, great ONSEN, interesting experience. The meals offered an opportunity to enjoy many dishes and try new things. The time by the pool to write our journals was excellent... nice to 'get your ONSEN on."
Transportation and Hotel facilities were fantastic
All excellent. Only one minor comment – the second hotel allowed the group to socialise much more, which allowed us to have many more conversations about our thoughts. At the first hotel there was no real place to do this which was a shame.
Fine
Fine - enjoyed being able to walk to the University.
Transport instructions from the airport were helpful. The hotel room was a little small (I think they varied!) but very functional. Transportation overall was excellent and I enjoyed the walk to the university.
The Mets Hotel in Kokubunji was very good, the rooms were compact but very clean as were the public areas of the hotel. Breakfast was adequate. Despite not having a restaurant or bar, the location of the hotel was excellent. It was easy to find places to eat in the evening as there were so many restaurants, bars and coffee shops. Being so near to the railway station and shopping mall was an added bonus. All transportation arrangements were superbly organised.
I thought that they were fantastic. I would have liked to have been based in Tokyo, but other than that, all of the arrangements were great.
very good
I was absolutely satisfied with the transportation arrangement and hotel facility.
The logistical and hosting aspects of the program were fantastic. All directions were clear, all contingencies accounted for, and everything was lovely.
I thought everything was wonderful! It would have been nice to know to bring a smaller bag for the trip to Yamanashi.

15. Anything else you'd like to add?

Text Response

Thankyou so much for giving me the opportunity to participate in such an amazing educational experience.

I haven't stopped talking about the two weeks since my return. Even though I have been teaching for 20 years at a high level, I feel I have learnt so much. It has changed what I do in my everyday practice, and has given me a whole new enthusiasm for teaching. I loved every minute! Thank you so much for the opportunity.

The lectures was meaningful to improve our knowledge in lesson study. The volunteers and the graduate students were very kind and helpful all the way in the entire program. I am amazed with their helpful hearts..Thank you to all of them.

I could never do justice to what I experienced and convey the collegiality that was built up over the programme between the LSIP team and the participants. If I could bottle it I would!!

Please can I go again??? Best learning experience I have had in a very long time, which seemed to come along at just the right time. It gave me the opportunity to consider in depth what I know, what I believe, and what I want as someone who has been involved in mathematics education forever. It also helped me to realise I can do things differently. It gave me new ideas and reminded me of old ones, and gave me confidence in what I value. And maybe its time for a new job! Thank you soooo much - it has been a very important learning experience for me.

Many thanks to the entire team for their professionalism and support through the whole trip.

Thank you so much. The past two weeks have shaped my future career.

Immersion is an incredible opportunity. This was an experience that changed my life in so many ways. This particular collection of professionals was magnificent. I learned so many things from their experiences and through our informal conversations while walking, over a beer, and breakfast at the hotel. I don't think there was a single member of the community who was not eager to engage in a professional conversation, a laugh, or social chat. It did not matter from where we came or our title in our home country... each voice was valued, respected, and heard. I'd like to suggest an LSIP PART II with this group next year. I can only imagine how much further we would grow. It would be interesting to build a part II experience into this program so that we might look at how we took Part I home and the next steps. I am eternally grateful for this experience.

N/A

Loved the experience! It's genuinely changed the way I view maths education.

I am so very grateful for the generosity and hospitality of our Japanese hosts. I feel I have learned and benefitted from the trip and hope this will provide me with greater incentive and means to impact how mathematics education is changing in Ireland

I just want to say that I am so grateful for having experienced this amazing learning opportunity in Japan. I enjoyed every single minute of the trip, both academically and socially. I am so fortunate to have met so many likeminded individuals who care so much about the teaching and learning of mathematics. It was a privilege to have been chosen to participate in LSIP 2015 and I will endeavour to improve the teaching and learning of mathematics forever after this unforgettable experience. THANK YOU SO MUCH.

no

I would again like to express by deepest gratitude for the time, insight, resources, kindness, and passion for improving mathematics education shared by everyone in the Project LSIP team.

<Annex 1>

List of Participants for Lesson Study Immersion Program 2015

June 22 - July2 in Tokyo, JAPAN

Special Guest Participant ;
Alan H. Schoenfeld,Ph.D.
Elizabeth and Edward Conner Professor of Education and Affiliated Professor of Mathematics,
University of California at Berkeley, Graduate School of Education,

External Evaluator ;
Jennifer Lewis, Ph.D.
Assistant Professor, College of Education, Wayne State University

	Name		Country	School/ Department
1	Ms.	Anne Brosnan	Ireland	Project Maths Development Team (PMDT)
2	Ms.	Aoibhinn Ní Shúilleabháin	Ireland	School of Mathematical Sciences, University College Dublin
3	Mr.	Brian Doig	Australia	Deakin University
4	Ms.	Bridget Clay	UK	National Teacher Enquiry Network (NTEN)
5	Mr.	Christopher Nazelli	USA	Wayne State University
6	Ms.	Hana Abdulmajid Abdulqawi ALshwal	Qatar	National Center for Educator Development, College of Education/Qatar University
7	Ms.	Jacqui Lomas	UK	Harris Federation, London Thames Maths Hub
8	Ms.	Jun Li	Australia	Deakin University
9	Ms.	Kalaivani Shanmugam	Malaysia	National Type of Tamil Ramakrishna, North-East District Education,State Education
10	Ms.	Kelly B. Goorevich	USA	The Ensworth School
11	Ms.	Mariel N. Laureano	USA	Prieto Math and Science Academy
12	Ms.	Mary O'Connor	UK	University of Birmingham
13	Ms.	Matilde Warden	UK	George Spencer Academy
14	Mr.	Matt Woodford	Uk	School in Nottinghamshire
15	Ms.	Melissa Warner	USA	O' Keeffe School of Excellence
16	Ms.	Monica G. McLeod	USA	Bennett Elementary School
17	Ms.	Pamela Maslyk	USA	Alaska Pacific University
18	Mr.	Peter Sides	UK	Notre Dame High School, Sheffield
19	Mr.	Phillip Noble	UK	The Redhill Academy
20	Ms.	Rosa Archer	UK	The University of Manchester
21	Ms.	Sandie Blakesley	UK	Education & Skills Service, CYPS, North Yorkshire County Council
22	Ms.	Sara McKee	Australia	Springside P-9 College- Caroline Springs
23	Ms.	Sarah Seleznyov	UK	London Centre for Leadership in Learning, Institute of Education at UCL
24	Mr.	Simon Mazumdea	UK	Altrincham Grammar School for Girls
25	Ms.	Tan Phei Ling	Malaysia	Methodist Girls' School in Penang

日本流授業を輸出

「教員同士の議論」新鮮

現場の教員による授業改善の活動など、日本の教育の長所を海外の教育関係者に伝える取り組みが盛んになっている。代表的なのが教員同士の議論を通じて授業の質を高める「授業研究」で、導入を試みる国が相次ぐ。日本政府や大学もこれからの国際貢献の一環として、国境を越えた「先生の学び合い」の充実に力を入れている。

6月下旬。米英両国やカタール、マレーシアなど6カ国で算数・数学教育に携わる教員、研究者ら27人が日本を訪れた。目的は東京学芸大が企画した、授業研究について学ぶプログラムへの参加。11日間の日程で7つの小中学校の授業を見学し、日本の専門家と指導法などを巡って意見を交わした。

一般に授業研究は①「分数の意味を理解させる」といった目標を立て指導案を作る②他の教員の前で研究授業をする③内容を批評し、結果を共有する――といった流れで行われる。一行は7月1日、東京都世田谷区立笹原小学校で、5年生を対象に行われた算数の研究授業に参加した。

授業のテーマは「小数の割り算」。大橋佑基教諭（38）は「1リットルで216円」「2リットルで420円」「1・6リットルで320円」という3本のペットボトル入りジュースを提示。最後のジュースの1リットル当たりの値段を求めるにはどうしたらいいか、と問いかけた。

「320÷1・6」「320×0・4」……。児童が自分なりに考えた答えを発表すると、大橋教諭は一つ一つ、理由を聞いて板書した。

「1・6で割ると、なぜ1リットル当たりの値段が出るのだろう」。次の時間に向けて子供たちの疑問が集約されたところで、授業を終えた。

海外からの参加者が注目したのが授業後の協議会だ。「1・6等分という言葉を使ったが、意味が分からない」「320÷1・6の計算はまだできないのに、この式で1リットル当たりの値段が出るのかという発問は適切か」……。大橋教諭には同僚から遠慮なく疑問がぶつけられる一方、「子供の疑問を子供が解決していくよい授業だった」と賛辞も寄せられた。

「海外の教員研修は教え方についてベテランなどが答えを与えるところから始まる。日本の授業研究は『思考力を高めるには？』といった疑問から始まり、1つの結論は出ない。だから継続性がある」。プログラムの責任者である学芸大の藤井斉亮教授（数学教育学）は授業研究の特質をこう説明する。

藤井教授によると、授業研究は米国で導入が始まり、ほかにも関心を寄せる国が増えている。1コマの授業で1つの問いを考える課題解決型の授業も海外の教員には新鮮で、模倣する動きがあるという。

プログラムの参加者からも日本式授業を評価する声が聞かれた。米シカゴで小中学校段階の子供が通う学校の校長を務めるマリエル・ロレアーノさん（40）は「校長として授業研究をどう支援していけばよいか分かった。現場の教員が協力して指導案をつくり、じっくり話し合うことが大事だ」と語った。

カタールで教師の職能開発などに携わるハナ・アシュワルさん（34）は「どう授業研究を導入していくか、国内で議論を盛り上げていきたい」と真剣な表情で話していた。

6カ国の教員らが参観し（写真上、7月1日、東京都世田谷区の区立笹原小学校）、授業研究について話し合った（2日、東京都小金井市の東京学芸大）